INDUSTRIAL MEMBERS

(Members of 2010 Industrial Advisory Board)

Abbott Nutrition

Cargill, Inc.

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Genencor

General Mills

Grain Processing Corporation

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PepsiCo

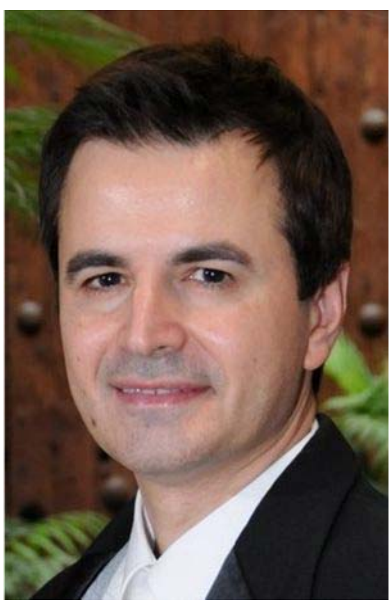
Procter & Gamble

Roquette

Tate and Lyle

In Memoriam

We are sad to convey that Adam Aboubacar passed away unexpectedly in September 2010. Adam had a long relationship with Purdue Food Science and the Whistler Center through his graduate and post-graduate studies. He earned his Ph.D. in 1997 with Bruce Hamaker and continued in his laboratory as a post-doctoral Research Associate on several projects. He was a faculty member of the University of the United Arab Emirates since 2005 and was dedicated to helping his native country of Niger advance in the area of food processing and general development.



It is with great sadness we share with you that our friend and Industrial Board liaison Frank Barresi passed away. Frank fought a courageous battle with cancer for the past year, and was an inspiration to everyone who knew him. Frank was the Senior Vice President of Research & Development at Grain Processing Corporation and had worked at GPC for 15 years.

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DIRECTOR'S STATEMENT

I am pleased to welcome you to our 2010 Whistler Center for Carbohydrate Research Annual Report. We had a very good year in terms of output and I believe quite relevant research geared to solve application-oriented problems in the world of food and industrial uses of carbohydrates. We welcomed Genencor as a new member and were happy to have Cargill back on our list of industrial members. In addition, we saw a number of new research projects among our faculty that are supported by member companies, as well as an increase in analytical service work. Our ten faculty and their research groups compete well for federal and other competitive grant funding, even in this difficult funding climate. I think this is in part due to our numerous internal and external research collaborations have moved many of us to a team approach in problem-solving research. Our analytical service which encompasses complex carbohydrate structural, physicochemical and rheological analyses began only two years ago and is growing. Of note too, we are in the process of hiring a person to enhance technical communications with our member and outside companies, extend our early and developing technologies, and move more actively to partner with other research groups here and overseas. This, we feel, will strengthen our capabilities as well as service our members in a better way.

Our 2010 activities included our annual May Whistler Center Board meeting and poster presentations from 34 active research projects, followed by our half-day Technical Conference with our 2020 Belfort Lecturer Prof. Jan Delcour from Katholieke Universiteit Leuven, Belgium. Jan has a broad range of expertise in cereal carbohydrates and spoke on his group's fascinating work on wheat arabinoxylans both regarding their role in bread dough and bread quality and their fermentative properties in the colon. Their pioneering work in this area has led to technologies for producing arabinoxylooligosaccharides as a new prebiotic ingredient. We were pleased also to have Prof. George Fahey with us from University of Illinois. George gave a wonderful talk on their *in vivo* dietary fiber work and gave a very practical view of where we stand in fiber and health research. Other related talks were by Dr. Senay Simsek, North Dakota State University, who spoke on arabinoxylans in frozen dough, and from our own faculty at Purdue who research in this general area. In October, we held our sixth annual Carbohydrate Short Course which is offered free to our member companies. This popular 3-day course covers a first day intensive on carbohydrate chemistry, structures and function; followed by 2 days of specialized half-day courses that this year included new topics including a primer on carbohydrates related to health ("Carbohydrate Nutrition 101"), "Physiologic Effects of Dietary Fiber from Plastic to Viscoelastic" given by Dr. John McRorie, a guest lecturer from Procter & Gamble, beverage emulsions and encapsulation, and a new view on glycemic carbohydrate nutrition; as well as popular sessions on starch modification, rheology of polysaccharides, complex carbohydrate analysis, dietary fibers and prebiotics and colon function, and polysaccharide structures. We discussed at our summer faculty retreat to offer another 1-day forum to follow our successful forum held in November 2009 on glycemic carbohydrates and physiologic response, and are planning a fall 2011 one on carbohydrate nanostructures and applications.

Our faculty, post-doctoral research scientists, and graduate students continue to receive recognitions and to win awards at annual scientific meetings. All this can be found in the following report. Looking ahead, we are working hard to serve the carbohydrate utilizing community and to improve ourselves in serving our members as well as provide new research findings and education to address both big and small questions in carbohydrate science. We are already well into planning for the 2012 International Hydrocolloids Conference which will be hosted by the Whistler Center May 14-18 at Purdue University. This premier meeting on hydrocolloids will bring together leading experts from around the globe to present and discuss their new research findings. We are fortunate to have Elsevier Publishing help us in administration of the conference as well as the International Carbohydrates Consortium which joins the

Whistler Center, the renowned hydrocolloids group from Wrexham, Wales and the carbohydrate research group from Food and Agriculture Canada at Guelph. The website is www.international-hydrocolloids-conference.com.

I invite you to read through our 2010 report, and feel free to contact myself or Marilyn Yundt, our Center coordinator, with inquires or comments

Sincerely,

Bruce R. Hamaker
Roy L. Whistler Chair Professor
Director

Starches, Non-Starch Polysaccharides, and Cereals:

Dr. BeMiller's lab group continued a study of the effects of the degree of channelization of normal corn starch on the properties of its modified starch products (Project 1), investigated the impact of the order of addition of rapidly reacting reagents and alkali in making modified starch products (Project 2), continued a study of the interactions of various starches and modified food starches with various hydrocolloids and factors that affect them by considering the effect of the content of amylose on interactions with hydrocolloids and interactions of hydrocolloids with commercial pea starch (Project 3), completed the investigation of whether normal corn starch that had been heat-moisture treated, then subjected to temperature cycling (HMT-TC) to convert it into a product that had a relatively high degree of slowly digesting starch (SDS) could be chemically modified to convert it into a functional modified food starch without substantial loss of its SDS content (Project 4), and investigated the effect of granule swelling on various derivatization reactions (Project 5). In particular, in Project 4, it was determined that, in some cases, subjecting the starch simply to the conditions of modification produced greater changes than did reaction with a reagent.

Dr. Hamaker's group mainly conducts research in the area of Carbohydrates and Health (see summary below), though also works with O. Campanella on better approaches to achieve high dietary fiber incorporation into foods; a nanoparticle composed of starch (amylase), soluble protein, and free fatty acids; and on ways to add value to corn zein through improvement of its functional properties. Project 10 describes the case of two arabinoxylan polysaccharides that have different solution properties regarding interaction and aggregation. An approach looking at solution conformation properties makes an interesting model of molecular characteristics that drive aggregation with application in beverages. In Project 8, we continue to learn more about a novel nanoparticle we discovered about 10 years ago and show now that it has the useful capability of carrying valuable hydrophobic small molecules in a soluble form. Three factors drive the research described in Project 16 on functionalizing non-wheat storage proteins such as corn zein: 1) making a viscoelastic protein that is similar to wheat gluten for the gluten-free industry, 2) replacing wheat flour with functional flours of sorghum or millet for developing countries to reduce expense and provide local farmers with better access to markets, and 3) increase value of an underutilized and cheap by-product of corn wet-milling.

Dr. Mauer has played a significant role in improving the understanding of the detrimental effects of moisture on crystalline and amorphous solids and the synergistic interaction of water with multi-component blends of food ingredients (Project 20). Work by Dr. Mauer and collaborators introduced the concept of "deliquescence lowering" to food science and showed that powder blends of highly water-soluble organic materials (including sugars, salts, organic acids, and vitamins) undergo the phenomena of deliquescence (first-order solid to solution phase transition) and deliquescence lowering, which can lead to both enhanced chemical reactivity and powder caking. Having shown that deliquescence lowering is relevant for food and bioactive products, Dr. Mauer followed up to show the consequences on the chemical and physical stability for complex blends. Amorphous ingredients also contribute to the chemical and physical instability in deliquescent blends. Ongoing studies have determined that anticaking agents can reduce the chemical stability of chemically-labile deliquescent ingredients, such as vitamin C, even when physical stability is improved. In multidisciplinary projects with pharmaceutical scientists and engineers, recommendations were developed for appropriate formulation, processing, packaging, and storage conditions to maintain product quality. Improved environmental control systems have been adopted by several food companies to avoid deliquescence-related problems with food products. For consumers, the quality of dietary supplements can be extended by avoiding storage in warm, humid environments (such as a bathroom) and instead storing products in a cool, dark pantry or in the freezer. A website is in the developmental stages for disseminating this information.

Dr. Yao's work has mostly focused on functional carbohydrate nanoparticles. His group has developed phytoglycogen-based amphiphilic nanoparticles which have shown potential in protecting lipids and delivering antibacterial compounds (Project 30). In addition, his work also includes the molecular structure of phytoglycogen (Project 32), interfacial behavior of phytoglycogen derivatives (Project 31), and the construction of carbohydrate polymer-based micro-particulates (Project 29).

Carbohydrates and Health:

Dr. Hamaker's group, through a number of collaborations both within the Whistler Center (B. Reuhs and O. Campanella) and externally, is active in the growing area of carbohydrates and health. The two main areas are approaches to control glucose delivery to the body and understanding physiologic consequences of extended or slow glucose release, and improving function of dietary fibers and their hydrolyzates for improved colon health and general well-being.

Work on glycemic carbohydrates is described in Projects 12 through 14. Having in the past focused mostly on starch form and fine structures that vary in digestion rate, we have more recently turned our attention to digestion of α-amylase degradation products at the level of the small intestine mucosal α-glucosidases. Projects 12 and 13 describe research using the four mucosal subunits found in the two brush border-bound enzyme complexes, maltase-glucoamylase (MGAM) and sucrose-isomaltase (SI). Through work with a larger team including B. Nichols of Baylor College of Medicine, R. Quezada-Calvillo, University of San Luis Potosi, Mexico, D. Rose, University of Waterloo, Canada, and M. Pinto, Simon Fraser University, and H. Naim, University of Hannover, we are understanding the unique roles of the four enzymes and how α-glucan substrate structures are digested. Recent identification of "control points" of glucogenesis is expanding our ideas of how glucose delivery to the body can be modulated. In Project 14, we work with another team on our USDA-funded integrated project, "Functional foods containing novel carbohydrates for energy balance and improved health" with collaborators in the Purdue Department of Psychological Sciences (T. Powley, R. Phillips, K. Kinzig) and Ohio University (M. Kushnick). You will find interesting results showing distal release of glucose from food materials correlates with delayed gastric emptying in a dose-response manner. Further studies are being conducted to look at satiety response and broadly how foods can be designed to achieve this result.

We continue to be active in research on dietary fiber structures and their function in the colon, both related to rate of fermentation for low bloating effect and availability of fermentative substrate in the distal colon, and for changes in the microbiota. This is also a collaborative effort with partners at Rush Medical School, Chicago (gastroenterologist, A. Keshavarzian), University of Michigan Medical School (molecular microbiologist, E. Martens), microbiologists (J. Patterson, Purdue; P. Gillevet, Virginia), and B. Reuhs and O. Campanella at the Whistler Center. In 2010, we came closer to describing the structural aspects of soluble arabinoxylans that determine fermentation rate and extent and growth for specific colonic bacteria, and substrates that drive different fermentative outcomes (Project 11).

Polysaccharide Structures:

Dr. Janaswamy's research demonstrates the potential use of polysaccharide fibers for developing novel and cost effective delivery vehicles. Their study on iota-carrageenan fibers reveals that crystalline polysaccharide fibers have the potential to embed drug molecules (Project 17) and nutraceuticals (Project 18) leading to cocrystal formation. X-ray diffraction patterns portray packing differences among the complexes. These cocrystals are highly water soluble and solution properties are significantly different. More importantly the polysaccharide matrix is found to thermally protect the embedded molecule up to elevated temperatures. In another study, they showed the effect of salt and sucrose on the behavior of iota-carrageenan (Project 19) at dilute concentrations.

Rheology:

Dr. Campanella's research focuses on the understanding of how mechanical and thermophysical properties of foods and pharmaceuticals are used to assess their quality and also how these properties may affect the processability of these materials. Given the complexity in their composition and the various conditions to which foods and pharmaceuticals are exposed during processing and storage, stability, functionality and quality under different conditions are key attributes that deserve careful attention and are being investigated in this research. Projects involving rheological characterization of foods and pharmaceuticals, physical chemical properties associated to the formation of structures, e.g. during gelling, formation of co-crystals, formation of nanostructures during self-assembling of biomolecules, the incorporation of fibers into foods as well as the role of these properties on material processability are being conducted.

Development of new materials and understanding the physico-chemical behavior of existing ones require a scientific foundation that eventually translates into high quality foods and improved quality of pharmaceuticals and nutraceuticals. Work in this area also focuses on the functional efficacy of polymers used as part of the food ingredients.

Glass transition is a key phenomenon in the area of food science to understand how processing and external conditions affect physical properties of materials during processing. Methods using both mechanical and thermophysical properties of powders, like Dynamic Mechanical Analysis (DMA), Differential Scanning Calorimetry (DSC-conventional and modulated) properties are being developed to study the functional properties of proteins in dough system (Project 16). In these projects rheological, thermophysical, spectrocopical and microscopical methods are being developed to study the effect and use of co-proteins that can improve the functionality of some cereal proteins, like for example zein.

Novel rheological methods have been developed to monitor the formation of a nanocomplex using a number of rheological and thermal techniques (Project 8). This study demonstrated the formation of the three-component complex in a more accurate way. Changes in the structure of the nanocomplex due to changes in the solvent could be also observed using rheological techniques. These results were supported by microscopy studies that clearly showed the presence of nanostructures with a regular rod shapes.

Rheological characterization of gels and molecular modeling are being used to study the properties of gels systems. These studies are of key importance for the formulation and preparation of food and non-food gels. Experimental validation of qualitative trends obtained from molecular modeling was performed in the rheology laboratory. Results showed that the flexibility of the polymeric chains forming the gel systems play an important role on the resulting viscoelastic properties. The phenomenon of thixotropy, which is variation in time of the rheology of these materials as a result of the effect of shear on the material structure is being studied and described by a new approach.

Characterization of fibers made from iota-carrageenan for the purpose of using this and other polysaccharides as a food ingredient or drug carrier were performed. Rheological, thermophysical and mass spectrometry methods were investigated to detect the presence of pharmaceutical drugs and valuable food nutrients in these fibers (Project 17). A new project has started (Project 7), which is aimed to physically modify (e.g. through high shear conditions) the molecular structure of hydrocolloids to improve their functionality. Preliminary studies have focused on xanthan gum, which is characterized rheologically and physico-chemically after application of high shear processes.

The rheological properties of soluble fiber solutions such as shear viscosity and the extensional viscosity of dough systems containing soluble fibers, as well as structural features of corn bran arabinoxylan prep

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 continuing to investigate the changes in secondary and tertiary conformations of proteins/polypeptides due to interaction with surfaces using molecular dynamics simulation (Projects 21 and 22). They are also currently investigating the mechanism of pore formation in lipid bilayers by antimicrobial peptides (Projects 22).

Chemical Structures and Functions of Polysaccharides:

Dr. Reuhs' research is focused on the contribution of bacterial polysaccharides to the infection of legumes. His group also studies the fate of the pectin during tomato ripening and processing in fruit viscosity (Project 25), structure-function relations, and the contamination of fresh produce by human pathogens (Project 24).

Genetics:

Dr. Weil's lab has continued to characterize mutant lines of corn that show altered starch digestion (Project 26) using glucometry and, working with Dr. Mauer, near-infrared reflectance spectroscopy. Lines that showed preliminary evidence for altered digestion have been increased and are being screened in larger volume assays for confirmation.

They have recently acquired an Eppendorf liquid-handling robot that is allowing us to develop a reliable, scaled down and high throughput protocol for these digestion assays. Recent funding with Yuan Yao through the Consortium for Plant Biotechnology is examining starch structure and comparative proteomics of the endosperm in these lines as well as in a collection of 27 diverse maize inbreds that represent most of the known, worldwide genetic diversity in this crop. In addition, a detailed genetic map using ultra-high throughput DNA sequencing has been generated for the inbred in which digestion mutants were made. This map will facilitate the identification of genes altered in the mutant lines and their gene products.

The Weil lab now has a mutant population of the important staple crop *Sorghum bicolor*. In addition to using this population to develop reverse genetics resources for sorghum, they are screening the population for useful varieties using high-throughput single seed digestion assays. In particular, together with Dr. Hamaker, they are focusing on those that show improved digestibility of the seed carbohydrates and proteins.

Another project in the lab that has started two years ago examines how plants partition the carbon they fix during photosynthesis into different forms and different locations within the plant. In corn, this is typically as starch in the kernels of the ear, but in close relatives of corn, 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.

In addition, the regulation of how carbon is partitioned into seed 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 new NSF-funded project is characterizing the contents, functions and genetic networks that characterize phloem function, carbon partitioning and yield.

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James N. BeMiller

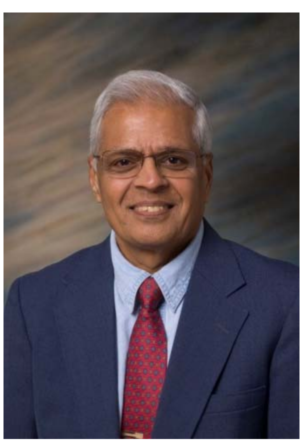
GENERAL RESEARCH AREAS
- Starch
- Carbohydrate chemistry

SPECIFIC RESEARCH AREAS
- Starch granule structure, reactivity, and behaviors
- Chemical and biological modifications of starch
- Structure-functional property relationships of polysaccharides
- Mono- and oligosaccharide chemistry
- 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

SPECIFIC RESEARCH AREAS

- Starch digestion control, low glycemic response/slow digestion and physiologic response
- Dietary fiber, modifications in functionality and colon fermentability
- 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

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
- Molecular dynamics simulations
- Developing novel and cost effective delivery systems using food hydrocolloids
- Tailoring polysaccharide structures for improved functionality
- Biotexture of plant tissue derivatives
- Starch crystallinity
- Structure-function relationships in biomaterials

Lisa J. Mauer

GENERAL RESEARCH AREAS

- Food chemistry
- Food packaging

SPECIFIC RESEARCH AREAS

- FT-IR spectroscopy
- Structure-function relationships of food ingredients
- FT-IR spectroscopy method development
- Water-solid interactions
- NASA food system, extended shelf life products
- Edible films and coatings

Ganesan Narsimhan

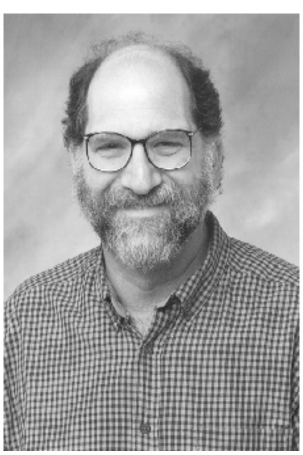
GENERAL RESEARCH AREAS
- Emulsions and foams
- Biopolymer interactions

SPECIFIC RESEARCH AREAS
- Stability and texture of food emulsions and foams
- Adsorption of proteins and protein-polysaccharide complexes at interfaces
- Conformation of proteins
- Pore formation in cell membranes by antimicrobial peptides
- Functional properties of proteins and protein-polysaccharide complexes
- Physical and chemical modification of proteins for use as food stabilizers
- Rheology of polysaccharide solutions and gels

Bradley L. Reuhs

GENERAL RESEARCH AREAS
- Polysaccharide analysis
- Plant cell wall compositions, structures, and functions
- Bacterial cell wall compositions, structures, and functions

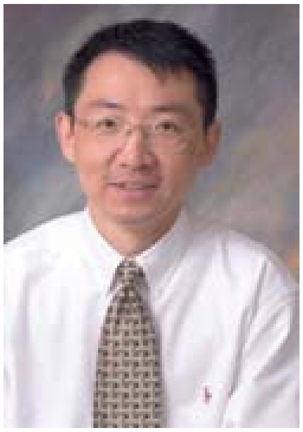
SPECIFIC RESEARCH AREAS
- Extractions and purification of acidic polysaccharides from cell walls of plants and bacteria
- Pectin analysis
- Capsule, gum, and lipopolysaccharides analysis
- Application of HPLC, GC-MS, and NMR to structural studies of carbohydrates, including polysaccharides
- Role of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



Clifford F. Weil

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

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



Yuan Yao

GENERAL RESEARCH AREAS
- 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 produects

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 spin off of Enzytech, Inc. where Dr. Gross was a co-founder and Vice President of R&D.

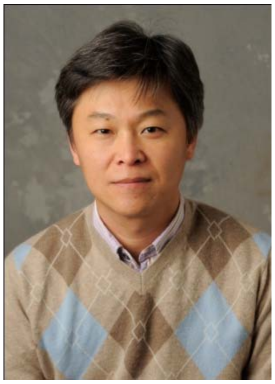
Sakharam K. Patil, Ph.D. is President of S.K. Patil and Associates. Dr. Patil was awarded a Ph.D. degree in Cereal Science by Kansas State University in 1973. He held several positions at American Maize Products Co., later Cerestar, from 1978 until his retirement in 2002. The positions included VP Marketing 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 FACULTY

Yong-Ro Kim graduated from Seoul National University, Seoul, Korea with B.S. in Food Science and Technology. He received his M.S. and Ph.D. degrees from Purdue University in Food Science. His Ph.D. research involved physicochemical properties of hard wheat flour dough during process especially in terms of water relations. He is associate professor in the Department of Biosystems & Biomaterials Science and Engineering, Seoul National University, Seoul, Korea, and was a visiting faculty in Dr. BeMiller's lab conducting collaborative research related to hydration properties of starch granules in various solvent-water mixtures.

Weihong Min is a professor of the Jilin Agriculture University, China. She visited Dr. Yao's lab and worked on the preparation of starch micro-particulates (Project 29) and returned to China in October.

Cheng Yang received his Ph.D. in Polymer Science from Sichuan University, China. He is a professor and the head of Department of Applied Chemistry at Jiangnan University, China. During 2003-2004 he worked as a research associate at the Department of Chemistry at the Chinese University of Hong Kong. He, as a visiting scholar, was awarded a government scholarship from China Scholarship Council to join Drs. Hamaker and Yao's labs from March 2009 to March 2010. His research field is focused on the structure and functions of starch and non-starch polysaccharides (Project 10).



Sang-Ho Yoo is an Associate Professor, Department of Food Science and Technology& Director of Carbohydrate Bioproduct Research Center (CBRC) Sejong University, Seoul Korea. He obtained his M.S. from Prof. Kwon Hwa Park's group at Seoul National University and Ph.D. under Prof. Jay-Lin Jane at Iowa State University. He is active in research using recombinant carbohydrate enzymes for synthesizing new glucan structures with novel applications. He spent 2010 on sabbatical with Dr. Hamaker.

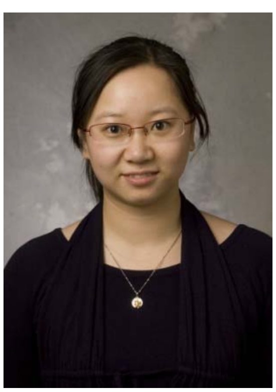
Jinghu Yu received his Ph.D in Precision Instruments and Precision Machinery from University of Science and Technology in Hefei, China. He is an associate professor at Jiangnan University, Wuxi, China. As a visiting scholar, he joined Dr. Campanella's lab from August 2010 to August 2011. His research field is focused on the mechanical behavior of viscoelastic material and the food processes simulation (Project 9).

Webin Zhang received his Ph.D. in Food Science from Jiangnan University in 2007. After that, he joined the faculty of School of Food Science and Technology in Jiangnan. He has been primarily working on enzymatic extraction of oil from oilseeds, development of traditional Chinese food as Jinhua ham and soymilk. He teaches Food Chemistry and Introduction to Food Science. He joined Dr. Hamaker's lab in April 2010 and worked on amylopectin structure and its iodine vapor binding property. Dr. Zhang has returned to China.

Dr. Mustapha Benmoussa received his Ph.D. degree from Laval University (Canada) in Plant Molecular Biology. His Ph.D. research project was 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. He joined Whistler Center for Carbohydrate Research team, and he is now working on non-food applications of modified starches such as for wastewater treatment and microalgae flocculation.

Sushil Dhital is a Ph.D. final year student at the Centre for Nutrition and Food Sciences, The University of Queensland, Australia. He has masters degree in business administration and food technology and has six years industrial followed by three years lecturing experience. He, as an exchange student for three months, joined Dr Hamaker's lab on September 2010. His current research is primarily focused on enzymatic digestion of granular starch.

Necla Mine Eren received a B.S. degree in Food Engineering from Ankara University, Turkey in 2009. She worked for Sakarya University, Turkey as a research assistant for 10 months. Necla came to Purdue in 2010 as a M.S. student with a scholarship from Ministry of National Education, Republic of Turkey. She is working with Dr. Campanella on physicochemical properties of biological and food gels (Project 7).

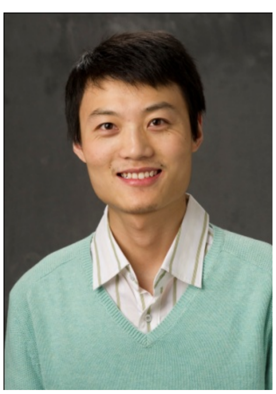


Lei Huang received her B.S. degree in Food Science and Engineering from Heilongjiang East University in 2007, and pursued her M.S. degree at Harbin University of Commerce beginning in September 2007. She joined Dr. Yao's lab in 2008 as a visiting scientist. Her research project was on the structure of phytoglycogen (Project 30). Lei Huang returned to China in December.

Raphael Mufumbo received his B.S. Agriculture degree in Crop Science from Makerere University, Kampala, Uganda. In 2007, he started his M.S. in Crop Science in the same university under the BIO-EARN scholarship through a grant from the Swedish International Cooperation Agency/Department for Research Cooperation (Sida/SAREC) where his thesis is about cassava starch functional properties in relation to molecular architecture. Raphael joined Dr. Hamaker's group in October 2009 for six-months as a visiting scholar with focus on analyzing the physicochemical and molecular properties of commercial starches on the East African market. The results will be useful to the cassava breeding programs in the sub-region with the emphasis of generating cassava varieties with novel starches of industrial importance. Raphael has returned to his studies in Uganda.

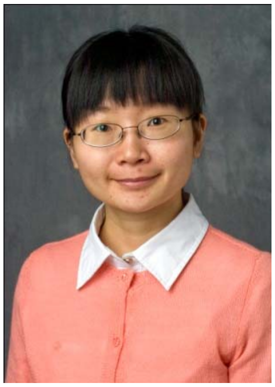
Rándol J Rodríguez is an undergraduate student in Food Science Department of Zamorano University, Honduras. He is developing the graduation project on quality control in tomato sauce process line by analyzing thermal treatment effect on non-starch polysaccharides and physical characteristics. In addition he has a background in agriculture with expertise on hydroponic tomato and pepper crops. He is visiting Dr. Yao's lab until April 2011. His work focuses on the structure analysis of starch, specifically, the chain length distribution of starch.

Vicente Espinosa-Solis received his B.S. in Biotechnological Engineering from Technologic Institute of Zacatepec and his M.S. degree from Development Center of Biotic Products. Mexico. He joined Dr. Jay-Lin Jane's group at Iowa State University as a visiting scholar during his M.S. program for 6 months. In 2008, he started his Ph.D. in DCBP. He was a visiting scholar in Dr. Hamaker's lab for one year. He is studying the digestion and fine structural properties of native and modified plantain and mango starches. Vincente has returned to his studies in Mexico.



Yiming Wang received his B.S. in 2008 from the Department of Bioengineering, College of Food Science and Engineering, Harbin Commercial University, China. He is currently a visiting student in Dr. Yao's lab studying the structure of starch and carbohydrate nanoparticles, as well as conducting research related to food safety (Project 32).

Lei Yang received his M.S. in 2006 from Tianjin University of Science & Technology (formerly Tianjin College of Light Industry), China. He is currently a visiting student in Dr. Yao's lab studying the modification of carbohydrate nanoparticles, as well as their applications for prolonged release of antimicrobial peptides (Projects 30 and 31).



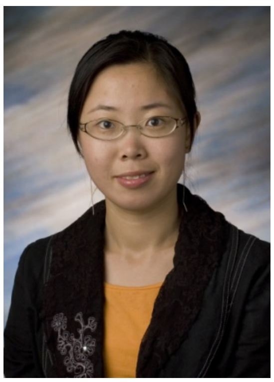
Ying Yang is a Ph.D. student at School of Food Science and Technology, Jiangnan University, China. She was awarded a governmental scholarship by China Scholarship Council (CSC) to continue her research work in the USA for one year. Ying joined Dr. Hamaker's group as a visiting scholar in August 2010, with her research project focused on polysaccharide-based delivery systems for conjugated linoleic acid.

Lu Zhou received her B.S. degree in Science from China Agricultural University in 2007 with a focus on the efficiency of the formulation of pesticide. She is working with Dr. Narsimhan as a visiting scholar for two years. Her research is focused on pore formation in DMPC liposomes by antimicrobial peptides (Project 23).

GRADUATE STUDENTS

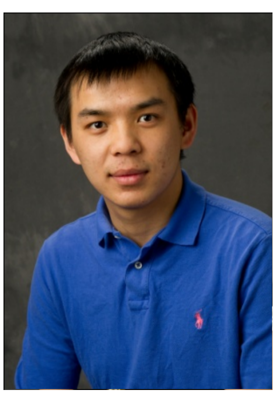
Patrick Breen received his B.S. in Biosystems Engineering in December 2009 from Michigan State University. He is a member of Dr. Weil's lab with his current research topic "Genetic Control of Starch Digestion".

Deepak Bhopatkar obtained his B.S. in Agriculture Science from Jawaharlal Nehru Agriculture University, India and an M.S. in Food and Bioprocess Technology at the Asian Institute of Technology, Thailand. His master research was on application of the biopolymer chitosan for controlled drug delivery. He joined Dr. Hamaker and Campanella's groups for his Ph.D. studies and is doing his research on a soluble nanoscale three-component complex, its mechanism of formation and potential carrying capacity for hydrophobic fourth components (Project 8).



Lin Bi received her B.S. degree in Bioengineering from Jilin Teachers' Institute of Engineering and Technology and earned her M.S. degree in Fermentation Engineering at Tianjin University of Science & Technology (formerly Tianjin College of Light Industry). She joined in Dr. Yao's lab in August 2007 to pursue her Ph.D. degree in Food Science. Her research focuses on the construction of carbohydrate dendrimers and nano-carriers and controlled release of active compounds (Project 30).

Mohammad Chegeni completed his B.S. in Biology from Ferdowsi University in 2002 in Iran. After that, he did his Master's work in Public Health at Ball State University. He joined Dr. Hamaker's group on January 2010 and started his Ph.D. on August 2010. His research focuses on gut enterocyte maltose sensing and sucrose-isomaltase maturation and trafficking with the aim of controlling glucose delivery to the body



Hector Chang received his B.S. degree in Agricultural and Biological Engineering (2009) in the field of Biological and Food Processing Engineering from Purdue University. During his undergraduate studies, he worked with Dr. Campanella in rheological studies of refrigerated dough. He is pursuing a M.S degree in Engineering and working under Dr. Narsimhan to study the conformation changes of polypeptides on a silica surface using molecular dynamics simulation (Project 21).

Hua Chen received her M.S. in 2009 from the Department of Food Science of South China University of Technology. She joined Dr. Yao's lab in 2009 and is currently a Ph.D. student. Her thesis focuses on the structure of native and modified carbohydrate nanoparticles and their functional properties such as digestibility, interfacial adsorption, and controlled delivery of lipophilic compounds (Projects 31 and 32).

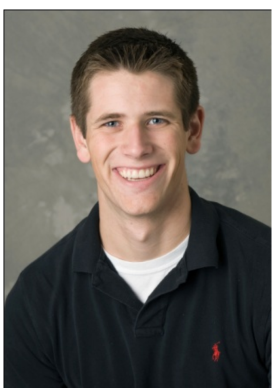
Min-Wen Cheng completed her B.S. in Plant Pathology from National Taiwan University in 2002. After that, she worked in the Institute of Plant and Microbial Biology, Academia Sinica in Taiwan as a research assistant for one year. She came to Purdue University in 2003 and finished her M.S. in the Botany and Plant Pathology Department in 2005. She joined Dr. Hamaker's group in 2006 as a Ph.D. student. Her Ph.D. project, under co-advisement from G. Zhang, was on the coordination of glycemic carbohydrate digestion and glucose absorption using a cell culture model system. Min-Wen graduated in May 2010 and currently resides in California.

Jennifer Cholewinski completed her B.S. degree in Food Science from the University of Idaho in May 2008. While earning her B.S., she performed research on barley to determine the effect of various fertilizing treatments on total starch and gelatinization profiles. Her research in Dr. Hamaker's lab as a M.S. student was to investigate the role that phenolic compounds have on the protein structures and starch digestibility of cereal foods (Project 15). Jennifer completed her degree in the fall of 2010 and works at Kerry Ingredients in Wisconsin.

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 where she is still employed. In January 2010 she joined Dr. Hamaker's group for a M.S degree funded by USAID Mali. Her research mainly focuses on the relationship between African porridges (thick and thin) and gastric emptying and satiety.

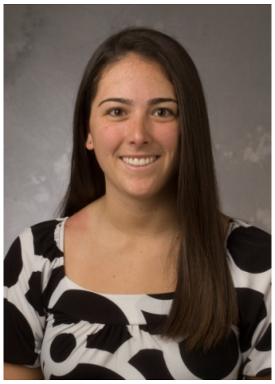
Dawn Dahl received her B.A. degree in Chemistry from Monmouth College in Monmouth, IL in 2001. She is currently employed at Grain Processing Corporation as a Quality Control Chemist and is working on her M.S. degree in Food Chemistry as a distance-learning student under the direction of Drs. Hamaker and BeMiller. Her research focuses on corn starch modification and different properties of the resulting product.

Matt Entorf graduated with a B.S. degree in Chemical Engineering from Iowa State University where he did some research in the hydrolysis of oligosaccharides from distiller's grains using silica catalyst. His M.S. degree work with Dr. Narsimhan involved characterizing foam stabilibity by macromolecules.



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 breadmaking and other applications within the gluten-free and functional protein areas (Project 16).

Mehtap Fevzioglu completed her B.S. and M.S. degrees in Food Engineering from Hacettepe University, Turkey. Her M.S. thesis research explored the effects of infrared treatment on the main constituents of rice and barley samples. She came to Purdue in 2008 as a Ph.D. student with a scholarship from the Ministry of National Education, Republic of Turkey. She is working with Drs. Campanella and Hamaker. Her research focuses on the structure and function of corn zein protein (Project 16).

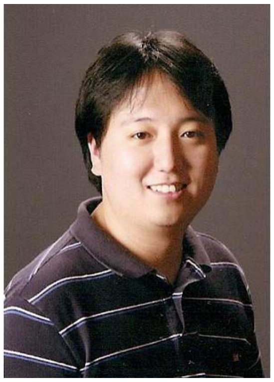


Kristin Gill received her B.S. degree in Agricultural and Biological Engineering from Purdue University in 2008 with a focus on Biological and Food Process Engineering. She is working with Dr. Campanella and Dr. Janaswamy to pursue a M.S. Her research focused on utilizing polymeric cocrystals for controlled drug delivery (Project 17). Kristin graduated and works at Sara-Lee in Chicago.

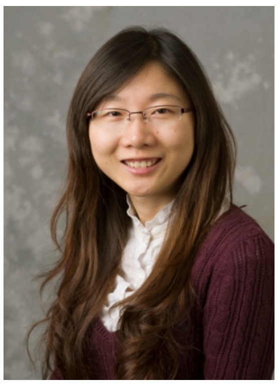
Morgan Goodall received her B.S. in Food Science from Purdue University in 2010. She joined Dr. Hamaker's lab as an undergraduate working on understanding the use of a high lysine, high digestibility sorghum mutant in bread formulations. She is currently pursuing her M.S. degree where she focuses on the protein structural and functional effects of incorporating high percentages of this sorghum mutant cultivar into wheat bread (Project 16).

Madhuvanti Kale received her B.S. degree in Food Engineering and Technology from the Institute of Chemical Technology, University of Mumbai (formerly known as UDCT) in May 2008. She joined Dr. Hamaker's lab in August 2008 for a Master's degree and is under the co-advisement of Dr. Campanella. Her research focuses on structure-function relationships of corn bran arabinoxylans (Project 10).

Amandeep Kaur is a veterinary graduate who obtained her Bachelors from Punjab Agricultural University, India. She worked on verotoxigenic *Escherichia coli* during her Masters with epidemiology and preventive veterinary medicine as her major and veterinary medicine as her minor field, respectively. After being awarded a Ross Fellowship, she joined Dr. Hamaker's group as a Ph. D. student in August 2007. The focus of her research is on dietary fiber and colon health (Project 11).



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 focuses 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 (Project 12 and 13).



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 will take a by-pass to the Ph.D. program. Her research mainly focuses on stability of on green tea catechins in simulated high relative humidity systems (Project 20).

Rebecca Lipasek graduate from Purdue University in 2008 with a B.S. in food science, with a minor in chemistry. She went to work for PepsiCo-Gatorade as a supply chain associate, working on new product launches and process and quality improvement. She then returned to Purdue to pursue her Master's degree in food chemistry in Dr. Mauer's lab. Her research area focuses on the deliquescence of various forms of vitamin C in both single and binary mixtures in terms of the effects of relative humidity, temperature, time, and particle size changes (Project 20).

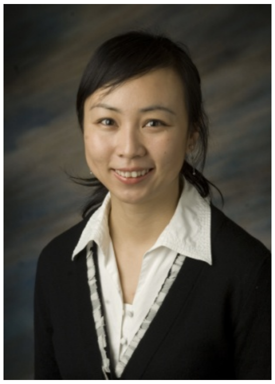
Mirwais Rahimi earned his B.S. in Agronomy from Herat University in Afghanistan in 2003. He began his career by working as an Extension worker with DACAAR (Danish Committee for Aid to Afghan Refugees) in 2003, and then joined World Vision, Afghanistan as an Agronomist on 2005. In 2006, Mirwais was awarded a Purdue/USAID Afghan Merit Scholars Program Fellowship to study for a M.S. degree at Purdue University and began is program in Food Science in 2009. Mirwais works in Dr. Hamaker's lab.

Pinthip Rumpagaporn earned her B.S. and M.S. degrees from the Department of Food Science and Technology, Kasetsart University, Bangkok, Thailand and presently is a Ph.D. student. She will be a faculty member of Kasetsart University after graduation. Pinthip originally came to Purdue under the support of the Thailand Commission on Higher Education and conducted research on resistant starch in Dr. Hamaker's laboratory from March 2006 until May 2007. She has continued her doctoral studies on the chemistry of cereal bran fibers and their function in the colon (Project 11).

Cordelia Running earned her bachelor's degree in Chemistry from Indiana University in Bloomington, Indiana. She joined Dr. Janaswamy's lab in 2010 to begin her master's studies. Her research focuses on structural analysis of psyllium and carrageenans as well as how the addition of salts and sweeteners may affect their functional behavior (Project 19).

Paulo Henrique Santos received his B.S. degree in Food Engineering and M.S. degree in Chemical Engineering from State University of Campinas (UNICAMP), Brazil. In 2008 he joined Dr. Campanella's group as a Ph.D. student. His Ph.D. project involves the mechanical characterization and molecular simulation of colloidal systems (Project 6).

Preetam Sarkar received his M.S. in 2010 from California State University-Fresno. He joined Dr. Yao's lab in 2010 and is currently a Ph.D. student. His thesis focuses on the interaction between bioactive compounds (such as antimicrobial peptides) and carbohydrate nanoparticles in emulsion and non-emulsion systems (Project 30).



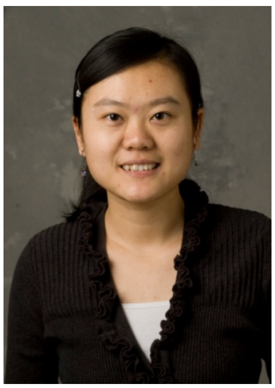
Xinyu Shen received her B.S. and M.S. degrees in Food Science and Technology from Jiangnan University (former Southern Yangtze University and Wuxi University of Light Industry) in 2002 and 2005, respectively. Her M.S. research involved studying lipid and protein extraction from tomato seeds and their functional and structural properties. In August 2005, she came to Purdue in pursuit of a Ph.D. degree in Food Science and joined Dr. Hamaker's group in 2007. Her Ph.D. project focused on the structure of amylopectin and its function, and has had external committee advisement from Profs. Eric Bertoft from University of Uppsala, Sweden and Genyi Zhang from Jiangnan University, China. Xinyu graduated in December 2010 and works for Novozyme in North Carolina.

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 is currently doing her Ph.D. supported by a scholarship from Ministry of National Education, Republic of Turkey. Since September 2010, she has been working with Dr. Hamaker on the inhibiton of human intestinal glucosidases.

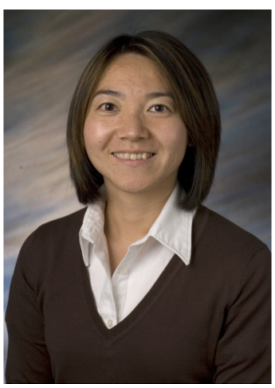
Stephany Tandazo graduated from Texas A&M University in May 2010 with a B.S. in Chemical Engineering, with a minor in chemistry. Stephany is working with Dr. Campanella and Dr. Hamaker. She joined the group in August 2010 to pursue her M.S. in Agricultural and Biological Engineering. Her research focuses on the structure of maize zein protein (Project 16).

Megan West received her B.S. in biochemistry from Purdue University in 2008. After completing a year of graduate school at the University of California, Davis in the Agricultural & Environmental Chemistry graduate group she returned to Purdue to complete her studies. She joined Dr. Lisa Mauer's lab in the fall of 2009 to work on the stability of bioactive food components in powdered systems (Project 20).

Bicheng Wu received her bachelor degree in Food Science and Technology from Zhejiang Gongshang University, China in 2009. She was an exchange student in Biochemistry from August 2008 to May 2009 at State University of New York at Oswego (SUNY-Oswego). She is currently pursuing her M.S. degree under the guidance of Dr. Reuhs, and her research focus is on fiber structure and tomato viscosity (Project 25).



Haidi Xu received her B.S. degree in Food Science and Engineering from Beijing Forestry University and her M.S. degree from the College of Food Science and Nutritional Engineering, China Agricultural University. She was awarded a government scholarship by the China Scholarship Council to pursue her Ph.D. degree in the USA. Haidi joined Dr. Hamaker's group in August 2008 and her research project focuses on dietary fiber chemistry and structure-function relationships related to colon fermentation (Project 11). She also works under the advisement of Dr. Reuhs and in collaboration with Dr. Eric Martens of University of Michigan Medical School.



Like Yan 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 breadmaking, tofu color prediction from the soybeans and soyflakes color. She joined Dr. Hamaker's lab for her Ph.D. and is doing research on slowly digestible starch and its physiologic and health effects. She works on a collaborative project with faculty from Purdue's Department of Psychological Sciences (Drs. T. Powley, R. Phillips, and K. Kinzig), as wells as with Dr. Buford Nichols at Baylor College of Medicine, Houston (Project 14).

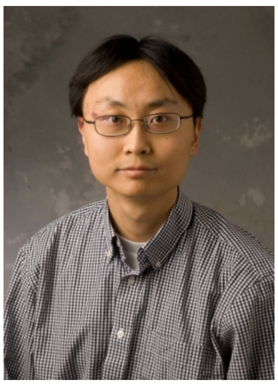
Nicolas Bordenave received a Master's degree in Chemistry of Renewable Resources from the National Institute of Chemistry of Toulouse (ENSIACET, France) in 2003. He joined the Wood and Biopolymers Laboratory (US2B, Bordeaux I University, France) and completed his Ph.D. degree in organic chemistry in 2007 on research of biodegradable and antimicrobial food packaging-based on paper and chitosan. In 2008, DR. Bordenave worked as a Post-Doctoral Research Associate on chemical modifications of guar gum in the Carbohydrates Laboratory (LG, Picardie University, France). In October 2008, he began work at the Whistler Center for Carbohydrate Research at Purdue University under the supervision of Dr. Yao on the topic of structure-function relationships of chemically and enzymatically-modified starch. In October 2009, Nicholas began work with Drs. Ferruzzi and Hamaker on phenol-protein interactions related to digestion and bioactivity. Nicholas works now for Pepsico in Barrington, Illinois.

Vijay Chaikam completed his Ph.D. at the University of West Virginia in 2009. In Dr. Weil's laboratory he is working with the Nested Association Mapping populations of maize and a set of defined mutations, including several that affect starch and carbohydrate partitioning, to identify the genes that interact with these mutations to impact the quantity and quality of starch and sugars that accumulate in corn seed and plant tissues. These data should define a number of new genes that impact starch digestibility and the capacity of the corn stalk to become a repository of sucrose at levels similar to its relative, sugarcane (Project 28). Vijay completed his work with Dr. Weil in November.

Reeta Davis obtained her B.S. in Food Science and Quality Control in 1999, and M.S. in Microbiology in 2003, from Mahatma Gandhi University, Kerala, India. She has also completed Ph.D. in Food analysis and Quality assurance from the Defense Food Research Laboratory (DFRL), Mysore, India. Her Ph.D. program was in Biotechnology on polyhydroxyalkanoates at the molecular level carried out at the Central Food Technological Research Institute (CFTRI), Mysore, India. She joined Dr. Mauer's lab in July as a Post-Doctoral Research Associate on FT-IR detection of food borne pathogens.

Amanda Deering received her B.S. and M.S. degrees in Biology from Central Michigan University. Her M.S degree focused on plant cell biology involved localizing a trypsin inhibitor specific to pumpkin phloem throughout the course of development of the tissue. She joined the Reuhs lab in 2007 and successfully defended her Ph.D. in 2010. She continues as a post-doctoral Research Associate and works on the process of internalization of human pathogens in plants (Project 24).

Mohamed Ghorab received a B.S. in Pharmaceutical Sciences from Cairo University, Egypt and his Ph.D. in Pharmaceutics from Duquesne University, Pittsburgh, PA. After completion of his doctorate degree, he worked for over five years in the Solids-Pharmaceutical R&D Department at Wyeth, Pearl River, NY. During that time, he was also an Adjunct Assistant Professor at Arnold and Marie Schwartz College of Pharmacy and Health Sciences, Long Island University, NY. In 2007, Mohamed became Associate Professor in the Pharmaceutics and Industrial Pharmacy Department at Helwan University, Egypt. He joined Dr. Lisa Mauer's lab and Dr. Lynne Taylor of the Industrial and Physical Pharmacy Department at Purdue in 2010 as a Post-Doctoral Research Associate. His research focuses on understanding the interaction between amorphous and crystalline deliquescent-possessing food and pharmaceutical ingredients and the impact of relative humidity on their behavior in mixtures (Project 20).



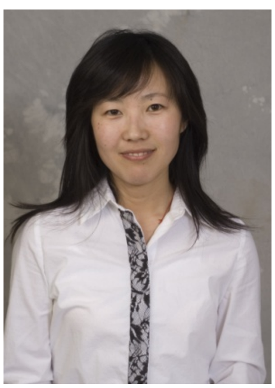
Kaho Kwok earned his B.S. in Chemistry from Eastern Michigan University; M.S. in Chemistry from the University of Wisconsin, and Ph.D. in Analytical Chemistry from Northern Illinois University. Kaho is a Post-Doc with Professor Lynne Taylor at Industrial and Physical Pharmacy and Professor Lisa Mauer. His research is to understand the fundamentals of the effects of deliquescence on the stability of pharmaceutical and food ingredients. Phase diagrams of these systems are generated to better understand the relationship between the water activity and the composition of these systems. Effort has also been put into understanding the surface properties of different pharmaceutical and food ingredients when deliquescence happens. The major focus is to determine the origins of the interfacial forces under different RH conditions using atomic force microscopy.

Nawel Khalef received her Ph.D. in Pharmaceutical Engineering Processes, Department of Industrial Pharmacy; Formulation and Pharmaceutical Engineering, Joseph Fourier University (UJF), Grenoble, France. She joined Dr. Campanella's group and Dr. Pinal's lab (Department of Industrial and Physical Pharmacy) as a visiting researcher. Her areas of research include (1) physical and chemical stability of pharmaceutical solids (2) moisture-solids interactions and consequences on physical stability (amorphous-crystalline changes) (3) water activity and surface energy assessment (4) APD-excipient interactions and (5) thermal characterization and development of methods (ITC, DSC, TGA). Nawel left the Center in July and has a faculty position at UJF.

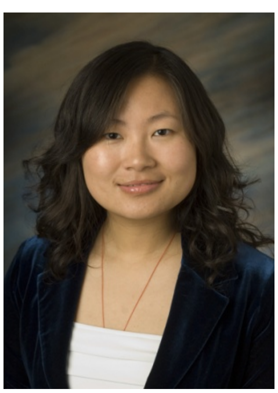
Hyun-Seok Kim earned B.S. and M.S. degrees in Food Processing and Engineering at Kyung Hee University, Korea. In 2004, he joined the research team of Dr. Kerry Huber at the University of Idaho to pursue a Ph.D. degree; he was awarded the degree in 2009. For his Ph.D. research, he investigated wheat starch A- and B-type granule microstructures and reactivities. In August 2009, he joined Dr. BeMiller's lab as a Post-Doctoral Research Associate. His research focus was devoted to understanding interactions of starch with hydrocolloids and other water-soluble polymers during and after pasting (Project 3). At the end of October, Dr. Kim returned to South Korea, having accepted a faculty position there.

Hui-Mei (Amy) Lin conducts research as a Post-Doctoral Research Associate with Dr. Bruce Hamaker. She has a Ph.D. in the area of starch structure from National Taiwan University and completed a Post-Doctoral fellowship focused on resistant maltodextrin structure with Dr. Jay-lin Jane at Iowa State University. Previously, she worked for a number of food and food ingredient companies related to hydrocolloids and flavor in positions ranging from product development to international marketing. Her research interests are starch digestion at the brush border area in the human body and consequential physiology response. The short term goal is to elucidate the relationship between starch structure and gut mucosal α-glucosidases digestion (Project 13). The long term goal is to control the dietary glucose generation and delivery to the human body to benefit human health.

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 Dr. 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 currently works on fiber rheology and incorporation into processed foods.



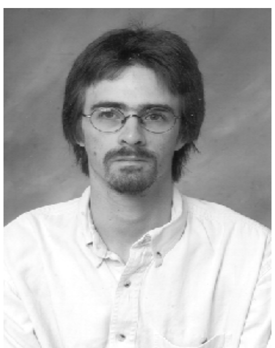
Wei Song received her M.S. and Ph.D. degree in Food Science from Tianjin University of Science and Technology. During her Ph.D. she studied in the Food Science Department of Cornell University as a visiting student. Her research focused on detecting the cellular antioxidant activity of common vegetables. She joined Dr. Yao's group as a Post-Doctoral Research Associate. Her project was on the structure-function relationship of carbohydrates. Wei returned to China in January.



Zhongquan Sui ("Spring") joined Dr. BeMiller's lab as a Post-Doctoral Research Associate in January 2008. Dr. Sui earned a Ph.D. degree in Food Science and Nutrition at the University of Hong Kong. Her undergraduate degree was in Food Science and Engineering from Shandong Agricultural University, China. Dr. Sui's research focuses primarily on the effects of different degrees of channelization on product characteristics of modified food starches made from corn starch (Projects 1, 2, 4, and 5).

Xiaoyu Wu earned his B.S. degree from the Department of Chemical Engineering in July 1999 and a M.S. degree from the Department of Biological Sciences and Technology at Tsinghua University. His M.S. research involved the stability of endostatin, an angiogenesis protein, under different conditions. He joined Dr. Narsimhan's group in August of 2004 to pursue a Ph.D. degree and is working on determining the properties of selected proteins on different interfaces. Xiaoyu earned his Ph.D. degree in May. His thesis is titled "Investigation of Conformational Changes of Protein Adsorbed on Silica Nanoparticle Surface". Xiaoyu continues at Whistler Center as a Post-Doctoral Research Associate (Projects 21, 22, and 23).

Research Staff



Dave Petros received his B.S. and M.S. in Biochemistry from Purdue University and is the Cereals Lab Research Assistant in the Hamaker lab and provides assistance in other areas of the Whistler Center.

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. His main research area is carbohydrate analysis using above mentioned analytical instruments.

Project Summaries Table of Contents

BeMiller

Campanella

Hamaker

Janaswamy

Mauer

Narsimhan

Reuhs

Weil

Yao

1. Bridging the Gap Between Starch Granule Architecture, Molecular Structure, and Reactivity

P.I.: J.N. BeMiller

Co-P.I.: K.C. Huber, Associate Professor (University of Idaho)

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: USDA-AFRI

Objective: To determine how differences in structures of the starch granules and polymers affect reaction with crosslinking and stabilizing reagents and to correlate structure and reactivity.

Progress: Six inbred lines with previously determined different degrees of channelization were again grown at the Purdue University Agronomy Center for Research and Education and harvested by Prof. Cliff Weil. Starch has been isolated from the 6 lines (B73, W22, W23, Al88, Oh43, Mo17), normal and waxy corn kernels, and normal and waxy wheat flours. The starches from the 6 inbred lines, before and after thermolysin treatment to remove surface protein, were acetylated with acetic anhydride (AA), octenylsuccinylated with octenylsuccinic anhydride (OSA) and crosslinked with adipic-acetic mixed anhydride (AAMA), phosphoryl chloride, and STMP. The 60 products have been examined by RVA and DSC (gelatinization and retrogradation endotherms) analysis. DS values have been determined for products of reaction with AA, OSA, and AAMA. Products of reaction with phosphoryl chloride and STMP have been submitted for P analysis. The obtained data is being analyzed.

Status: Active.

2. Investigation of the Impact of the Order of Addition of Reagent and Catalyst in Starch Modification

P.I.: J.N. BeMiller

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: USDA-AFRI

Objective: To investigate the impact of allowing highly reactive reagents to infiltrate the granule matrix prior to initiation of reaction by adjustment of pH, in contrast to adjusting the pH before adding the reagent as is normally done.

Progress: Commercial (C), laboratory-isolated (LI), and protease (thermolsyin)-treated commercial (PTC) normal (NMS) and waxy maize (WMS) starches were used. (From previous work, it was known that the amount of external surface and channel protein present on the granules was LI>C>PTC.) Also examined were reactions of commercial and laboratory-isolated normal wheat starch (NWS) and laboratory-isolated waxy wheat starch (WWS). The 12 starch preparations were each reacted with 3 crosslinking reagents (acetic-adipic mixed anhydride [AAMA]), phosphorus oxychloride [$POCl_3$], and sodium trimetaphosphate [STMP]), the first 2 of which, at least, are thought to be very reactive, and 3 stabilizing reagents (acetic anhydride [AA], succinic anhydride [SA], and octenylsuccinic anhydride [OSA]), all of which are believed to be quite reactive. The products were characterized by determining DS values and by RVA and DSC analysis. Most results indicated differences in degrees of reaction between the two methods, except for the two reagents that produce distarch phosphate, viz., $POCl_3$ and STMP. Data for NMS, for example, indicated (for products of reaction with crosslinking reagents) that there was a greater degree of crosslinking for the reaction with AAMA and little difference for reactions with $POCl_3$ and STMP (except for final viscosity of the $POCl_3$ product, which also indicated an increase [AAMA > $POCl_3$]) for products of the reaction in which granules were impregnated with the reagent before initiating the reaction as compared to products made in the usual way. Properties of the products of reaction with stabilizing reagents indicated a greater degree of substitution for products of reaction with SA and AA and little difference in the product of reaction with OSA (except for peak viscosity in which the OSA product also indicated an increase [SA>AA>OSA]) for products made by first impregnating the granules with reagent. DS data is still being collected, and other data from all 12 starch preparations is being analyzed. So far, in general, the results confirm the hypothesis that, in at least some cases, the granular patterns of reaction and product characteristics can be altered by impregnating granules with the reagent before the catalyst is added.

The same experiments have been done with starches treated with a protease to remove protein from their channels.

Status: Active. Manuscript in preparation.

3. Elucidation of Functional Interrelations Between Starch Products and Hydrocolloids and Other Water-Soluble Polymers

P.I.: J.N. BeMiller

Researcher: Hyun-Seok Kim, Ph.D. Research Associate

Sponsor: Whistler Center for Carbohydrate Research

Objectives: (1) To determine if synergistic interactions between certain native starches and certain water-soluble polymers (WSPs), especially polysaccharides, are a function of the amount of amylose (AM) in the starch and/or its molecular size. (2) To determine if synergistic interactions found between certain native starches and certain WSPs are a function of the molecular size of the WSP. (3) To determine if interactions between amylopectin (AP) and WSPs are a function of the average chain length and/or radius of gyration of the AP. (4) To determine if interactions between modified starches and WSPs are functions of the extent and type of modification of the starch. (5) To determine if there is a combination of a native and/or a modified starch and a WSP (soluble dietary fiber in the case of a food hydrocolloid) that is effective enough in generating the desired rheological, textural, or other properties to allow elimination or reduction in the amount of the normally required modification of the starch. (6) To determine the extent of any synergistic interactions between hydrocolloids and commercial pea starch.

Progress: (Objective 6) Combinations (starch-hydrocolloid 19:1 w/w) of commercial pea starch and members of 5 families of hydrocolloids were examined by RVA and dynamic rheology. Addition of xanthan delayed apparent pasting, i.e., increased the apparent pasting temperature (app. Tp), and resulted in less breakdown and setback. Use of the two types of CMC (another ionic gum) with the lowest DS values (0.76, 0.74) and MWs resulted in an increase in app. Tp. Use of 2 types with greatest DS values (0.83, 0.89) and highest MWs resulted in even higher app. Tp. RVA parameters for the lowest-viscosity-type product were little changed. However, the medium- and high-viscosity-types produced increased peak and final viscosities. The lowest viscosity-type of guar gum (a neutral gum) produced a slightly increased app. Tp. The other products produced slightly greater app. Tp (over that produced by the lowest viscosity type). All 4 viscosity types produced increased peak and final viscosities. Three viscosity types of methylcellulose (MC) (also a neutral gum) possessing the same methyl ether content (30.1-30.6%) were used. None changed the app. Tp. The lowest viscosity type increased the peak viscosity only very slightly; the final viscosity was unchanged. Increases were seen for peak and final viscosities as the MW of the MC increased, probably due to the thermal thickening. Five types of HPMC with different amounts and ratios of methyl and hydroxypropyl ether groups were used. The high- and the 2 medium-viscosity types produced slightly greater final viscosities, while the two low-viscosity types decreased the final viscosity. Trough viscosities were unchanged. Only a little variation was found in peak viscosities and app. Tp, except for the medium-viscosity type with a low methyl ether content (23.4%) and a relatively high hydroxypropyl ether content (8.9%), which produced a higher app. Tp. It was concluded that, overall, enhanced paste viscosities of pea starch-hydrocolloid composites (except for the lowest viscosity types) indicate synergistic interactions between pea starch and hydrocolloids roughly in the order: guar gum (all MWs) > MC (higher MWs) > CMC (higher MWs) > xanthan > HPMC. Dynamic rheological data is still being analyzed. In general, all gums (except for the lowest viscosity types) increased G' over that of the control (starch-alone) paste. All hydrocolloids, whatever their MWs, increased G'', with the higher-viscosity types having the greater effect. In every case, as the MW of the gum increased, tan δ increased, indicating that the pastes became more liquid like, although all composite pastes were more solid-like (more elastic) than were the control pastes. A tentative conclusion is that there is a synergism between the hydrocolloids and the pea starch that results in a firmer paste but any network formed by this synergism is weaker than that formed by amylose and that the gums inhibited the retrogradation that results in network formation.

(Objective 1) Rice flours were obtained from the International Rice Research Institute. Starches with amylose (AM) contents of approx. 0%, 15%, 22%, and 28% were isolated from the flours. The effects of various hydrocolloids (19:1 w/w starch-hydrocolloid ratio) on various pasting and paste properties (RVA) were determined. Three are summarized here. All peak viscosities were increased over that of the control (no added hydrocolloid). For the 3 AM-containing starches, the increases in peak viscosity were in the order HPMC < alginate < CMC < guar gum < xanthan, and all peak viscosities of AM-containing starches were reduced over the values for the waxy rice starch composites. Also, peak viscosities decreased as the AM content increased. The effects on final viscosities, which includes effects of breakdown and setback, were mixed in terms of both the effect of the specific hydrocolloid and the AM content of the starch.

In terms of dynamic rheological data, with all 5 hydrocolloids, the loss tangent (tan δ) decreased as the AM content increased from 0% to 28%, but addition of a hydrocolloid always increased tan δ over that of the control paste. The tentative conclusion is that AM seems to play a definite role in starch-hydrocolloid interactions, but the volumes of data are still being analyzed and interpreted to determine just how.

Status: Suspended for lack of funding. Manuscript in preparation.

4. Crosslinked and Stabilized In-Kernel, Heat-Moisture-Treated and Temperature-Cycled Normal Corn Starch

P.I.: J.N. BeMiller

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: Open for sponsorship

Objective: To determine effects of crosslinking and stabilization on the paste and pasting properties and paste digestibilities of normal corn starch prepared using the conditions determined by R. Wongsagonsup, S. Varavinit, and J.N. BeMiller [Increasing slowly digestible starch content of normal and waxy maize starches and properties of starch products, *Cereal Chemistry*, 85 (2008) 738-745] to be optimal for increasing the content of slowly digesting starch (SDS) to determine if a product with both an increased content of SDS and desirable functional properties can be made.

Progress: Kernels of normal maize were subjected to a heat-moisture treatment (HMT) followed by a temperature cycling (TC) regime that was previously shown the produce slowly digesting starch (SDS) and resistant starch (RS) (Wongsagonsup et al., 2008). This starch (in-kernel HMT-TC normal maize starch [NMS]) was then subjected to a low level of crosslinking with phosphoryl chloride, to hydroxypropylation, and to crosslinking followed by hydroxypropylation to determine if it could be converted into a slowly-digesting modified food starch. Five controls were used. Digestibility after cooking, RVA parameters, and DSC parameters of gelatinization and retrogradation were determined. Crosslinked in-kernel HMT-TC NMS had the greatest amount of SDS, but only 3.1% (compared to 1.3% in the native starch). Hydroxypropylated and crosslinked and hydroxypropylated in-kernel HMT-TC NMS had the greatest amount of RS, but only 35% and 33% respectively (compared to 16% in the native starch). Derivatization changed the physical properties of in-kernel HMT-TC NMS. It was also found that subjecting the starches used in this study to the time, temperature, pH, and salt concentration conditions used for derivatization made significant changes to the physical properties of the starch. In fact, subjecting in-kernel HMT-TC NMS and HMT-TC laboratory-isolated NMS to the conditions used for derivatization but without any added reagent made greater changes in the peak viscosity than did derivatization. The same was not true, however, for laboratory-isolated NMS. And for the most part, the starches subjected to the conditions of derivatization alone also produced different final viscosity values, indicating that whatever changes in granule structure and behavior occurred as a result of treatment with reaction conditions were carried through the RVA cooling cycle.

Status: Manuscript submitted.

5. Effect of Granule Swelling on Derivatization of Starch

P.I.: J.N. BeMiller

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: USDA-AFRI

Progress: Normal maize starch has been reacted with acetic anhydride, succinic anhydride, and octenylsuccinic anhydride and crosslinked with acetic adipic mixed anhydride and phosphoryl chloride in the presence of sodium chloride, sodium sulfate, and sodium citrate to give 3 different levels of swelling (from highest to lowest). The products have been subjected to RVA analysis.

Status: Active

6. Experimental and Modeling the Gelation Phenomenon

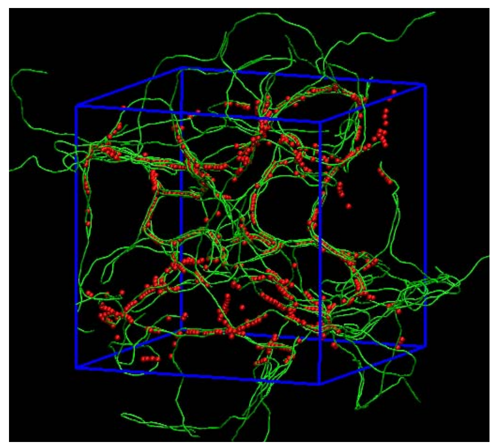
P.I.s: O.H. Campanella and M. Carignano (Northwestern University, Chicago)

Researcher: Paulo H. Santos, Ph.D. Student

Sponsor: Multidisciplinary Research Initiative (MURI)

Objective: 1) Perform computational simulations on the formation process of colloidal gels; (2) Investigate the interplay between the size of particles and the range of the interaction potential among them to study how these two factors affect the gelation process; (3) Perform simulated and experimental viscoelastic tests to investigate the mechanical of properties of colloidal gels; (4) Investigate complex systems and their gelation process such as those formed by macromolecules and (5) perform experimental rheological studies on polymeric gels to validate theoretical models. Develop models to describe the properties of gels/systems that have rheological properties depending on time (thyxotropy)

Progress: Gelling components, in food and non-food systems, are in a state that is not in equilibrium and that makes them very complex to study. Computational studies on the formation process of colloidal or particle gels and determination of their mechanical properties help to understand these mechanisms in a more systematic manner. The effect of different conditions was investigated, in particular to investigate how these conditions affect the viscoelastic properties of those gels. Moreover, experimental measurements were carried out in laboratory to determine time dependent and dynamic viscoelastic properties of these gel systems. Simulations involving long chain molecules that may form a percolated network and consequently a gel like structure are being investigated. Many macromolecules such as proteins and polysaccharides form such complex structure with particular mechanical properties under specific conditions. Computational studies are helping to predict rheological properties of food and non-food gel systems. Systems that exhibit structure dependent properties (also called thixotropy) were characterized theoretically and experimentally using an empirical and rheological tests.



(Snapshot of a Polymeric gel)

Status: Active. Manuscripts published (A.6 and 13) and in press (B.5).

7. Enhancing the Functional Properties of Hydrocolloids, Including Their Sysnergistic Action in the Presence Of Other Hydrocolloids

P.I.s: O.H. Campanella and S. Janaswamy

Sponsor: Government of Turkey

Research: Necla Mine Eren, M.S. Student

Objective: 1) Characterize the physico chemical and molecular characteristics of hydrocolloids that have been subjected to high shear/pressure treatments, 2) Study changes in the synergetic properties of hydrocolloids that have been physically and enzymatically modified to enhance their functional properties.

Progress: The rheological and functional properties of food hydrocolloids like gelling and stabilizers agents have been exploited by the food industry. In addition molecular make up of these polysaccharides and its influence on these rheological and functional is reported in the literature. However, transformations of these hydrocolloids by physical or enzymatic means have not been studied in great detail. Neither the effects of these transformation and potential synergisms of these hydrocolloids are mixed with other hydrocolloids when they are physically on enzymatically modified. Rheological methods are being used to capture the macrostructural response of the modified structure while size exclusion chromatography coupled with laser scattering, and techniques such as circular dichroism are used to monitor changes on molecular characteristics. Preliminary results have shown significant rheological changes using a number of rheological techniques while changes in the molecular properties are more subtle. Further research will be focusing on the effects of solvent conditions characteristics of the treated hydrocolloids. The use of enzymatic treatment with the aim of reducing the molecular weight of these hydrocolloids to study its effects on the hydrocolloid solution properties are being evaluated.

Status: Active

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

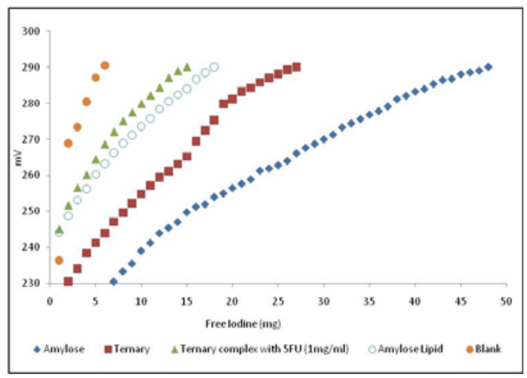
P.I.s: O.H. Campanella and B.R. Hamaker

Researcher: Deepak Bhopatkar, Ph.D. Student

Sponsor: USDA-AFRI

Objectives: To understand mechanistic and formation aspects and applications of a novel soluble nanoscale particle comprised of amylose, soluble protein, and lipids.

Progress: We previously showed a complexation of amylose, protein, and FFA resulting in soluble high molecular weight (6-7 million Da) nanoparticle (radius of gyration, 20-70 nm). Its ability to carry valuable lipid-based compounds (e.g., CLA, DHA, EPA) complexed in the interior cavity of the amylase component was demonstrated last year. This year's work focused mainly on the potential of this nanoparticle to carry other valuable hydrophobic small molecules in soluble form. It was found through potentiometric titration that approximately 50% of the interior hydrophobic helical cavities of amylose, as it exists in the complex, is empty and available for binding such compounds (see figure). Moreover, small hydrophobic molecules were found to be captured in the soluble complex such as a-napthol, thymol, fluorescein, and 5-fluorouracil. Studies are continuing on binding and release kinetics, as well as further characterization of the nanoparticle. The difficulty of making functional drinks containing non-water-soluble bioactive compounds makes this research potentially significant to foods, and solubilization of relatively hydrophobic drugs has pharmaceutical application.



Status: Active. Manuscript published (A.13).

9. Novel Development for Assessing Texture of Foods

P.I.s: O.H. Campanella

Researcher: Jinghu Yu, Visiting Faculty, Jiangnan University

Sponsor: Jiangnan University, Wuxi, China

Objective: Create a bionic masticatory robot to measure the mechanical properties of food materials and to evaluate more precisely the texture of foods in replacement of the combined traditional texture analysis and food evaluation by a sensory panel which often do not provide a good assessment of food texture.

Progress: Variability in the texture of food during consumption and its effect on mouth feeling of foods are not well understood. Research on the relationship of stress and strain of foods during the chewing is helpful to reveal food texture in human's mouth. Food materials are viscoelastic materials and previous studies have found that the measured food texture was dependent on deformation or strain, deformation or strain rate and time. Thus, stress-strain relationships for food materials have been established under conditions that resemble those existing when a food is consumed by humans. Current work is now focusing on the characterization of the viscoelastic material and simulating the food masticatory/chewing process using stress-strain or rheological modeling. Future work will focus on the chewing robot designing. The bionic robot is designed to masticate the food with a defined trajectory/deformation and the force act on tooth will be recorded. The recorded data will be calculated and analyzed using relevant rheological models to evaluate the texture food as it would be perceived by human consumption. Temperature control and changes in the food moisture content will be incorporated in the robot design.

Status: Active

10. Cereal Arabinoxylan Properties Related to Incorporation into Processed Products

P.I.: B.R. Hamaker and O.H. Campanella

Researchers: Madhuvanti Kale, M.S. Student;

Collaborator: C. Yang, Visiting Faculty

Sponsor: MAFMA, available for sponsorship

Objective: Understand structure to rheological function relationships of corn arabinoxylans with the aim of defining dietary fibers for better incorporation into processed foods.

Progress: Fiber incorporation in foods has, to date, been approached largely in an empirical manner, with emphasis on modifying process conditions and formulation and fiber characteristics to obtain an acceptable product. While we continue to study insoluble fibers and their incorporation into foods, this year's focus was on solution behavior of soluble arabinoxylans, including their conformation and aggregation behavior. Chemical structure of fibers affects their solution behavior and, in this case, arabinoxylans from various cereal sources, which have different structures, showed different properties in solution. Studies on alkaline-soluble wheat bran arabinoxylans suggested a semi-flexible rod-like conformation in water, with varying estimates of persistence length and flexibility. In the present study, the conformation and aggregation behavior of alkali extractable arabinoxylans from corn and wheat bran were investigated by SEC-MALS and dynamic light scattering. The fractal dimension (df) of corn bran arabinoxylans was found to be 1.47 while that of the wheat bran arabinoxylans was 1.42. The structure factor $\rho = \langle R_g \rangle / \langle R_h \rangle$ was found to be 1.70 and 2.23 for corn and wheat arabinoxylans respectively. This indicates a stiffer conformation for wheat arabinoxylans, which may be attributed to higher branching on the polymer, as evidenced by its higher arabinose to xylose ratio. Based on the "wormlike chain" model without considering intermolecular interaction, the persistence length (Lp) of corn arabinoxylans was found to be lower than that of wheat arabinoxylans. Even in very dilute solutions, both corn and wheat bran arabinoxylans formed compact aggregates with the fractal dimension of about 3.0 in water. The concentration dependence of aggregation of wheat arabinoxylan was much stronger than that of corn arabinoxylan. Understanding solution behavior of fiber polysaccharides related to structural properties will allow for better identification of proper fibers for specific uses, as well as strategies to enzymatically modify fiber structures for certain behaviors.

Status: Active. Manuscript published (A.8) and in press (B.4).

11. Dietary Fibers and Colonic Fermentation

P.I.: B.R. Hamaker

Researchers: Pinthip Rumpagaporn, Amandeep Kaur, Haidi Xu, Ph.D. Students

Collaborators: A. Keshavarzian (Rush School of Medicine, Chicago); J. Patterson (Department of Animal Sciences, Purdue); P. Gillevet (George Mason University, Virginia); E. Martens (University of

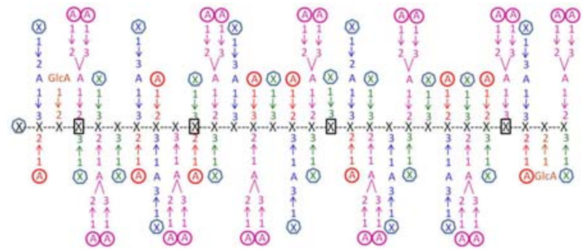
Michigan Medical School); B. Reuhs and O. Campanella

Sponsors: Fellowships (Purdue and P.R. China government), Whistler Center, available for sponsorship

Objective: Identify and characterize dietary fiber structures and hydrolyzates that promote slow fermentation, low bloating, and desirable changes to the colonic microbiota.

Progress: In 2010, we were active in two areas of research: 1) arabinoxylan structures and their fermentation rate properties, and 2) *in vivo* mouse study to investigate outcome of using dietary fibers that are fermented differently.

Arabinoxylans with varying structures have dissimilar fermentation profiles and can result in variable advantages to colon health and general well-being. The objective of the first study was to investigate the major structural determinants of slow fermentation rate of arabinoxylans. Alkali-soluble arabinoxylans were fractioned and sometimes hydrolyzed in different ways to produce a range of structures with different fermentation rate properties. The slowest rate of fermentation of arabinoxylans was found in a wheat hydrolyzate (WH), followed by (in ranked order) corn hydrolyzate (WH), corn (CAX), rice hydrolyzate (RH), and sorghum (SAX). Linkage analyses showed that these arabinoxylans are highly branched polymers with degree of substitution higher than 64%. The major structural factor associated with slow fermentation in these samples was found to be type of linkage of the branched constituents, and not MW, A/X ratio, or degree of substitution. Overall, slow fermenting WH, and CAX and CH had high amounts of branches with single xylose units. A unique structural difference that may be responsible for the slower fermentation rate of the WH was the amount of a oligosaccharide side chain with two second level sugars linked at O-2,3 of the xylan backbone-linked arabinose residue (see figure for proposed structure). The next less important structural feature related to fermentation rate seemed to be the amount of oligosaccharide side chains with the second sugar (xylose, arabinose, or galactose) linked at O-2, O-3, and O-5 of the xylan backbone-linked arabinose residues.



Proposed wheat arabinoxylan structure.

In a related study, CAX was treated by three AX-degrading enzymes in different combinations to produce a series of AX molecules differing in their fine structures. The enzymes used were an endoxylanase and two arabinofuranosidases with distinct specificity. Fourteen samples were obtained including native corn AX. Monosaccharide composition was determined by GC and linkage profiles were analyzed by methylation-GC-MS. Utilization of these structurally different AX molecules by human colonic pure strains of Bacteroides was studied. Based on their structural information and bacterial growth results, five of the fourteen samples were chosen to do in vitro fermentation by human fecal microbiota. Structural information indicated that multiple enzymatic hydrolyses retained certain linkages that are responsible for slow fermentation. Pure-culture and human fecal fermentation results confirmed these hypotheses and led to the conclusion that terminal xylosyl, linked arabinosyl and disubstituted xylosyl residues are responsible for complex branching patterns that are related to their initial slow fermentation properties. A novel hydrolyzed small AX structure was found to have an ideal fermentation profile for colon health with slow initial gas production and highest bacterial growth yield.

2) This study examined fermentative substrates that are digested by colonic bacteria at different rates and with different availability to different bacteria types. For instance, resistant starch type II (RS2) provides accessible starch to starch-binding bacteria (e.g., *Bacteroides*) while starch entrapped in alginate microspheres must be digested by extracellular secreted amylases/glucoamylases. FOS was used as a fast fermenting substrate, and effect on bacteria was observed in luminal and mucosa-associated microbiota from different parts of the large intestine. Forty C57BL6/J mice aged 6 weeks were acclimatized for a week and then fed with four test diets (n = 10) for a period of 2 weeks. Stool samples were collected at day 0, 3, 7, 11 and 14. At day 14, intestinal contents and tissues were collected upon dissection. FOS caused cecal hypertrophy and

also increased content weight. In all the treatments, SCFA increased from day 0 to 14 in the stool and decreased with the site of fermentation from cecum towards the distal colon. Total SCFA were highest during RS2 fermentation that also showed extended fermentation towards the distal colon. Mol% of butyrate of starch-entrapped microspheres in the distal colon at day 14 was twice that of RS2 suggesting that different bacteria were promoted by the two different types of starch. DNA was extracted from cecal and distal colon tissues and stool at day 0 and 14 to perform length heterogeneity PCR (LH-PCR). Principal Coordinates Analysis indicated clustering of specific microbiota in the distal colon as well as 14 d stool samples indicating an alteration in the microbiota population in response to fermentable dietary fibers. Mucosal-associated microbiota was changes by each of the substrates, though were not differentiated among treatments. Specific microbiota changes are being investigated. The data supports the view that dietary fiber types can be identified that promote microbiota changes.

Status: Active. Manuscripts published (A.14 and 18) and in press (B.8).

12. Enzyme Treatments of Starch to Obtain Slower Digesting Glycemic Carbohydrate

P.I.: B.R. Hamaker

Researcher: Byung-Hoo Lee, Ph.D. Student

Sponsor: USDA-AFRI

Objective: Synthesize branched starch structures with moderated digestion property and to develop of a better understanding of how starch structure impacts digestion.

Progress: This project is a continuation with inclusion of in vitro and in vivo testing. Modified waxy corn starch (WCS) structure was made using two types of enzymes, glycogen branching enzyme (GBE) for increasing α-1,6 linkages and β-amylase for decreasing α-1,4 chain length, and by changing reaction sequence at optimal pH and temperature. GBE and β-amylase treatments produced modified WCS which has increased α-1,6 linkages points and less α-1,4 linkages. HPAEC profiles of α-limit dextrins made with human α-amylase showed a higher amount of branched chain limit dextrins and of higher molecular weight compared to limit dextrins of waxy corn starch. In vitro (Englyst) and in vivo rat testing showed an increase in slowly digesting component of modest amount from the Englyst assay and in rats both a delay in time to glycemic peak and higher extended blood glucose levels. However, the larger question appears to be how much delayed glucose release is needed to elicit a beneficial physiologic effect. See project 12 below for evidence that distal glucose release correlated to gastric emptying in a dose response fashion.

Status: Active.

13. Human Glycemic Carbohydrate Digestion at the Mucosal α-Glucosidase Level

P.I.: B.R. Hamaker

Researcher: Amy Lin, Ph.D. Research Associate; Byung-Hoo Lee, Ph.D. Student

Collaborators: B. Nichols (Baylor College of Medicine, Houston), R. Quezada-Calvillo (University of San Luis Potosi, Mexico), D. Rose (University of Toronto, Canada)

Sponsor: Available for sponsorship, USDA-AFRI

Objective: Using human starch degrading enzymes, recombinant and tissue-derived, to explore specific relationships between starch structures and kinetics of digestion by human enzymes for control of glucogenesis at the level of the small intestine mucosal enzymes.

Progress: For starch digestion to glucose, two luminal α-amylases and four gut mucosal α-glucosidase subunits are employed. In this year's work, direct digestion capability of individual mucosal α-glucosidases on cooked (gelatinized) native starch, and digestion of different a-glucosidic linkages was determined. In the first study, gelatinized normal maize starch was digested with N- and C-terminal subunits of recombinant mammalian maltase-glucoamylase (MGAM) and sucrase-isomaltase (SI) of varying amounts and digestion periods. Without the aid of α-amylase, Ct-MGAM demonstrated an unexpected rapid and high digestion degree near 80%, while other subunits showed 20 to 30% digestion. These findings suggest that Ct-MGAM is an important candidate for inhibition to control dietary glucose generation from gelatinized starch and potentially can compensate for developmental or pathological amylase deficiencies.

In the second study, recombinant MGAM and SI subunits were reacted with different types of disaccharides based on monosaccharide compositions and different α-linkages, to elucidate their hydrolysis abilities to provide a better understanding of the range of carbohydrate digestion. Notably, each of the four subunits had α-(1, 2), (1, 3) and (1, 4) hydrolysis activities, but N-SI at 100 U was the only one to have α-(1, 6) hydrolysis activity. However, each subunit had α-(1, 6) hydrolysis activity at extended reaction times up to 72 hours with isomaltose and palatinose. Moreover, sucrose hydrolysis activity was detected from both C-SI and C-MGAM though with lower relative activity than maltose hydrolysis. All types of α-glycosidic linkages can be hydrolyzed by mucosal enzymes with different hydrolysis properties based on mucosal α-glucosidase subunits. Major subunit hydrolysis activity is related to linkages and resulting conformations of disaccharides. This is the first report of α-glucogenic activity of various disaccharides for each mucosal enzyme subunit and can be applied to make tailor-made linkage types of digestible carbohydrates for controlled digestion rate.

Status: Active. Manuscripts published (A.15, 17 and 19).

14. Physiological Response Studies of Starchy Materials With Defined Digestion Profiles

P.I.s: B.R. Hamaker

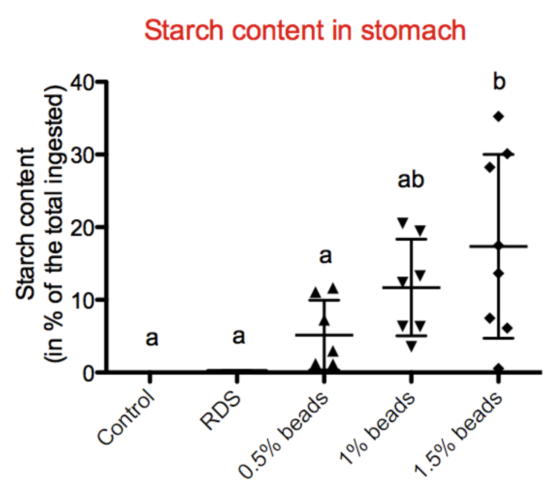
Researcher: Like Yan, Ph.D. Student

Collaborators: T. Powley, R. Phillips, K. Kinzig (Department of Psychological Sciences); M. Kushnick (Ohio University); B. Nichols (Baylor College of Medicine)

Sponsor: USDA-AFRI

Objective: Study of physiologic responses to slowly digestible carbohydrates with controlled digestion profiles.

Progress: Ileal infusion of carbohydrates has been shown to inhibit gastric emptying. However, such effect via dietary delivery of glucose has not been demonstrated. Our aim in this study was to examine the effect of materials with varying degrees of slow glucose release on gastric emptying and glucose/insulin levels. Alginate-entrapped starch microspheres with different slow digesting rates were fabricated. Sprague Dawley rats were assigned to 5 test groups: 1) blank control; 2) Polycose; and 3, 4, 5) slow, slower, and slowest digesting microspheres. Animals were fasted 24 hr prior to oral gavaging of respective test material. Blood insulin, glucose, and starch content from the segments of the GI tract were measured. Glucose response profiles to the 3 slowly digesting microspheres showed an incrementally lower and more sustained glucose release compared with Polycose. Insulin response showed a similar trend. Among the microsphere groups, the amount of starch retained in the stomach increased ($P<0.05$) between slow and slowest digesting microspheres 2 hr after gavaging, and all microsphere treatments were higher than Polycose that showed no remaining stomach glucan (see figure below). Gastric emptying was positively correlated to dietary glucose delivery to the distal small intestine in a dose response fashion and conceivably could be a practical dietary approach to controlling gastric emptying.



Status: Active. Manuscript in press (B.7).

15. Sorghum Phenolics Drive Protein Polymerization That Affects Starch Digestion

P.I.s: B.R. Hamaker and M. Ferruzzi

Researcher: Jennifer Cholewinski, M.S. Student

Sponsor: Available for sponsorship

Objective: To understand the basis of the lower starch digestibility of cooked sorghum products.

Progress: Many sorghum-based foods have relatively low protein and starch digestibility. Previously, we had shown that the protein component in the grain tends to form a web-like network that surrounds gelatinized starch granules, essentially entrapping them for a slow digestion rate. In this study, we investigated the reason that sorghum flour behaves in this manner and other cereal flours do not. It was found that phenolic compounds are present that promote sulfhydryl-disulfide interchange leading to protein polymerization that seems to be related to the extensive protein network that forms. Using chicken egg albumin as a model protein to observe protein polymerization, it was found that phenolic extract from sorghum strongly promotes polymerization while maize extract does not. Further work suggests that anthocyanin derivatives in the sorghum phenolic extract act as electron transferring agents. Thus, as antioxidants they reduce the disulfide bond and as oxidizers facilitate new disulfide bond formation with new or pre-existing free sulfhydryl groups. The cascade of the sulfhydryl-disulfide interchange reaction promotes protein polymerization and results in extensive web-like protein structures that contain gelatinized starch granules.

Status: Active.

16. Use of Corn Zein Proteins as Functional Viscoelastic Polymers

P.I.s: B.R. Hamaker and O. Campanella

Researcher: Mehtap Fevzioglu, Ph.D. Student, Daniel Erickson, M.S. Student, Stephanie Tandazo, M.S. Student, Morgan Goodall, M.S. Student

Sponsor: USDA

Objectives: The overall goal of the proposed work is to understand how to manipulate cereal prolamin structures, particularly corn zein as a by-product of the wzr-milling process, to change its functional properties by either changing processing conditions like temperature (above the material glass transition) or by adding a co-protein. Because there is not a mechanistic understanding of how the co-protein functions or the role of other factors on formation of the viscoelastic aggregate, an emphasis is placed on the fundamentals of the phenomenon, however practically-oriented studies are also included in this large project in which four graduate students are participating. The immediate application of such work is in the replacement of wheat gluten with a gluten-free viscoelastic protein in leavened baked products for wheat intolerant individuals, mainly those with celiac disease. The longer term goal is to understand how to create new functions in non-wheat cereal proteins for uses such as in texturized proteins, binders, and matrix and structure formers.

Specific objectives are:

1. To develop model systems using corn zein to test and understand how secondary β-sheet structure can be modified to affect functional properties.

2. To test a range of β-sheet "stabilizers" such as co-proteins and conditions including high temperature, high pressure, pH, and ionic strength in the formation and stability of viscoelastic aggregates.

3. To determine the effect of observed structural changes on rheology of the system.

4. To develop optimum protein mixtures and conditions for zein use in leavened products.

Progress: Mehtap Fevzioglu - Wheat gluten proteins have a unique property to form a viscoelastic dough upon hydration and mixing which is essential to obtain appropriate rheological properties for baking. Previous studies done in our laboratory indicated the increase on β-sheet structure with a subsequent decrease in α-helix structure was a condition that makes zein behaves as a viscoelastic dough. A co-protein, such as High Molecular Weight Glutenin HMWG was used to stabilize the β-sheet structure of zein, which was assessed by FTIR and rheological analyses of model dough systems.

Small and large deformations rheological tests were used to quantify the effects of adding HMWS to zein protein. Fourier Transform Infrared (FTIR) spectrometry was used to record the secondary structures of proteins in dough state. Addition of HMW-GS changed the rheological properties of zein dough systems. Increase in elasticity and extensional viscosity values of zein dough systems were observed and infrared spectra also indicated changes in zein structure with HMWS addition.

Morgan Goodall - The properties of a high digestibility, high lysine (HDHL) sorghum grain containing proteins (kafirins) that participate in the protein network forming the dough are being studied. Dough extensibility tests clearly showed that HDHL sorghum kafirins are functionalized when mixed at 35°C, i.e. above the glass transition temperature (Tg), so kafirin in the HDHL sorghum grain was able to contribute to the composite dough system whereas normal sorghum does not. Extensibility of the dough prepared with HDHL was significantly improved. The results are showing that kafirin is able to contribute to the formation of a protein network during mixing which is necessary for superior quality of composite dough and bread.

Daniel Erickson - Methods to elucidate the formation of protein fibrils of protein solutions under various solvent conditions (e.g. ethanol concentration) are being developed using hydrogen/deuterium exchange and mass spectrometry. It is expected that the method could provide quantitative and site-specific structural information on the proteins in an amorphous solid state, i.e. once these fibrils are formed. Such information could be compared with results obtained using other techniques such as FTIR, and rheology.

Stephanie Tandazo - The transformation of dry gluten to a rubbery state while increasing water content is known as the glass transition. Glass transition is considered a secondary kinetic transition and understanding of this phenomenon can help to explain changes on viscoelasticity conferred to dough systems and protein functionality. Work is being conducted to create various dough systems (zein/ gluten/ zein+co-protein + water + starch) that would be able to reproduce same rheological properties as wheat gluten in the bread making process and their glass transition temperatures being measured. Addition of co-proteins such as HMWG or casein to zein and studies of how these co-proteins affect zein functionality are being also conducted.

Status: Active.

17. Polymeric Cocrystals for Drug Delivery

P.I.s.: S. Janaswamy, O.H. Campanella and R. Pinal (Department of Industrial Pharmacy)

Researcher: Kristin Gill, M.S. Student

Sponsor: Available for sponsorship

Objective: Some of the important attributes of an efficient drug carrier are accurate dosage, controlled release, safety of handling and minimal side effects. In this regard, utilization of hydrocolloids, in lieu of synthetic polymers, that are inexpensive and Generally Recognized as Safe (GRAS) materials is very much desirable. Further, carriers with stable structure are advantageous for obtaining preferred release profiles. This research utilizes crystalline hydrocolloid fibers as substrates for encapsulating and releasing drug molecules toward developing novel delivery vehicles.

Progress: Several cocrystals comprising iota-carrageenan fibers and drugs such as ibuprofen, benzocaine, furosemide, and sulfapyridine have been prepared. The complexes were characterized by x-ray fiber diffraction, rheological measurements and differential scanning calorimetry. Results suggest that drug molecules can be effectively incorporated in the crystalline iota-carrageenan network and released in a controlled manner.

Status: Active.

18. Hydrocolloids for the Stability and Bioavailability of Nutraceuticals

P.I.: S. Janaswamy

Researcher: Susanne R Youngren, Undergraduate Student

Sponsor: Available for sponsorship

Objective: A wide variety of functional foods, food supplements, bioactive ingredients and nutraceuticals have surfaced for prevention and treatment of chronic diseases such as diabetes, obesity, cardiovascular disease and cancer. Their incorporation in food formulations and bioavailability, however, are major technological challenges mainly due to their intrinsic poor water solubility as well as low stability during processing and storage conditions. In order to reap their complete biological functionality effective encapsulation and protection, mainly aimed at increasing their bioavailability, are very much in need.

Progress: Curcumin has been encapsulated in iota-carrageenan fibers. Crystalline nature of complexes suggests that carrageenan fibers can provide stability for the embedded molecule during delivery process. The temperature at which encapsulation takes place is found to have influence on the total amount of Curcumin embedded in the fibers.

Status: Active.

19. Effect of Salt and Sucrose on the Functional Behavior of Iota-Carrageenan

P.Is.: S. Janaswamy, O.H. Campanella

Researcher: Cordelia A Running, M.S. Student and Bhavesh K. Patel, Research Associate

Sponsor: Available for sponsorship

Objective: In food formulations, polysaccharides are routinely used to control the functional properties such as water binding, viscosity, thickening and stability of dispersions. Addition of other food ingredients, notably sugars and salts, significantly alters physical properties such as solubility, hygroscopicity and crystallinity. For example, incorporation of sucrose modifies the solvent properties whilst salt promotes gelation among hydrocolloids. In this regard, a detailed knowledge on the physical and chemical interactions among food ingredients such as salt, sucrose and hydrocolloids would enlighten the underlying molecular mechanisms that govern structure-function relationships and macroscopic behavior in food systems.

Progress: Effect of sucrose and salt on the three-dimensional structure, viscoelastic and thermal properties of iota-carrageenan at dilute concentrations 0.2, 0.5, 1.0, and 1.5% (w/w) has been analyzed. The study demonstrates that addition of sucrose in the presence of salt significantly alters the functional behavior of iota-carrageenan.

Status: Active.

20. Water-Solid Interactions: Deliquescence

P.I.: L.J. Mauer

Researchers: Rebecca Lipasek, Ph.D. Student; Na Li, Ph.D. Student; Megan West, Ph.D. Student; Dr. Mohamed Ghorab, Ph.D. Research Associate; Yuhong Zhao, Ph.D. Research Associate

Sponsor: Available for sponsorship, Nestec

Objective: Determination of the impact of deliquescence and other 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 and other water-solid interactions in food systems containing crystalline as well as 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 ingredients and that reaction rates and kinetics are influenced by this deliquescence lowering. This has relative importance for the formulation, sequencing, blending, storage, packaging, and stability of dry ingredient mixtures and final food products.

Status: Active.

21. Molecular Dynamics Simulation of Polypeptides Tethered to Surface

P.I.: G. Narsimhan

Researchers: Xiaoyu Wu, Research Associate, Hector Chang, M.S. Student

Sponsor: Army Natick Research Lab

Objective: (1) Conduct Molecular Dynamics (MD) simulations for a antimicrobial peptide Cecropin P1 C adsorbed to silica surface to determine its equilibrium secondary and tertiary conformations (2) Calculate the potential energy of adsorption of the peptide on the silica surface (3) Conduct MD simulation of Cecropin P1 tethered at the C terminal to polyethylene oxide linker which is bound to the silica surface.

Progress: Molecular dynamics (MD) simulation was carried out for the antimicrobial peptide Cecropin P1 C in solution, Cecropin P1 C adsorbed onto silica surface as well as for Cecropin P1 C tethered to silica surface with a polyethylene oxide (PEO) linker of two different lengths for explicit solvent using AMBER simulation program. Low energy structure for Cecropin P1 C in solution that is obtained after 30 ns of simulation consists of two regions of high α helix probability (residues AKKLEN and EGI) with a sharp bend, consistent with the available structures of other antimicrobial peptides. The structure at low ionic strength of 0.02 M exhibits two regions of high α helix probability (residues AKKLEN and EGI) whereas at higher ionic strength of 0.12 M, the molecule was more compact and had three regions of higher α helix probability (residues TAKKLENSA, ISE and AIQG) with an increase in α helical content from 33.5% to 38.9% as a result of shielding of electrostatic interactions. Replica exchange molecular dynamics simulation in the temperature range of 278 to 376 K indicated a loss of α helical content at higher temperatures. Water density profile in the vicinity of silica surface in the presence of adsorbed Cecropin P1 C showed two peaks at distances of around 2.94 A and 5,01 A; the location of the peaks moved slightly away from the silica surface compared to the corresponding peaks in the absence of polypeptide (2.82 A and 4.88 A). H2 bond density profile in the vicinity of silica surface exhibited a single peak in the presence of Cecropin P1 C (at 2.94 A) which was only slightly different from the profile in the absence of polypeptide (2.82 A) thus indicating that Cecrpin P1 C is not able to break the H2 bond formed by the silica surface. Water density and H2 bond density peaks decreased in intensity at higher temperatures even though the location of these peaks from the silica surface remained the same. The conformation of adsorbed Cecropin P1 C on silica surface indicated two regions of high α helix probability (residues AKKLEN and EGI) with the relative orientation of these regions being slightly different for different initial distances of Cecropin P1 C from the silica surface at the start of the simulation. The α helix probability for different residues of adsorbed Cecropin P1 C is not significantly different from that of Cecropin P1 C in solution at low ionic strength of 0.02 M whereas there is a decrease in the probability only in the second region of residues EGI at higher ionic strength of 0.12 M. The conformation of Cecropin P1 C tethered to silica surface with a (PEO)6 linker exhibited two regions of high α helix probability (residues AKKLEN and EGI) as opposed to that of Cecropin P1 C tethered to silica surface with a (PEO)3 linker which exhibited only one α helical region (residues AKKLEN); the conformation of Cecropin P1 C in solution is closer to the former than latter as a result of less surface interaction of tethered polypeptide with a longer linker. Tethered Cecropin P1 C to silica surface at low ionic strength of 0.02 M is found to exhibit lower α helix (19.8% and 29.8% for (PEO)3 and (PEO)6 respectively) compared to adsorbed (30.5%) with this difference being more pronounced for smaller linker molecule. The decrease in α helix compared to that in solution is more pronounced for tethered Cecropin P1 C than adsorbed.

Status: Active. Manuscript submitted (A.26).

22. Investigation of the Conformation of Model Polypeptides using Molecular Dynamics Simulation

P.I.: G. Narsimhan

Researcher: Xiaoyu Wu, Ph.D. Student

Sponsor: Army Natick Research Lab

Objectives: (1) Molecular dynamics (MD) simulation of peptides consisting of five to fifteen amino acids such as lysine and serine in an aqueous medium to determine their equilibrium conformations. (2) MD simulations for (i) peptides consisting of different lengths of a single amino acid (lysine or serine) and (ii) peptidic diblock copolymer consisting of these two amino acids in varying architectures.

Progress: The molecular dynamics (MD) simulation of 11 polypeptides of different amino acid composition (ratio of serine/lysine), length and position of serine were conducted using AMBER 10.0 program. Two different MD procedures were followed. In the first (classical simulation), the simulation was conducted at 300K for 15 ns. In the second, Replica Exchange Molecular Dynamics simulation procedure was followed in which the simulation was conducted for 5 ns for eight different temperatures (270, 300, 334, 370, 413, 470, 513 and 570 K). The polypeptides have 7-12 amino acids with the ratio of serine/lysine between 0.25 to 0.5. 3D structure, end-to-end distance, radius of gyration and the propensity to form α helix structure as obtained by classical MD and REMD methods for SKKKKKKKKS were comparable. As a result, subsequent simulations were carried out using classical MD to reduce computation time. The lowest energy conformation as well as probability of α helix formation for different residues were obtained for all the 11 polypeptides. Pair comparisons showed that polypeptides with higher serine/lysine ratio, larger number of amino acids or adjacent serine residues have higher propensity to form α-helical structures. Predicted values of α helix by simulation seems to compare qualitatively with experimental values though experimental values of β sheet were much higher. These results can be employed to design the architecture of polypeptide with a mixture of amino acids in order to control its secondary conformation. In order to understand the interaction of these polypeptides with titania surface, MD simulations have been initiated to obtain the polypeptide conformation in the vicinity of titania. Both implicit and explicit solvent simulations indicated negligible α helix for adsorbed SKKKKKKKKS on rutile surface with a more extended conformation compared to that in solution. Calculations are underway to obtain the binding energy and conformations of polypeptide in the vicinity of titania of different crystal forms as well as in the vicinity of edges and corners. These results would provide insight on the effect of polypeptides on titania crystal growth.

Status: Active. Manuscript published (A.27).

23. Pore formation in DMPC liposomes by antimicrobial peptides

P.I.: G. Narsimhan

Researchers: Lu Zhou, PhD student**,** Xiaoyu Wu, Research Associate

Objectives: (1) Preparation of liposomes (DMPC, DPPC) with entrapped fluorescent dye; characterization of its size, shape and charge. (2) Experimental measurement of leakage of fluorescent dye from the liposome into the aqueous medium as a function of time when exposed to antimicrobial peptides such as Mellitin, of different polypeptide concentrations and pH – evaluation of critical peptide lipid ratio and rupture time. (3) Development of a mathematical model for the prediction of rupture time of lipid bilayers due to insertion of polypeptides accounting for the force of insertion as well as for the nature of pore (hydrophobic or hydrophilic) – delineation of different mechanisms (barrel stove and toroidal) of pore formation by polypeptides.

Progress: Antimicrobial peptides (AMP) belong to a large and varied class of relatively short peptides family and constitute host-defense system in many living organisms, capable of killing inter alia, Gram negative and Gram positive bacteria. They have the ability to penetrate the cell membrane, form pores which eventually lead to cell death. In this investigation, 1,2-Dimyristoyl-sn-glycero-3-phosphocholine (DMPC) liposomes were used as model systems in lieu of cells since they encapsulate aqueous solution with a phospholipid bilayer. Experiments were conducted with liposomes consisting of fluorescent calcein, FD-4 and FD-20 which were exposed to antimicrobial peptides Melittin. Liposomes were negatively charged (zeta potential of -25 to -30 mV) and of 150 nm size. Positively charged antimicrobial peptides adsorbed onto the liposome surface due to charge interactions. The leakage of fluorescent dye as a result of pore formation was demonstrated by confocal microscopy and was monitored by fluorescence of the external phase. Circular dichroism results showed that insertion of Melitin into the lipid bilayer induced α helical structure. Results indicated that there was a lag time (rupture time) before formation of pores. This lag time was found to be larger for larger size dye molecules (dye size increasing in the order calcein < FD-4 < FD-20). Such a behavior can be explained by the formation of larger pores by aggregates at higher Mellitin concentration. The extent of rupture was found to be larger for larger peptide/liposome ratio.

Status: Active

24. Stability of *E. Coli* and Other Human Pathogens on Fresh Produce

P.I.: B. Reuhs

Researchers: Amanda Deering, Ph.D. Student; Andrew Curtis, M.S. Student; and Jae Wook Yoon, Ph.D. Student

Sponsor: USDA-CSREES

Objectives: (1) Examination of bacterial stability during transfer from initial contamination source through irrigation system to vegetable production site. (2) A study of the mobility and stability of bacterial cells on the roots and leaves of fresh produce. (3) An analysis of the efficacy of decontamination systems on fresh produce.

Progress: We are using bioluminescent cells to track colonization along the growing root during the first 20 days of plant development. We have determined various potential carbon sources for the human pathogens in the plant environment.

Status: Active.

25. Factors Contributing to the Viscosity Difference of Hot-and Cold-Break Tomato Products

P.I.: B. Reuhs

Researchers: Bicheng Wu, M.S. Student

Sponsor: Available for sponsorship

Objectives: In tomato product manufacturing, the initial "break" stage is critical to the quality attributes of the final product. Hot-break (HB) products (break above 90°C) maintain higher viscosity at the cost of degraded color and flavor as compared to the cold-break (CB) products.

Progress: Several studies have suggested that the relatively low viscosity of CB tomato product results from the break-down and release of water-soluble pectic oligomers by the pectolytic enzymes, whereas HB solublized more intact pectic polymers. In this study, we examined the contribution of pectin to the viscosity of both HB and CB tomato products, which were immediately collected after breaking. Solublized pectin in serum was analyzed by GC and HPSEC-MALLS-RI, and it showed that the hot-break tomato serum contains a higher amount of higher molecular weight pectin than cold-break serum, which was responsible for its higher serum viscosity. However, the amount of pectin in both the HB and CB sera is much too low to play a significant role in the gross viscosity of HB and CB tomato products. We demonstrated that instead of pectin, rheological properties of the tomato pulp have a major contribution to product viscosity. The tomato pulp was separated from the serum and reconstituted with an equivalent amount of water for shear-flow measurements of the pulp solution. It shows that tomato pulp solution has comparable viscosity to that of tomato paste, and that the hot-break tomato pulp solution is more viscous than the cold-break. An oscillatory frequency sweep test on the HB and CB tomato pulp solutions showed that there is a difference in the viscoelastic behaviors of the tomato pulps after these two breaking methods, and that this is responsible for tomato product viscosity.

Status: Active.

26. High-Value Corn Starch

P.I.: C. Weil

Collaborator: L. Mauer, Y. Yao

Researchers: Alona Chernyshova, M.S. Student

Sponsor: Whistler Center, Consortium for Plant Biotechnology Research

Objectives: Genetics and mutagenesis are used to develop maize lines that produce specialized corn starches. The working hypothesis is that maize 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. Large populations of mutagenized seeds are being developed in the inbred maize lines W22 and B73. We have screened ~500 families of these seed and identified mutants that slow digestion to a steady release that eventually reaches normal levels of overall glucose release, and identified other lines where there is more digestion in 20 minutes than normal starch achieves in 2 hours. We now want to understand what has been altered in these lines (*e.g.*, starch structure? interacting protein?).

Progress: We have identified ~100 families segregating for altered digestion rate (analyzing both cooked and raw flour). We have coupled NIR spectroscopy with a two enzyme digestion and glucometry, allowing us to control more precisely for input starch and consistent mixing. We are identifying homozygotes from these families for more detailed genetic and chemical analysis,

Understanding differences in non-starch components that alter starch digestibility also requires a more accurate understanding of differences in proteins that interact with the starch in flour. We are initiating studies to examine the endosperm proteome of rapidly and slowly digesting starch mutants using stable isotope labeling and mass spectrometry.

Status: Active.

27. Genes Controlling Starch Channelization

P.I.: C. Weil

Collaborator: J.N. BeMiller

Sponsor: Available for sponsorship

Progress: In conjunction with Yenny Widya and Dr. BeMiller, we have been analyzing genetic changes associated with differences in the number of channels formed in starch channels. Previous data from the BeMiller lab had shown differences in channel number among inbred maize lines. Two of these inbreds, B73 and Mo17, are the source of recombinant inbred lines (RILs) that have been mapped extensively over the last several years. Using the data on how much actin can be extracted from channels in these recombinant inbred lines (the Relative Degree of Channelization), we have been able to use association mapping techniques to identify regions very likely to have genes that control channel formation. Interestingly, several of these regions contain actin and tubulin genes, and a number of others have genes that have endosperm morphology mutant phenotypes. As the maize genome is sequenced over the course of the next year, the details of the genes in these candidate regions will become clear and we will be able to test their specific roles in forming channels in maize starch granules.

A better difference in channelization was observed between B73 and another inbred, Oh43. A set of 200 RILs has been developed at Cornell University from these two inbreds and these have been extensively genotyped. We are performing association analyses on these RILs as well, to correlate with the data obtained from Mo17.

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.

28. Genetic Interactions That Impact Starch Quantity and Quality

PI: C. Weil

Researchers: Vijay Chaikam, Ph.D. Research Associate

Progress: Many mutations show differences in the phenotypes they cause when they are moved into various genetic backgrounds. A highly diverse set of 27 maize inbreds has been used to create a gene mapping resource called the Nested Association Mapping (NAM) panel. Together with Dr. G. Johal in the Botany Dept., Dr. Weil has developed a way to use the 6000 NAM lines to map genetic networks that alter how mutations affect traits. He and his Post Doctoral Vijay Chaikam have crossed the starch mutants *ae1* and *wx* to these diverse inbreds to identify interacting genes that affect starch quantity and quality. Once the affects have been determined, the NAM populations will allow us to quickly identify and isolate novel genes that alter starch characteristics.

Status: Active

29. Starch-Based Micro-Particulates

P.I.: Y. Yao

Researcher: Weihong Min, Visiting Faculty

Sponsor: Available for sponsorship

Objectives To make starch-based micro-particulates that can: 1) be resistant to hydrothermal treatment encountered in food processing, 2) release encapsulated compounds (e.g. polyphenols or lipids) when subjected to the digestion by amylases in the GI tract.

Progress: Progress has been made to use starch materials to prepare microparticles. The goal is to prepare microcapsules which are partially resistant to boiling and can be effectively disrupted to release encapsulated nutrients by an Englyst-type enzyme digestion procedure. The procedure of microparticle and microcapsule preparation is emulsion-based, using finely tuned starch structures to ensure suitable solidification. A specific focus has been to reduce the particle size of starch particulates to <50 μm.

Status: Active.

30. Carbohydrate-Based Colloidal Assemblies to Prolong Nisin Activity against Listeria Monocytogenes

P.I.s: Y. Yao, A. Bhunia

Researchers: Lin Bi, Ph.D. Student; Preetam Sarkar, Ph.D. Student; Lei Yang, Visiting Scholar

Objective: To develop carbohydrate-based colloidal assemblies that can effectively bind antimicrobial peptides (e.g. nisin) and realize their prolonged efficacy against food pathogens such as *Listeria monocytogenes.*

Progress: We have prepared oil-in-water emulsions using PG-OS and other emulsifiers to complex antimicrobial peptides. This research proved that PG-OS nanoparticles are more effective than other emulsifiers to retain the activity of nisin against *L. monocytogenes*. To understand the mechanism of peptide binding and release, the adsorption behavior of nisin with nanoparticle-mediated assemblies is being studied, using the LC/MS/MS approach to precisely quantify nisin in aqueous system. The technology developed will have great potential in protecting foods susceptible to pathogenic contaminations. These foods include raw and cooked meat, fresh vegetables and fruits, and dairy products.

Status: Active.

31. Functional Properties of Amphiphilic Carbohydrate Nanoparticles

P.I.: Y. Yao

Researchers: Hua Chen, Ph.D. Student and Lei Yang, Visiting Scholar

Objective: To evaluate the digestibility and interfacial adsorption of phytoglycogen octenyl succinate (PG-OS). These properties govern the performances of PG-OS in emulsion-based colloidal assemblies.

Progress: Our previous studies has shown that the *in vitro* digestibility of PG-OS was lower than that of native phytoglycogen (PG) and the reduction of digestibility was associated with the degree of substitution (DS). In this project, we further explore the digestibility of PG-OS in an emulsion system. The hypothesis is that the interfacial adsorption of PG-OS leads to a local enrichment of nanoparticles which may affect (possibly increase) the rate of amylolysis during digestion. In this work, a number of PG-OS materials will be used to prepare emulsions. These emulsions will be subjected to Englyst *in vitro* digestion test. The morphology of these emulsions will be imaged using cryo-TEM to characterize the degradation of PG-OS-based interface during a digestion process. This work is pivotal for understanding the digestion-triggered release of lipophilic compounds in the oil phase.

Status: Active

32. Particulate and Branch Structure of Phytoglycogen Nanoparticles

PI: Yuan Yao

Researchers: Lei Huang, Visiting Student; Hua Chen, Ph.D. Student; Yiming Wang, Visiting Student

Objective: To reveal the particulate and branch structure of phytoglycogen in comparison with amylopectin.

Progress: Through monitoring the glucose release and the change of particle size and molecular density of phytoglycogen during the hydrolysis by amyloglucosidase (AMG), we have successfully revealed the particulate structure of phytoglycogen nanoparticles compared with amylopectin. During AMG hydrolysis, the dispersed molecular density of amylopectin remained at around 60 g/mol·nm^3. In contrast, the density of phytoglycogen was reduced from about 1,200 to 950 g/mol·nm^3. This suggests a very high density of phytoglycogen in aqueous dispersion and also reveals an important dendrimer-like structural characteristic of phytoglycogen: a density increment towards the external region of nanoparticle.

Currently, we are working on using beta-amylolysis to probe the branch structure of phytoglycogen. Specifically, during beta-amylolysis we monitor the maltose release from phytoglycogen and amylopectin, their particulate structure, and the chain length distribution of produced dextrins. This work is particularly important for understanding the role of glucan branching in the synthesis of starch and phytoglycogen. It may also benefit the structure engineering of phytoglycogen-based nanoparticles.

Status: Active

PUBLICATIONS AND OTHER SCHOLARLY ACTIVITIES

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

BeMiller

1. **M. Benmoussa**, **B.R. Hamaker**, C.-P. Huang, D.M. Sherman, **C.F. Weil**, **J.N. BeMiller**. Elucidation of maize endosperm starch granule channel proteins and evidence for plastoskeletal structures in maize endosperm amyloplasts. *Journal of Cereal Science* 52:22-29.
2. **Y. Widya**, **N. Gunawan**, **J.N. BeMiller**. Methods for determining relative average number of channels per maize starch granule and digestion of raw granules of mutant maize cultivars by amyloglucosidase. *Cereal Chemistry* 87: 194-203.
3. **J.N. BeMiller.** Roy Lester Whistler 1912-2010. *Advances in Carbohydrate Chemistry and Biochemistry*, 64:2-17.
4. **J.N. BeMiller**. Carbohydrate analysis, *in* Food Analysis, S.S. Nielsen, ed., Springer, New York, 4th Ed., pp. 147-177.
5. K.C. Huber, **J.N. BeMiller**. Modified starch: chemistry and properties, *in* Starches, A.C. Bertolini, ed. CRC Press, Boca Raton, pp. 145-203.

Campanella

6. **P.H.S. Santos**, R. Arnold, W. E. Anderson, M. A. Carignano, **O.H. Campanella**. Rheology of JP-8/SiO2 and RP-1/SiO2 gels, *in* IAENG Transactions on Engineering Technologies, v.4, AIP Conference Proceedings, 1247, pp. 288-300.
7. **D.C. Gonzalez**, **N. Khalef**, **K. Wright**, M.R. Okos, **B.R. Hamaker**, **O.H. Campanella**. Physical aging of processed fragmented biopolymers. *Journal of Food Engineering* 100:187-193.
8. **M.G. Abiad**, **O.H. Campanella**, M.T. Carvajal. Assessment of thermal transitions by dynamic mechanical analysis (dma) using a novel disposable powder holder. *Pharmaceutics* 2:78-90.
9. **M.G. Abiad**, **D.C. Gonzalez**, **B. Mert**, **O.H. Campanella**, M.T. Carvajal. A novel method to measure the glass and melting transitions of pharmaceutical powders. *International Journal of Pharmaceutics*, 396:23-29.
10. S. Basu, M. Moiz Diwan, **M.G. Abiad**, Y. Zheng, **O.H. Campanella**, A. Varma. Transport characteristics of dehydrogenated ammonia borane and sodium borohydride spent fuels. *International Journal of Hydrogen Energy* 35:2063-2072.
11. G. Chen, M. Peleg, **O.H. Campanella**. Calculation of the total lethality of conductive heat in cylindrical cans sterilization using linear and non linear survival kinetic models. *Food Research International* (on line copy).
12. **M.S. Kale**, **D.A. Pai**, **B.R. Hamaker**, **O.H. Campanella**. Structure–function relationships for corn bran arabinoxylans. *Journal of Cereal Science* 52:368-372.
13. **P.H. Santos**, **O.H. Campanella**, M.A. Carignano. Brownian dynamics study of gel-forming colloidal particles. *Journal of Physical Chemistry B* 114:13052-13058.
14. **A. Shah**, **G. Zhang**, **B.R. Hamaker**, **O.H. Campanella**. Rheological properties of a soluble self-assembled complex from starch, protein and free fatty acids. *Journal of Food Engineering* (on line copy).
15. **S. Simsek**, Y. Zhang, **O.H. Campanella**. Physicochemical properties of arabinoxylans in refrigerated dough. *Food Research International* 43:2119-2125.

See Hamaker paper 19.

Hamaker

16. **D. Rose**, J.A. Patterson, **B.R. Hamaker**. Structural differences among alkali-soluble arabinoxylans from maize (Zea mays), rice (Oryza sativa), and wheat (Triticum aestivum) brans influence human fecal fermentation profiles. *Journal of Agriculture and Food Chemistry* 58:493–499.

17. **D.J. Rose**, K. Venema, A. Keshavarzian, **B.R. Hamaker**. Starch-entrapped microspheres show a beneficial fermentation profile and decrease in potentially harmful bacteria during in vitro fermentation in fecal microbiota obtained from patients with inflammatory bowel disease. *British Journal of Nutrition* 103:1514-1524.

18. G. Zhang, **B.R. Hamaker**. Review: Cereal carbohydrates and colon health. *Cereal Chemistry* 87:331-341.

19. G. Zhang, **M. Maladen**, **O.H. Campanella**, **B.R. Hamaker**. Free fatty acids electronically bridge the self-assembly of a three-component nanocomplex consisting of amylose, protein, and free fatty acids. *Journal of Agricultural and Food Chemistry* 58:9164-9170.

20. M.I. Klein, L. DeBaz, S. Agidi, H. Lee, G. Xie, **A.H. Lin**, **B.R. Hamaker**, J.A. Lemos, H. Koo. Dynamics of Streptococcus mutans transcriptome in response to starch and sucrose during biofilm development. *PLoS ONE 5*: e13478.

21. M.A. McCrory, **B.R. Hamaker**, J.C. Lovejoy, P.E. Eichelsdoerfer. Pulse consumption, satiety and weight management. *Advances in Nutrition* 1:17-30.

See BeMiller paper 1.

See Campanella papers 7, 12 and 14.

Janaswamy

See Yao paper 33.

Mauer

22. **L.J. Mauer**, L.S. Taylor. Deliquescence of pharmaceutical systems. *Pharmaceutical Development and Technology* 15:582-594.

23. **A. Stoklosa**, I. Weiss, B. Bugbee, M. Perchonok, **L.J. Mauer**. Composition and functional properties of Apogee and Perigee compared to common terrestrial wheat cultivars. *International Journal of Food Properties* (Available early online October 2010).

24. **L.J. Mauer**, L.S. Taylor. Water-solids interactions: Deliquescence. *Annual Review of Food Science and Technology* 1:41-63.

25. W. Tongdeesoontorn**, L.J. Mauer**, S. Wongruong, P. Rachtanapun. Water vapour permeability and sorption isotherms of cassava starch based films blended with gelatin and carboxymethylcellulose. *Asian Journal of Food and Agro-Industry* 2: 501-514.

26. **A. Hiatt**, L.S. Taylor, **L.J. Mauer**. Influence of simultaneous variations in temperature and relative humidity on chemical degradation of two vitamin C forms and implications for shelf-life models. *Journal of Agricultural and Food Chemistry* 58:3532-3540.

27. **K. Kwok**, **L.J. Mauer**, L.S. Taylor. Phase behavior and moisture sorption of deliquescent powders. *Chemical Engineering Science* 65:5639-5650.

28. **K. Kwok**, **L.J. Mauer**, L.S. Taylor. Kinetics of moisture-induced hydrolysis in powder blends stored at and below the deliquescence relative humidity: Investigation of sucrose-citric acid mixtures. *Journal of Agricultural and Food Chemistry*. 58:11716-11724.

Narsimhan

29. **G. Narsimhan**. Analysis of creaming and formation of foam layer in aerated liquid. *Journal of Colloid and Interface Science* 345:566-572.

30. **X. Wu**, **G. Narsimhan**. Characterization of the effect of electrostatic interaction on the structure of trp-cage using molecular dynamics simulation. *Molecular Simulation* 36:1086-1095.

Reuhs

31. M. Habteselassie, M. Bischoff, B. Applegate, **B.L. Reuhs**, R.F. Turco. Understanding the role of agricultural practices in the potential colonization and contamination by *E. coli* in the rhizosphere of fresh produce. *Journal of Food Protection*. 11:2001-2009.

Weil

32. **C.F. Weil**, R. Monde. vEMS mutagenesis and point mutation discovery, *in* Molecular Genetic Approaches to Maize Improvement, B. Larkins and A. Kriz eds., Springer-Verlag, Amsterdam.

See BeMiller paper 1.

Yao

33. **W. Song**, **S. Janaswamy**, **Y. Yao**. Structure and *in vitro* digestibility of normal corn starch: effect of acid treatment, autoclave, and β-amylolysis. *Journal of Agricultural and Food Chemistry* 58:9753-9758.

34. **S.L. Scheffler**, **L. Huang**, **L. Bi**, **Y. Yao**. In vitro digestibility and emulsification properties of phytoglycogen octenyl succinate. *Journal of Agricultural and Food Chemistry* 58:5140-5146.

B. Papers and Book Chapters In Press

BeMiller

1. **J.N. BeMiller**. Contributions of Roy L. Whistler to carbohydrate polymer science. *Carbohydrate Polymers*.

2. **J.N. BeMiller**, K.C. Huber. Starch, *in* Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Weinheim, Germany.

Campanella

3. **O.H. Campanella**. Chapter 2. Instrumental techniques for measurement of textural and rheological properties of foods, *in* Emerging Technologies for Evaluating Food Quality and Food Safety, Cho, Y.J. and Sukwon Kang, S. eds. CRC Publisher, pp 6-53.

4. **M. Kale**, **D.A. Pai**, **B.R. Hamaker**, **O.H. Campanella**. Incorporation of fibers in foods: a food engineering challenge, *in* Food Engineering Interfaces, Aguilera, J.M., Simpson, R., Welti-Chanes J., Bermudez-Aguirre, D., and Barbosa-Canovas, eds. G.V. Food Engineering Series, Springer, pp 69-98.

5. **P.H.S. Santos**, M.A. Carignano, **O.H. Campanella**. Qualitative study of thixotropy in gelled hydrocarbon fuels. *Engineering Letters* 19:1. (Advance online publication: 10 February 2011).

6. J.M. Bouvier, **O.H. Campanella**. Extrusion processing technology, *in* Food and Non-Food Biomaterials, J. Wiley.

See Reuhs paper 16.

See Hamaker paper 7.

Hamaker

7. **M. Moussa**, X. Qin, L.F. Chen, **O.H. Campanella, B.R. Hamaker**. High quality instant sorghum porridge flours for the West African market using continuous processor cooking. *International Journal of Food Science and Technology.*

8. **Kaur, A., Rose, D.J., Rumpagaporn**, P., Patterson, J.A., **Hamaker, B.R.** In vitro batch fecal fermentation comparison of gas and short-chain fatty acid production by "slowly fermentable" dietary fibers. *Journal of Food Science*.

See Campanella paper 4.

Janaswamy

See Yao paper 19.

Mauer

9. **A. Stoklosa**, I. Weiss, B. Bugbee, M. Perchonok, **L.J. Mauer**. Composition and functional properties of Apogee and Perigee compared to common terrestrial wheat cultivars. *International Journal of Food Properties* (Available early online Oct. 20, 2010).

10. **A. Hiatt**, L.S. Taylor, **L.J. Mauer**. Effects of co-formulation of amorphous maltodextrin and deliquescent sodium ascorbate on moisture sorption and stability. *International Journal of Food Properties.*

11. **A. Stoklosa**, D.E. Nivens, M. Perchonok, **L.J. Mauer**. Effects of low-dose gamma-radiation on select wheat characteristics. *International Journal of Food Properties* (Available early online Sept.16, 2010).

12. **A. Hiatt**, M.G. Ferruzzi, L.S. Taylor, **L.J. Mauer**. Deliquescence behavior and chemical stability of vitamin C forms (ascorbic acid, sodium ascorbate, and calcium ascorbate) and blends. *International Journal of Food Properties* (Available early online Dec. 1, 2010).

13. W. Tongdeesoontorn, **L.J. Mauer**, S. Wongruong, P. Sriburi, P. Rachtanapun. Effect of carboxymethylcellulose concentration on mechanical and physical properties of biodegradable cassava starch-based films. *Chemistry Central Journal.*

14. **M.E. West**, **L.J. Mauer**. Development of an integrated approach for the stability testing of flavonoids and ascorbic acid in powders. *Food Chemistry*.

Narsimhan

15. **X. Wu**, C. Mello, R. Nagarajan, **G. Narsimhan**. The effect of interaction with silica surface on the conformation of antimicrobial peptide Cecropin P1 C using molecular dynamics simulation. *Langmuir.*

See Yao paper 17.

Reuhs

16. Y. Zhang, S. Simsek, **O.H. Campanella**, J.B. Ohm, H. Chang, **B.L. Reuhs**, M. Mergoum. Rheological changes in refrigerated dough during storage in relation to proteins. *Journal Food Process Engineering*.

Yao

17. **L. Bi**, L. Yang, **G. Narsimhan**, A. Bhunia, **Y. Yao**. Designing carbohydrate nanoparticles for prolonged efficacy of antimicrobial peptide. *Journal of Controlled Release.*
18. **L. Huang**, Y. Yao. Particulate structure of phytoglycogen nanoparticles probed using amyloglucosidase. *Carbohydrate Polymers.*
19. **Y. Yao**, **S. Janaswamy**. Gene dosage effect on starch structure studied using maize polygenic model containing ae and su1 mutant alleles. *Food Chemistry*.
20. **L. Bi**, L. Yang, A. Bhunia, **Y. Yao**. Carbohydrate nanoparticle-mediated colloidal assembly for prolonged efficacy of bacteriocin against food pathogen. *Biotechnology and Bioengineering*.

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

January

1. **O.H. Campanella**. Characterization of food and biomaterials using acoustic and ultrasound waves. Nanosonics and Ultrasonics Workshop. St Joseph College, Trichy, India.

February

2. **B.R. Hamaker**. Dietary fibers with targeted colonic action and prebiotic effect. Rush Medical School, Immunology Section, Chicago, IL.
3. **B.R. Hamaker**. Presentation and participation in Food Security Summit, Purdue University, West Lafayette, IN.

March

4. **Y. Yao.** Plant-based dendrimer-like carbohydrate nanoparticles. Dow AgroSciences, Zionsville, IN.
5. **K. Gill**, **S. Janaswamy**, **O.H. Campanella**. Crystalline polysaccharide matrices for protecting bioactive components in food formulations. Indiana-IFT, West Lafayette, IN.
6. **B.R. Hamaker**, **P. Rumpagaporn**, **D. Rose**. Use of cereal bran native and hydrolyzate arabinoxylans for dietary fibers with different fermentation profiles. American Chemical Society annual meeting dietary fiber symposium, San Francisco, CA.
7. **L. Yan**, S. Avery, S.K. Chacko, J.K. Fraley, B.L. Nichols, **B.R. Hamaker**. Slowly digestible starch diets alter proximal glucosidase activity and glucose absorption. Experimental Biology annual meeting, Anaheim, CA.
8. **A.H. Lin**, B.L. Nichols, R. Quezada-Calvillo, D.R. Rose, L. Sim, **B.R. Hamaker**. Starch digestion with human mucosal enzymes at alpha-limit dextrin level. Experimental Biology annual meeting, Anaheim, CA.
9. **O.H. Campanella**. A new perspective to study the mechanical properties of soft foods and biomaterials. Jiangnan University, Wuxy, China.

June

10. **R. Davis**, Y. Burgula, J. Irudayaraj, **B.L. Reuhs**, **L.J. Mauer**. Fourier transform infrared (FT-IR) spectroscopy coupled with filtration and immunomagnetic separation for the detection of *Escherichia coli* O157:H7 in ground beef. Biennial IEEE UGIM (University Government Industry Micro/nano) Symposium. West Lafayette, IN.
11. **A.J. Deering**, **B.L. Reuhs**, **L.J. Mauer**. Nanostructural differentiation between live and dead Escherichia coli cells using FT-IR spectroscopy and comparison of detection limits using quantitative PCR (qPCR). University Government Industry Micro/nano (UGIM) Symposium, West Lafayette, IN.

12. **X. Wu**, **G. Narsimhan**. Characterization of conformation of proteins/polypeptides immobilized at liquid-solid interfaces using molecular dynamics simulations. International Conference on Bio/Abio Molecules at Interfaces, Christchurch, New Zealand.
13. **B.R. Hamaker**, **A.H. Lin**, **B.H. Lee**. Mucosal glucosidases and carbohydrate digestion. Starch Digestion Consortium meeting, Vancouver, Canada.
14. **B.R. Hamaker**. Starch fine structure and digestion: Is there a case for slow digestion? International Hydrocolloids Conference, Shanghai, China.
15. **B.R. Hamaker**, G. Zhang, **A.H. Lin**, **B.H. Lee**. Controlled glucose release from corn starch and its products and implications on diabetes and obesity. Corn Utilization and Technology Conference, Atlanta, GA.

July

1. **S. Janaswamy**. Effect of guanidinium ions on the three-dimensional ordering of iota- and kappa-carrageenan helices. New developments in fiber diffraction: cryo-, micro-diffraction and complementary techniques, American Crystallographic Association (Session 03.01), Chicago, IL.
2. **K. Gill**, **S. Janaswamy**, **O.H. Campanella**. Polymeric cocrystals for vitamins delivery. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
3. **B.K. Patel**, **S. Janaswamy**, **O.H. Campanella**. Gelation of iota-carrageenan at dilute concentrations: Roles of sugar and guanidine hydrochloride. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
4. **P.S. Santos**, M.A. Carignano, **O.H. Campanella**. Effect of particle concentration on the rheological properties of colloidal gels. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
5. **K. Gill**, **S. Janaswamy**, **O.H. Campanella**. Utilizing polymeric cocrystals for vitamin delivery. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
6. **M. Fevzioglu**, L. Mosharraf, **O.H. Campanella**, **B.R. Hamaker**. Effect of HMW glutenin in zein dough rheology and optimization of mixograph parameters. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
7. **P. Rumpagaporn**, **O.H. Campanella**, **B.R. Hamaker**. Heat and pH stability of corn alkali-extractable arabinoxylan and its xylanase-hydrolyzate and their viscosity behavior. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
8. **D. Bhopatkar**, G. Zhang, **O.H. Campanella**, **B.R. Hamaker**. Effect of Hofmeister series anions on the structural properties of water soluble starch-protein-lipid nano-complex. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
9. **M.S. Kale**, M.T. Wolf, **O.H. Campanella**, **B.R. Hamaker**. Effect of alkali treatment conditions on the oxidative gelling properties of corn bran arabinoxylans. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
10. **A. Shah**, G. Zhang, **O.H. Campanella**, **B.R. Hamaker**. Dynamic rheological method to study the interaction between starch, protein and lipid during cooling. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
11. N. Vaidya, J. Lu, **O.H. Campanella**, C.M. Corvalan. Predicting the caking in amorphous food powders: A numerical study. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
12. **B.R. Hamaker**, **L. Yan**, **B-H. Lee**, T. Powley, R. Phillips, K. Kinzig, M. Kushnick, G. Zhang, B. Nichols. Defined glucose release profiles of glycemic carbohydrates and their physiologic effect. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.
13. **X. Shen**, G. Zhang, **B.R. Hamaker**. Impact of amylopectin long chains on its functional properties. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

14. **H. Xu**, **P. Rumpagaporn**, **M. Kale**, **B.L. Reuhs**, **B.R. Hamaker**. Structural subunits of alkali-extractable arabinoxylans from corn bran. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

15. **B.-H. Lee**, **A. Lin**, R. Quezada-Calvillo, B.L. Nichols, D.R. Rose, L. Sim, **B.R. Hamaker**. Hydrolysis properties of mammalian mucosal glucogenic enzymes on various oligosaccharides. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

16. **A. Lin**, B.L. Nicolas, R. Quezada-Calvillo, D.R. Rose, L. Sim, **B.R. Hamaker**. Starches with different fine structures are digested differently at the human brush border level. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

17. **J.F. Lefort**, **L.J. Mauer**, G. Sadler. An overwrap packaging model for extended food shelf-life on future NASA space missions. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

18. **R. Davis**, **B.L. Reuhs**, **L.J. Mauer**. Identification and classification of *E. coli* O157:H7 strains at serotype levels by Fourier transform infrared (FT-IR) spectroscopy techniques combined with multivariate analysis. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

19. **R. Davis**, **B.L. Reuhs**, **L.J. Mauer**. Detection and quantification of live bacteria in the presence of dead bacteria in different food matrices using Fourier transform infrared spectroscopy (FT-IR). Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

20. **M. West**, **L.J. Mauer**. Methods for determining the effects of moisture on stability of flavonoids and ascorbic acid in powder blends. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

21. **N. Li**, M.G. Ferruzzi, **L.J Mauer**. Kinetic study of green tea catechin stability in simulated high relative humidity systems. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

22. L.S. Taylor, **L.J. Mauer**. Fundamentals, effects and consequences of deliquescence in multicomponent food systems. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

23. **R.A. Lipasek**, **N. Li**, **M. West**, L. Taylor, **L.J. Mauer**. Effects of temperature on deliquescence and deliquescence lowering. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

24. **R.A. Lipasek**, **L.J. Mauer**, L. Taylor. The effects of anticaking agents, temperature and relative humidity on the chemical and physical stability of powdered vitamin C. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

25. **A.J. Deering**, **B.L. Reuhs**, **L.J. Mauer**. Comparison of detection limits for differentiation between live and dead Escherichia coli cells using FT-IR spectroscopy and quantitative PCR (qPCR). Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

26. P.Y. Phoon, L.N. Paul, J.W. Burgner II, **G. Narsimhan**, M.F. San Martin-Gonzalez. Influence of compactness of interfacial adsorbed protein layer on oxidative stability of O/W emulsions. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

27. **A.J. Deering**, R.E. Pruitt, **B.L. Reuhs**. Examination of the internalization of *Escherichia coli* O157:H7 in mung bean, Vigna radiata, following seed contamination. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

28. **L. Bi**, L. Yang, A.K. Bhunia, **Y. Yao**. Emulsion-based system for prolonged efficacy of nisin against Listeria monocytogenes. Institute of Food Technologies Annual Meeting & Food Expo, Chicago, IL.

August

29. **J.N. BeMiller**. Roy L. Whistler, 25th International Carbohydrate Symposium, Tokyo, Japan.

30. **H. Chang**, **X. Wu**, C. Mello, R. Nagarajan, **G. Narsimhan**. Conformation of antimicrobial peptide Cecropin P1 C immobilized on silica surface using molecular dynamics simulation. ACS National Meeting, Boston, MA.

31. **B.R. Hamaker**, G. Zhang, **A.H. Lin**, **B.H. Lee**. Slowly digestible starch and its potential physiologic effect. IUFoST biennial meeting, Cape Town, South Africa.

September

32. **Y. Yao.** Carbohydrate and food nanotechnology. Pepsico International Webcast, Barrington, IL
33. **B.R. Hamaker**. Project areas related to carbohydrates and health. Pepsico International Webcast, Barrington, IL.
34. **B.R. Hamaker**, **P. Rumpagaporn**, **H. Xu**, D. Rose, **L. Yan**, **A.H. Lin**, **B.H. Lee**, **O.H. Campanella**. Cereal bran arabinoxylans – structure, functionality and gut health. Nestle Research Centre, Lausanne, Switzerland.
35. **B.R. Hamaker**. The concept and implications of slow release glycemic carbohydrates. International Life Sciences Institute (ILSI) Carbohydrate Working Group, Washington, D.C.
36. A. Dechelette, **O.H. Campanella**, C. Corvalan, P.E. Sojka. An experimental investigation on the breakup of surfactant-laden shear-thinning jets. ILASS – Europe 2010, 23rd Annual Conference on Liquid Atomization and Spray Systems, Brno, Czech Republic.

October

37. **X. Shen**, G. Zhang, E. J. Bertoft, **B.R. Hamaker**. Amylopectin fine structure: Mechanism of the long chain function. American Association of Cereal Chemists International annual meeting, Savannah, GA.
38. **B. Lee**, **B.R Hamaker**. Different human pancreatic α-amylase digestion property of highly branched starch. American Association of Cereal Chemists International annual meeting, Savannah, GA.
39. **H. Kim**, **J.N. BeMiller**. Effects of hydrocolloids on the pasting and paste properties of commercial pea starch. American Association of Cereal Chemists International annual meeting, Savannah, GA.
40. **Z. Sui**, **J.N. BeMiller**. Effects of the order of addition of reagent and catalyst on modification of starch with rapidly-reacting reagents. American Association of Cereal Chemists International annual meeting, Savannah, GA.
41. **B.K. Patel**, **B.R. Hamaker**, **O.H. Campanella**. Enhancing the functionality of corn fiber gum as an emulsion stabilizing agent by conjugation with whey protein isolate. American Association of Cereal Chemists International annual meeting, Savannah, GA.
42. **M. Cheng**, G. Zhang, K. Kim, **B.R. Hamaker**. Influence of different sugars on the behavior of Caco-2 cells. American Association of Cereal Chemists International annual meeting, Savannah, GA.
43. **P. Rumpagaporn**, **B.R. Hamaker**. Production of arabinoxylooligosaccharides from corn alkali-extractable arabinoxylan. American Association of Cereal Chemists International annual meeting, Savannah, GA.
44. **M.S. Kale**, C. Yang, **O.H. Campanella**, **B.R. Hamaker**. Relationship between solution and gel behavior of arabinoxylans: Effect of structure on properties in aqueous systems. American Association of Cereal Chemists International annual meeting, Savannah, GA.
45. **H. Xu**, **B. Reuhs**, **B.R. Hamaker**. Removal of the 3-O-substituent from 2, 3-disubstituent increases the enzymatic degradability of alkali-extractable arabinoxylans from corn bran. American Association of Cereal Chemists International annual meeting, Savannah, GA.
46. **M. Fevzioglu**, **O.H. Campanella**, **B.R. Hamaker**. Studies on the improvement of the elastic component of corn zein doughs. American Association of Cereal Chemists International annual meeting, Savannah, GA.
47. **A. Lin**, B.L. Nichols, R. Quezada-Calvillo, D.R. Rose, L. Sim, **B.R. Hamaker**. The differential roles of the four mammalian mucosal glucosidase subunits in starch digestion. American Association of Cereal Chemists International annual meeting, Savannah, GA.
48. **N. Bordenave**, M. Ferruzzi, **B.R. Hamaker**. Influence of food matrix on the stability of polyphenols through processing. American Association of Cereal Chemists International annual meeting, Savannah, GA.

49. **S. Janaswamy**. Novel hydrocolloid matrices for protecting bioactive components in food formulations. American Association of Cereal Chemists International annual meeting, Savannah, GA.
50. **O.H. Campanella**. A Soluble nanoscale self-assembling complex from starch, protein and lipid for healthy nutrient delivery. Neutron and Foods Conference, Sidney, Australia.

November

51. **R. Davis**, **A. Deering**, **B.L. Reuhs**, **L.J. Mauer**. Detection, identification, discrimination, and classification of foodborne pathogens using Fourier transform infrared (FT-IR) spectroscopy and chemometrics. USDA Purdue Annual Meeting, Philadelphia, PA.

December

52. **B.R. Hamaker**, **D. Bhopatkar**, **O.H. Campanella**. Novel carrying capacity of self-assembled soluble nanocomplex. USDA-NIFA Nanotechnology Grantees' Conference, Washington, D.C.

E. GRADUATE DEGREES AWARDED

1. **Min-Wen Cheng, Ph.D.,** Digestion and Absorption of Glycemic Mono- and Disaccharides Using the Caco-2 cell Model, May.
2. **Kristin Gill, M.S.,** Characterization of Polymeric Cocrystals, August.
3. **Amanda Deering, Ph.D.,** Examination of the Internalization of Human Pathogenic Bacteria in Plants, December.
4. **Xinyu Shen, Ph.D.,** Amylopectin Fine Structure: Mechanism of the Long Chain Function, December.
5. **Jennifer Cholewinski, M.S.,** Sorghum Endosperm Components Responsible for Promoting Protein Polymerization Through Sulfhydryl-disulfide Interchange, December.

F. RECOGNITIONS, AWARDS, AND HONORS

1. **Bruce Hamaker**, 2010 Foods and Nutrition Hall of Fame Awards, Purdue University.
2. **Lisa Mauer**, 2010 Purdue Agricultural Research Award for her work in water-solid interactions, spectroscopy and shelf life of food for space missions.
3. **Lisa Mauer,** "Faculty Award of Merit" from the Purdue University Chapter of Gamma Sigma Delta recognized for excellence in research.
4. **Lisa Mauer,** Fellow of the Purdue University Teaching Academy 2010.
5. **Ganesan Narsimhan**, 2010 Elected as Fellow of American Institute of Chemical Engineers.
6. **Amanda Deering's** "Examination of the internalization of Escherichia coli O171:H7 in mung bean, Vigna radiata, following seed contamination" received 2nd place at the IFT Microbiology papers completion.
7. **Madhuvanti Kale's** "Effect of alkali treatment conditions on oxidative gelling properties of corn bran arabinoxylans" received First Prize in the Carbohydrate Division at the IFT Carbohydrate paper completion.
8. **Pinthip Rumpagaporn's** "Heat and pH stability of corn alkali-extractable arabinoxylan and its xylanase-hydrolyzate and their viscosity behavior" received Second Prize in the Carbohydrate Division at the IFT Carbohydrate poster completion.
9. **Paulo H. Santos** paper was awarded the "Best Student Paper Award of the International Conference in Chemical Engineering 2010" at the World Congress on Engineering and Computer Science.

G. SPECIAL EVENTS

Whistler Center Short Course, October 5-7, 2010

The Center offered a three-day Short Course October 5-7, 2010. 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.

Tuesday Sessions:

1. Introduction to structures and properties of polysaccharides, J. BeMiller
2. Polysaccharide architecture, R. Chandrasekaran
3. Starch granule structure and properties, J. BeMiller
4. Basic principles in rheology, O. Campanella
5. Chemical modification of polysaccharides, J. BeMiller
6. Enzymatic and physical modification of starch, Y. Yao
7. Sweeteners and polyols, Y. Yao
8. Tour of Whistler Center Laboratories (optional)

Wednesday and Thursday Breakout Sessions:

9. Advances in modification of starch properties, J.N. BeMiller
10. Beverage emulsions, encapsulation, G. Narsimhan and S. Janaswamy
11. Carbohydrate Nutrition 101, B.R. Hamaker
12. Rheology for polysaccharides/macromolecules and function, O. Campanella
13. Genetic modification of plant carbohydrates, Y. Yao and C. Weil
14. Complex carbohydrate structure analysis (non-starch), B. Reuhs and L. Mauer
15. New view on glycemic carbohydrate nutrition, A. Lin and B. Hamaker
16. Physiologic effects of dietary fiber from plastic to viscoelastic, J. McRorie
17. Polysaccharide architecture and functionality including starch, R. Chandrasekaran
18. Dietary fiber/prebiotics and colon function, A. Kaur, P. Rumpagaporn, B.R. Hamaker

BELFORT LECTURE

2010 Belfort Lecturer
Dr. Jan Delcour

Dr. Jan Delcour gave his May 12, 2010 presentation "Basic Insights in Cereal Non-Starch Polysaccharides and Their Conversions as a Basis for Progress in Cereal Based Biotechological Processes" as part of the Belfort Lecture Series. Dr. Delcour is Professor of Food Chemistry and Biochemistry at the Katholieke Universiteit Leuven, Belgium. Dr. Delcour obtained B.Sc. (1977), M.Sc. (1980), and Ph.D. (1985) degrees in Food Science and Technology from the Katholieke Universiteit Leuven where he now is responsible for the Laboratory of Food Chemistry and Biochemistry. Dr. Delcour's research focuses on cereal constituents and the way they affect quality and nutritional profile of cereal-derived products such as bread, malt, beer, and animal feed. Dr. Delcour is co-author of over 325 original peer reviewed international publications, and of more than 20 patent applications and/or patents. He was awarded the Excellence in Teaching and William F. Geddes Memorial Awards as well as the Thomas Burr Osborne Medal of AACC International. He has a track record in the development of novel technologies for the food industry from concept stage till industrial application. Examples include the patented and licensed discovery of xylanase inhibitors, and the development of arabinoxylan oligosaccharide as a novel and wheat derived prebiotic. Jan Delcour is co-founder and Chairman of the Science Advisory Board of FUGEIA (www.fugeia.be) and, with R. Carl Hoseney co-authored the 3rd Edition of the textbook "Principles of Cereal Science and Technology" (AACC International, St. Paul, MN, 2010).