INDUSTRIAL MEMBERS

(Members of 2011 Industrial Advisory Board)

Cargill, Inc.

ConAgra Foods

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Genencor

General Mills

Grain Processing Corporation

Nestlé

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Roquette

Tate and Lyle

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DIRECTOR'S STATEMENT

It is my pleasure to welcome you to our 2011 Whistler Center for Carbohydrate Research Annual Report. We work in the realm of carbohydrates for foods and industrial purposes, and that world is certainly changing. Carbohydrate biopolymers are increasingly being viewed as the basis of new materials with novel properties and applications. Carbohydrates are no longer the bad-boys of health, but instead quality of carbohydrates is beginning to be understood by consumers and health professionals. Dietary fiber, in many minds an entity unto itself, is to scientists a vast array of structures with different potential functions in the body and in foods. At the Whistler Center, we do research in these areas and I encourage you to peruse through this report to find out just what we do, and how we might impact your world through research, training, or service.

In this rather difficult funding environment, we continue to do well with a large staff and high research output. In 2011, we had 74 staff members including faculty, graduate students, post-doctoral scientists, research staff, and a continually increasing number of visiting faculty and scientists. We have moved determinedly into frontier research areas on carbohydrate biomaterials, health-related applications, process optimization, and crop genetics. We are in the process of expanding partnerships with select elite institutions in Asia where we get complementation of skills and ability to solve problems in the carbohydrate arena. Last year, we added two new faculty members to the Whistler Center. Dr. Amy Hui-Mei Lin, Assistant Research Professor, was hired both to enhance our communication with our members and strategic planning, and to expand our research effort in glycemic carbohydrates. Dr. Owen Jones, Assistant Professor, is a new faculty in the Department of Food Science and in the Center with a background in food physical chemistry and focus on biopolymer interactions for new materials and textures.

In 2011, we saw two Whistler Center faculty members promoted, Lisa Mauer to Full Professor and Yuan Yao to Associate Professor. At our annual May Whistler Center Board meeting, we had 38 posters presented from our students and other scientists. Our renowned Belfort Lecture was given the following day by Dr. Geoff Fincher, Professor of Plant Science from University of Adelaide, Australia on "Fine structure of polysaccharides from plant cell walls: from human health to biofuel production", a timely topic for many in the Center. We gave our popular Whistler Center Short Course to member company participants on October 10-12 (outline shown on page 64). Additionally, we organized symposia at major international scientific meetings held in the US.

Our activities for 2012 include hosting the 11^{th} International Hydrocolloids Conference on May 14-18 at Purdue University. The conference titled "Biofunctionality and Technofunctionality of Hydrocolloids" will bring together leading international experts in the hydrocolloid field to present and discuss their new research findings. Along with our partner, Elsevier Publishing, and as part of the International Carbohydrates Consortium we are proud to host this important event. In June with IFT, the Whistler Center will sponsor a short course "Designing carbohydrate supramolecular structures for food" at the IFT annual meeting in Las Vegas.

Please read our 2011 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 and his post-doc (Dr. Sui) continued studies of the impacts of the order of addition of rapidly reacting reagents and catalyst, i.e., alkali, (using corn and wheat starches) and the removing of granule surface protein (using wheat starches) in making crosslinked and stabilized products (Projects 1-3). Results showed that there were differences in the products in both cases, i.e., changing the order of addition of reagent and catalyst and removal of granule surface protein, and that the differences depended on the type of starch and the reagent used for modification.

Dr. Hamaker's group continues to work on starch fine structure and function, though most of this is in the Carbohydrates and Health area reported below. With collaborators at DCBP in Mexico, further studies were done relating starch fine structure, in this case of mango and green banana (or plantain) starches, to digestion properties. A clear relationship between proportion of long chains in amylopectin and higher slowly digestible (SDS) and resistant starch (RS) exists with some differences noted for these fruit starches. Banana starch, in particular, when cooked formed distinct aggregates that included high amount of retrograded starch with comparably high SDS and RS contents.

Our previously found nanoparticle made from soluble amylose, protein, and fatty acid was shown to solubilize sparingly small molecules such as flavors, aromas, and a chemotherapeutic drug, 5-fluorouracil (Project 8).

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 34). In addition, his work also includes studying molecular structure of phytoglycogen, and structure-genotype relationships of starch (Projects 33 and 35).

Carbohydrates and Health:

Dr. Hamaker's research mainly focuses on the area of carbohydrates and health with projects on control of rate of digestion of glycemic carbohydrate and potential beneficial physiologic effects, and dietary fiber poly- and oligosaccharides for targeted function in the colon.

In our work on glycemic carbohydrates, much of our attention has been on the mucosal a-glucosidases and control of their glucose generation, and physiologic effects of delivery of glucose to the more distal region of the small intestine. Projects 11 and 12 describe new strategies to control digestion of glycemic carbohydrates and its consequent effect on gastric emptying and sustained energy delivery to the body. We work with collaborators named in the Project Summaries section in fields of medicine, molecular biology, enzymes, and appetite physiology.

Investigations on dietary fiber and colon health have shown an unexpected specificity of fiber structure promoting bacterial growth and fiber structural features that indicate rate of fermentation for a desired low bloating and extended fermentation effect. Changing accessibility of starch to the colon microbiota was found to alter microbial phyla and promote butyrate production. Summaries are found in Project 10.

Dr. Lin is part of the Starch Digestion Consortium (SDC), which includes Buford Nichols of USDA/ARS Children's Nutrition Research Center at Baylor College of Medicine, Roberto Quezada-Calvillo, University of San Luis Potosi (Mexico), David Rose, University of Waterloo (Canada), Mario Pinto, Simon Fraser University (Canada), Hassan Naim, University of Hannover (Germany), and Bruce Hamaker. Dr. Lin continues her work on glycemic carbohydrate that has led to a new concept that starch source influences dietary glucose generation at the small intestinal mucosal alpha-glucosidase level. Recently Dr. Lin successfully developed the method to quantify residual starch in the mouse small intestine that expanded an *in vivo* study using a MGAM-knock-out mouse model, and increased knowledge on the digestion roles of individual alpha-glucosidase subunits from an *in vivo* perspective. Amy continues working on the characterization of slowly digestible dextrins (or hard-to-digest dextrins) that are resistant to both alpha-amylase and alpha-glucosidase digestion. With a Visiting Faculty, Dr. Junrong Hwang, research is being pursued on how starch molecular branching patterns drive different rates of digestion at the mucosal brush border. With collaborator A. Opekun at Baylor College of Medicine, Dr. Lin is producing ^{13}C-enriched designer carbohydrates for clinical study. The aims are 1) to test the hypothesis that dietary management, using slowly digestible starch, can relieve symptoms of congenital sucrase-isomaltase deficiency (CSID), 2) test the digestion role of sucrose-isomaltase (SI) in a mutant SI-deficient shrew model and CSID patients. Dr. Lin's future work will include developing ^{13}C enriched designing carbohydrate for testing fermentability in the colon.

Polysaccharide Structures:

Dr. Janaswamy's research demonstrates the potential use of polysaccharide fibers in developing novel and cost-effective delivery vehicles. Their study on iota-carrageenan fibers reveals that crystalline polysaccharide fibers can embed nutraceuticals (Project 15) leading to polymeric cocrystals. X-ray diffraction patterns portray packing differences among the complexes. More importantly the polysaccharide matrix thermally protects the embedded molecules at elevated temperatures. In another study, they showed that gelation is achievable in lambda-carrageenan, a viscosifying agent of carrageenan family of polysaccharides, solutions by using trivalent iron ions (Project 16). Their systematic studies about the effect of co-solutes on structure-function relationships of polysaccharides revealed that in the presence of salt, rebiana (high intense sweetener, stevia) and sucrose participate in the junction zone organization of iota- and kappa-carrageenans (Projects 17 and 18). They also demonstrated the promotion of synergistic interactions among polysaccharide chains in the presence of the hydrogen bond breaker urea (Project 19). In an effort to understand the polysaccharides structural transformations during cations, co-solutes and small molecules interactions, their time-resolved x-ray diffraction studies on iota-carrageenan (Project 20) showed that this biopolymer adopts at least two stable structures with different rate constants during cation exchange from sodium to calcium ions. These results coupled with solution behaviors provide novel insights about the molecular Interactions, dynamics and functionality of polysaccharides that contribute to the development of value-added functional foods.

Dr. Jones's research follows the impact of polysaccharides on biopolymer structural development, particularly among food protein systems. Polysaccharides contribute to structural formation in biopolymer systems through electrostatic, hydrogen-bonding, and dispersion forces that can be carefully manipulated by environmental conditions. Structural development involves study of physical phenomena at a fundamental level through spectroscopic techniques and calorimetry, while the formation of sub-micrometer structures is gauged through light scattering and atomic force microscopy techniques. Ultimately, the aim of this research is to understand both fundamental physical interactions and improved methods for the formation of food-compatible structures among value-added purposes, such as encapsulation or texture development (Projects 21 and 22).

Rheology:

Dr. Campanella's research focuses on the understanding how physicochemical properties, including mechanical and thermophysical properties, of foods and pharmaceuticals influence quality and the processability of these materials. Given the complexity in their compositions 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 attention and are being investigated by Dr Campanella. Projects involving rheological characterization of foods and pharmaceuticals, and physical chemical properties associated to the formation of structures are being conducted, e.g. during gelling, formation of nanostructures during self-assembling of biomolecules, incorporation of fibers into foods as well as the role of these properties on material processability. Changes in protein structures by processing conditions such as temperature, or the addition of other macromolecules such as proteins are being studied using rheological and spectroscopic techniques such as FTIR. The impact of this research is on the area of new materials and improved foods from a nutritional and textural standpoint. Development of new materials and understanding the physicochemical behavior of existing ones require a scientific foundation that involves modeling and experimental verification. Work in this area also focuses on the functional efficacy of polymers used as part of the food ingredients.

Glass transition is a phenomenon of significance in the area of food science and technology to understand how external conditions and composition affect physical properties of materials during processing and storage. 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 14). 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. Model systems are being used to understand mechanisms of viscoelasticity enhancement of other non-gluten cereal-based systems. This functional change is believed to be the result of developing fibrous, β-sheet-rich protein networks; however, current understanding of the physicochemical properties of these viscoelastic polymers is limited. This research aims to present a mechanistic framework for approaching this system by highlighting structure/function relationships in wheat gluten, zein's aggregative behavior, efforts to improve zein-starch dough functionality, and potential areas of interest moving forward.

Novel physicochemical and rheological methods have been developed to monitor the formation and stability of nanocomplex formed by the interaction of starch, protein and fatty acids (Project 8). A thermodynamic analysis performed on data obtained with Differential Scanning Calorimetry (DSC) demonstrated that the formation of the three-component nanoparticle is a thermodynamically feasible process leading to a thermodynamically stable system unlike nanoemulsions which are unstable systems. These results were supported by microscopy studies that clearly showed the presence of nanostructures with a regular rod shapes. Effect of salts (Hofmeister series) on the complex formation and molecular conformation was studied using DSC and rheology.

Rheological characterization of gels and molecular modeling were used to study the viscoelastic properties of gel systems. Experimental validation of qualitative trends obtained from molecular modeling was performed. Results showed that the flexibility of the polymeric chains forming the gel system plays an important role on its resulting viscoelastic properties and have a close relationship with its functionality (Project 4).

Project 5 is aimed to physically modify (e.g. through high shear conditions) the molecular structure of hydrocolloids to improve their functionality. Studies focused on xanthan gum, which was characterized rheologically and physicochemically after application of high shear processes at two different pressures (69 MPa and 276 MPa). Both treated groups and a control (untreated xanthan gum solution) were stored at two different temperatures (4°C and 25°C) for 11 weeks. Results showed that samples had a decreased viscosity and elasticity upon the treatment compared to the control untreated sample. Decrease in viscosity and viscoelasticity was attributed to the increased maximum packing of the system by the wider distribution of molecular weights and sizes of the treated samples, which were evaluated by size exclusion chromatography and multi-angle laser scattering. Results also showed that not only the viscoelastic behavior of the solutions was changed by the treatment, but also an increased sensitivity of viscoelasticity with temperature was observed. This indicated the loss of structured network with the shear treatment. In addition to rheology, circular dichroism spectra of treated samples supported the less structured and more disordered network upon high pressure homogenization. Measurements of viscosity and viscoelasticity over the time stored showed that the rheological characteristics of the treated xanthan gum and control did not vary through the storage time, at both storage temperatures, which would indicate that the modifications in the structure of the xanthan gum molecules were irreversible and not purely intermolecular.

Arabinoxylans (AXs) obtained from cereal brans have a large potential for the production of healthy foods and pharmaceuticals. They are obtained by treatment cereal brans with alkali. One of the objectives in line with the overall objective of the project was to determine the effect of alkali treatment conditions on oxidative gelling of corn bran AXs. AXs extracted through mild alkali treatment formed strong gels through ferulic acid (FA) crosslinking. Increasing harshness of alkali treatment caused a decrease in average FA content of AXs and elasticity of gels formed with them. It was found that the average FA content in the sample is not a good indicator of gelling capacity. It was hypothesized that this could be due to the presence of molecules with different FA contents within a sample. Molecules rich in FA can form crosslinks and participate in the network, while those with low FA contents cannot. Different alkali treatment results in preparations with some molecules richer in FA than others. The former can form crosslinks and participate in the gel network. A gel is formed only if there is a sufficiently large proportion of participating molecules in the network. This concept of participating molecules is proven by establishing the presence of crosslinks in non-gelling samples through chromatographic and rheological measurements through the Cox-Merz rule. It may be useful in designing gels with different strength, texture and colonic fermentation properties (Project 9).

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 23-25).

Chemical Structures and Functions of Polysaccharides:

Drs. Reuhs and Hamaker have studied complex structures of arabinoxylans as they relate to colon fermentation properties (described above), but also in relation to the heterogeneity of the internal structure of the polysaccharide. In corn bran arabinoxylan, they have for the first time found a repeating unit structure with varying density and complexity of branches off the xylan backbone. Such repeating structures are likely found in all arabinoxylans and may help to describe their functionality in creating viscous solutions or gels, and specificity toward colonic bacteria.

Genetics:

Dr. Weil's lab has continued to characterize mutant lines of corn that show altered starch digestion (Project 28) and, working with Dr. Mauer, altered 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 are also mapping genes for variation in starch digestibility of both cooked and uncooked flour in diverse maize inbreds. One inbred is notable for the slower digestion of its cooked flour and they are beginning to identify the genes responsible using recombinant inbred lines.

They have developed a reliable, automated, scaled-down and high throughput protocol for these digestion assays. Working with Dr. Yao they have begun to examine starch structure in the endosperm of these lines. 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 (Project 32).

Another project in the lab examines how plants partition the carbon they fix during photosynthesis into different forms and different locations within the plant (Project 31). In corn, this is typically as starch in the kernels of the ear, but in close relatives of corn, the carbon can be stored as high levels of sugar in the stalk. Both from a biofuel and from a food ingredient standpoint, it would be useful to develop varieties that grow to large biomass and that accumulate sugar in the stalk, similar to what is observed for sugarcane or sweet sorghums. Several tropical varieties of maize already show significantly higher stalk sugar (as high as 20%) than is typical for corn and we are pursuing breeding strategies to better understand the genes responsible and their control of this process. Using association mapping in recombinant inbred and doubled haploid lines; they are now focused on identifying genes that impact sugar accumulation. In addition, they are pursuing a reverse genetic strategy to knock out specific invertase enzymes to increase stalk sugar. Finally, they are working with cell biologist Dan Szymanski to characterize the timing and location of sugar accumulation, learning how to better optimize sugar yield.

In addition, the regulation of how carbohydrates are partitioned into seed, sugar or biomass is under genetic control, but is poorly understood. Together with colleagues at the University of Missouri, the University of Florida, and St. Michael's College, a NSF-funded project is characterizing the contents, functions and genetic networks that characterize phloem function, carbon partitioning and yield. In the past year the Weil lab has identified nearly 100 new mutants that impact carbon partitioning in maize. Mapping populations have already been made for 37 of these mutants and will be completed for the remainder this summer.

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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

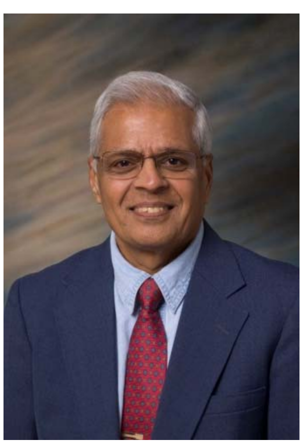
Osvaldo H. Campanella

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 and functionality

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

Owen Jones

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

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

Amy Lin

GENERAL RESEARCH AREAS
- Starch structure
- Carbohydrates and health
- Polysaccharides and functionality

SPECIFIC RESEARCH AREAS
- Starch granule structure
- Enzymatic modifications of starch
- Starch digestion

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
- 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

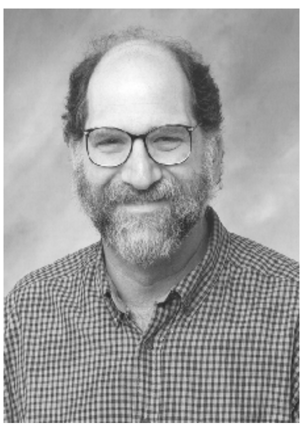
Bradley L. Reuhs

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



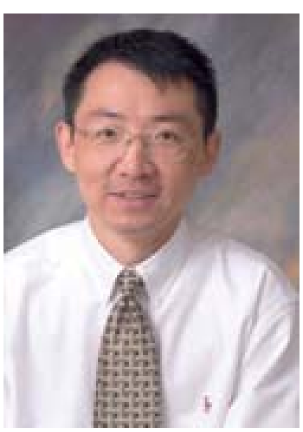
Clifford F. Weil

GENERAL RESEARCH AREAS

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

SPECIFIC RESEARCH AREAS

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



Yuan Yao

GENERAL RESEARCH AREAS

- 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

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

GENERAL RESEARCH AREAS

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

SPECIFIC RESEARCH AREAS

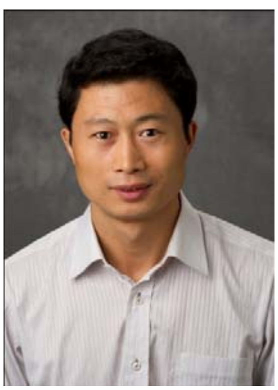
- Adsorption of polymers on colloids, vesicles, and emulsions
- Polyelectrolytes and surfactant interactions and functional properties of coacervates
- Surface modification and characterization
- Design, modification and application of starches in consumer products

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

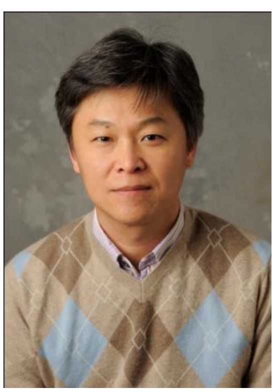
Sakharam K. Patil, Ph.D. is President of S.K. Patil and Associates. Dr. Patil was awarded a Ph.D. degree in Cereal Science by Kansas State University in 1973. He held several positions at American Maize Products Co., later Cerestar, from 1978 until his retirement in 2002. The positions included VP Marketing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

Jinling Fan is an Associate Professor of Food and Bioengineering College, Henan University of Science and Technology, China. She received her Ph.D. of Food Science from Jiangnan University, China. Her research is on phytochemical chemistry with a focus on food pigments and flavonoids. She joined Dr. Yao's lab in July 2010 as a visiting faculty with her research project focuses on development of strategies for incorporation and stabilization of flavonoids with carbohydrates.

Junrong Huang is an Associate Professor at the Department of Food Science and Engineering, Shaanxi University of Science and Technology, Shaanxi Province, China. She received a Ph.D. degree from Wageningen University, The Netherlands and her other degrees at Jiangnan University, Wuxi, China. Dr. Huang was co-advised by Dr. Z. Jin at Jiangnan University, Dr. A.G.J. Voragen, and Dr. H.A. Schols at Wageningen University studying the properties and molecule structure of modified starches. Her current research focuses on enzymatic hydrolysis patterns on starch granules, starch granule organization, and textural properties influenced by starch fine structure. She was awarded a governmental scholarship by the China Scholarship Council to pursue her study in the USA for a year. Dr. Junrong Huang joined Dr. Hamaker's group for her sabbatical year (Aug 2011-Aug 2012).

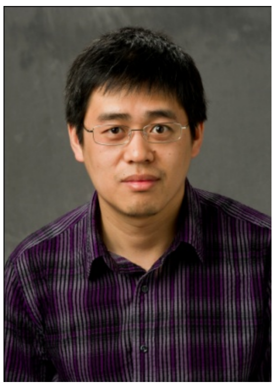


Liqiang Wang is an Associate Professor in the Department of Packaging Engineering at Jiangnan University, Wuxi, China. He received his Ph.D. degree in Agricultural Mechanization Engineering from Shenyang Agricultural University, Liaoning Province, China. He joined Dr. Campanella's group as a visiting faculty from August 2011 to August 2012. His research focuses on the performance of edible materials for food packaging. The aim of his project is to understand how viscoelastic properties of polysaccharides affect physical and mechanical characteristics, barrier and heat sealing properties, and packing performance of polysaccharide-based edible packaging films.

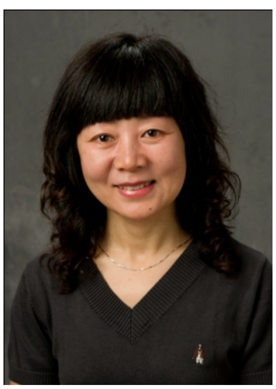


Sang-Ho Yoo is an Associate Professor, Department of Food Science and Technology and Director of the Carbohydrate Bioproduct Research Center (CBRC) at Sejong University, Seoul Korea. He obtained his M.S. from Prof. Kwon Hwa Park's group at Seoul National University and Ph.D. under Prof. Jay-Lin Jane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

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 faculty he joined Dr. Campanella's lab in August 2010. His research field is focused on the mechanical behavior of viscoelastic materials and food processes simulation. Dr. Yu returned to China in August 2011.



Ligang Zhang is an Associate Professor and Associate Director of Food Science Department, Food College, Northeast Agricultural University, China. He received his M.S. Degree in Animal Nutrition and Feed Science and his Ph.D. of Dairy Science, Northeast Agricultural University, China. His research is on bioactive components extraction and function, mainly focusing on milk-borne growth factors, insulin-like growth factor I and transforming growth factor beta II. He joined Dr. Hamaker and Dr. Campanella's group as a visiting faculty. His research is focused on the properties of arabinoxylans of different molecular characteristics and how they affect the functionality in terms of viscosity and gelling properties.



Yuhong Zhao received her M.S. and Ph.D. degrees in Food Science, from Northeast Agricultural University, Harbin, China. She is an Associate Professor of Food Science and Engineering Department at Northeast Forestry University, mainly focusing on extraction, separation, analysis and application of bioactive components of forestry products such as blueberry, pine nut and antler. She has joined Dr. Mauer's group as a visiting faculty. Her research project is on the effect of solid state formulation strategic on stability of curcumin.

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.

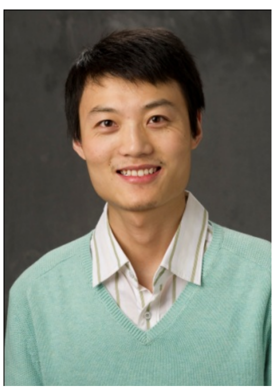
Sung Jun Ma is a manager of the Food Starch and Sweetener Laboratory at the R&D Center, Daesang Corporation, South Korea. He received his M.S. degree in Chemical Engineering from Hanyang University. In 2005, he joined Daesang Corporation. He is in charge of development of functional oligosaccharides and high value by-products. He joined Dr. Hamaker's group in May 2011 and his research project focuses on effective development of soluble dietary fiber from corn bran.

Sukanya Maicaurkaew is a Ph.D. student from Department of Food Technology, Suranaree University of Technology, Nakhon Ratchasima, Thailand. She has a M.S. degree in food technology from Prince of Songkla University, Songkla, Thailand and has lectured at Suratthani Rajabhat University, Suratthani, Thailand. Sukanya's Ph.D. research project focuses on pre- and postharvest changes of inulin in the Jerusalem artichoke. She joined Dr. Hamaker's lab in August 2011 for six months as a visiting scholar.

Ilkem Demirkesen Mert is a final year Ph.D. student at the Department of Food Engineering, Middle East Technical University, Turkey. She was awarded a governmental scholarship by The Council of Higher Education to continue her research work in the USA. She joined Dr. Campanella and Hamaker's group as a visiting scholar in September 2011 with her research project focused on optimization of gluten-free bread formulations to be baked in infrared-microwave combination oven. Ilkem will also work on the development of methodologies to use nanoparticles to bind and mask bitter flavors in beverages such as coffee.

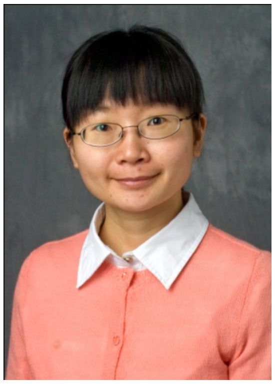
Julian De La Rosa Millan received his B.S. in Biochemical Engineering from the Technologic Institute of Acapulco and his M.S. degree from Development Center of Biotic Products (DCBP), Mexico. He joined Dr. Jay-Lin Jane's group at Iowa State University as a visiting scholar during his M.S. program for 5 months. In 2009, he started his Ph.D. in DCBP. His current research is primarily focused on enzymatic hydrolysis patterns on starch granules, starch granule organization and fine structure, and textural properties of thermal treated plantain starches. He joined Dr. Hamaker's group in March as a visiting scholar.

Rándol J Rodríguez was an undergraduate student in the Food Science Department of Zamorano University, Honduras. His graduation project was on the quality control of a 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 worked under Dr. Yao on the structural analysis of starch, specifically, the chain length distribution of starch, and has recently joined his group as a M.S. student.



Yiming Wang received his B.S. in 2008 from the Department of Bioengineering, College of Food Science and Engineering, Harbin Commercial University, China. He was a visiting student in Dr. Yao's lab studying the structure of starch.

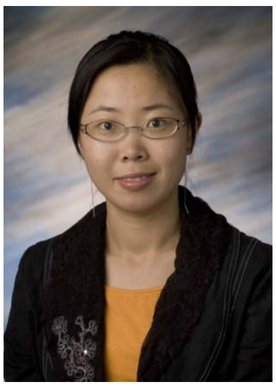
Lei Yang received his M.S. in 2006 from Tianjin University of Science & Technology (formerly Tianjin College of Light Industry), China. He was a visiting student in Dr. Yao's lab until July studying the modification of carbohydrate nanoparticles, as well as their applications for prolonged release of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



Ying Yang is a Ph.D. student at School of Food Science and Technology, Jiangnan University, China. She was awarded a governmental scholarship by the China Scholarship Council (CSC) to continue her research work in the USA for one year. Ying joined Dr. Hamaker and Dr. Campanella's group as a visiting scholar in August 2010, with her research project focused on polysaccharide-based delivery systems for conjugated linoleic acid. Yin also worked on the gelation of sodium alginate molecules developing an innovative gelation method based on the rapid concentration of diluted solutions of alginate and calcium. The novel method provides a potential for encapsulation of novel compounds. Ying returned to Jiangnan University in August.

Lu Zhou received her B.S. degree in Science from China Agricultural University 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.

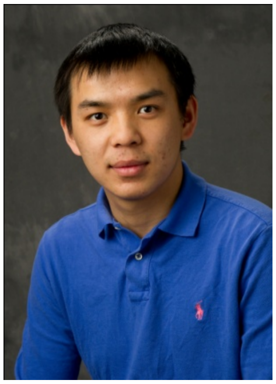
Deepak Bhopatkar obtained his B.S. in Agriculture Science from Jawaharlal Nehru Agriculture University, India and an M.S. in Food and Bioprocess Technology at the Asian Institute of Technology, Thailand. His master research was on application of the biopolymer chitosan for controlled drug delivery. He 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.



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 focused on the construction of carbohydrate dendrimers and nano-carriers and controlled release of active compounds. Lin graduated in December.

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".

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 a 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 anti-microbial peptides on a silica surface using molecular dynamics simulation.

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.

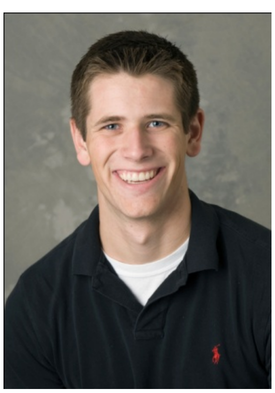
Tingting Chen received her B.S. and M.S. degree in Food Science and Technology from Nanchang University. Her M.S. study was about immunoassay development for small-molecular food contaminants. She joined the Dr. Hamaker's group and started her Ph.D. in August 2011 with a governmental scholarship from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

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 has focused on the relationship between African traditional starchy foods and gastric emptying, satiety and energy delivery.

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

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. Matt left Whistler Center in February and is working for Dow Chemical.

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.



Daniel Erickson earned his B.S. in Chemical Engineering from Iowa State University in May 2010. He arrived at Purdue University in August 2010 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. Daniel by-passed his M.S. degree in 2011 and is currently a Ph.D. student.

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.

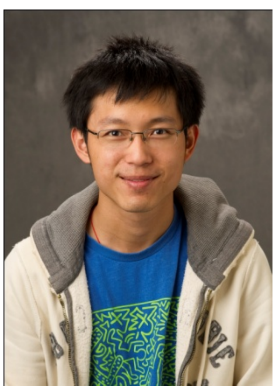
Morgan Goodall received her B.S. in Food Science from Purdue University in 2010. She joined Dr. Hamaker's lab as an undergraduate working on understanding the use of a high digestibility/high-lysine sorghum mutant in bread formulations. Her M.S. studies focus on the protein structural and functional effects of incorporating high percentages of this sorghum mutant cultivar into wheat bread with potential application in sorghum-growing regions of Africa.

Stacey Hirt received a B.S. in Food Science from Purdue University in 2011. She is continuing her M.S. research with Dr. Jones. Her research focuses on stability of beta-lactoglobulin and pectin systems to the Hofmeister series of salts.

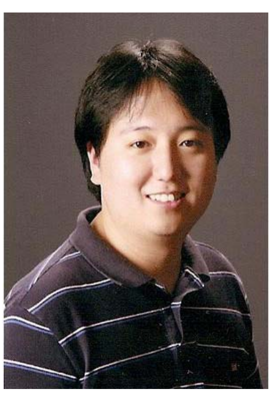
Madhuvanti Kale received her B.S. degree in Food Engineering and Technology from the Institute of Chemical Technology, University of Mumbai (formerly known as UDCT) in May 2008. She joined Dr. Hamaker's lab in August 2008 for a Master's degree which she later by-passed to a Ph.D. program, and is under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

Amandeep Kaur is a veterinary graduate who obtained her Bachelor's degree from Punjab Agricultural University, India. She worked on verotoxigenic *Escherichia coli* during her Master's 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.

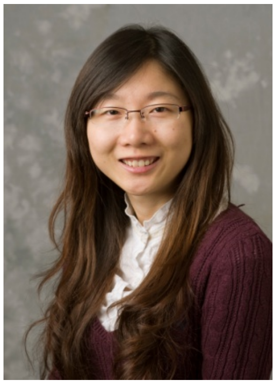
Lisa Lamothe is originally from La Ceiba in Honduras. In 2006, she received her B.S. degree in Food Science & Technology from Zamorano University where her research focused on the prevention of lactose crystallization in two formulations for milk jam varying in total solids content. Lisa received her M.S. degree in 2009 with Dr. Hamaker where she worked on the development of a screening method using NIR spectroscopy for the selection of breeder-improved popcorn lines. After graduating she worked as a Quality Control Supervisor for one of Cargill Meats Central America's meat processing facilities in Honduras. After one year at this position, she decided to return and is currently working towards her Ph.D. degree studying the modification of dietary fiber solubility and fermentability characteristics of alternative grain sources.



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



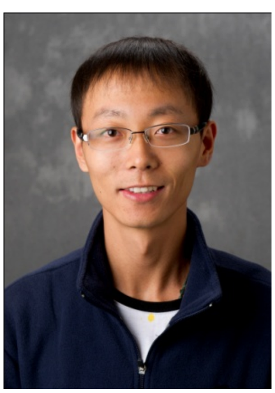
Byung-Hoo Lee received his B.S. and M.S. in Food Science and Technology from Sejong University in Korea. His M.S research was characterization of carbohydrate-active enzymes and application to various corn starches. In August 2008, he joined Dr. Hamaker's group. His Ph. D. research has focused on structural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



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.

Rebecca Lipasek graduated from Purdue University in 2008 with a B.S. in food science and 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. Rebecca then returned to Purdue to pursue her M.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.

Krystin Marrs received a BSA in food science and a BSAB in applied biotechnology from the University of Georgia in May 2010. She arrived at Purdue University in August 2011 in pursuit of an M.S. degree in Food Science under Dr. Lisa Mauer. Her research focuses on the physical and chemical stability of amorphous and crystalline powders.



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

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 his program in Food Science in 2009. Mirwais has graduated in May and returned to Afghanistan where he lives in Herat and works with a NGO.

Pinthip Rumpagaporn earned her B.S. and M.S. degrees from the Department of Food Science and Technology, Kasetsart University, Bangkok, Thailand and was a Ph.D. student with Dr. Hamaker. 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. She graduated in May and returned to Bangkok as a faculty member of Kasetsart University.

Cordelia Running earned her bachelor's degree in Chemistry from Indiana University in Bloomington. She joined Dr. Janaswamy's lab in 2010 for her M.S. studies. Her research focused on structural analysis of psyllium and carrageenans as well as how the addition of salts and sweeteners may affect their functional behavior. She graduated in December and has continued her Ph.D. studies with Dr. Mattes in the Department of Nutrition Science.

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 involved the mechanical characterization and molecular simulation of colloidal systems. Paulo has graduated and is now working at Corn Products International in Bridgewater, NJ.

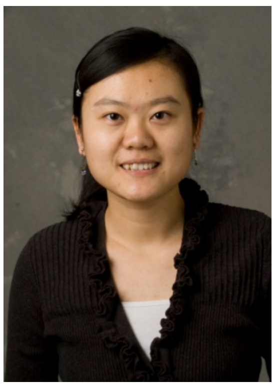
Preetam Sarkar received his M.S. in 2010 from California State University-Fresno. He joined Dr. Yao's lab in 2010 as a Ph.D. student. His thesis focuses on the interaction between bioactive compounds (such as antimicrobial peptides) and carbohydrate nanoparticles in emulsion and non-emulsion systems.

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 inhibition of human intestinal glucosidases for control of glycemic carbohydrate digestion.

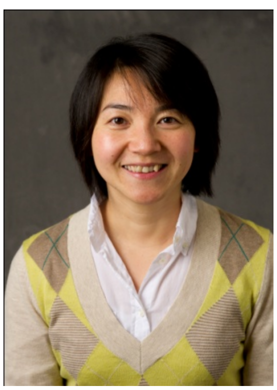
Stephany Tandazo graduated from Texas A&M University in May 2010 with a B.S. in Chemical Engineering and a minor in chemistry. Stephany is working with Drs. Campanella and Hamaker. She joined the group in August 2010 to pursue her M.S. in Agricultural and Biological Engineering. Her research focuses on corn zein protein functionality in doughs.

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.

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 pursued her M.S. degree under the guidance of Dr. Reuhs, and her research focused on fiber structure and tomato viscosity. Bicheng completed her M.S. Degree in August. Her thesis was titled "Tomato Product Viscosity".



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. She also works under the advisement of Dr. Reuhs and in collaboration with Dr. Eric Martens at the University of Michigan Medical School.



Like Yan graduated from Shanghai University of Science and Technology with a B.S. in Food Science and Technology 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.

Laura Zimmerer received a B.S. degree in Food Science and Technology and a minor in Chemistry from Texas A&M University in 2011. Laura came to Purdue in 2011 as a M.S. student with the Purdue Industry Fellows Program. She is working with Dr. Jones on the encapsulation of flavor oils utilizing beta-lactoglobulin and pectin systems.

Ph.D. Post-Doctoral Research Associates

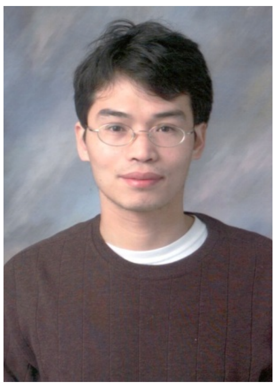
Reeta Davis obtained her B.S. in Food Science and Quality Control in 1999, and M.S. in Microbiology in 2003, from Mahatma Gandhi University, Kerala, India. She has also completed Ph.D. in Food analysis and Quality assurance from the Defense Food Research Laboratory (DFRL), Mysore, India. Her Ph.D. program 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. Reeta left Whistler Center in June for a postdoctoral associate position at University College, Dublin, Ireland.

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 and 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.

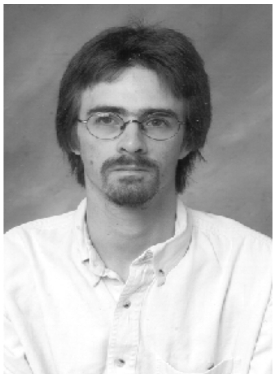
Bhavesh Patel received a B.S. degree in Dairy Technology from Gujarat Agricultural University, Anand, India and a M.S. degree in Food Technology from Central Food Technological Research Institute (CFTRI), Mysore, India. His Ph.D. in Food Science was from Pennsylvania State University where his research 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 has most recently worked on fiber rheology and incorporation into processed foods.

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 focused primarily on the effects of different degrees of channelization on product characteristics of modified food starches made from corn starch. She completed four years of post-doctoral studies at the end of 2011.

Tobias Wojciechowski received a Ph.D. from the University of Reading/Scottish Crop Research Institute (SCRI), UK in July 2010. Tobias began at Purdue University in July 2011 working with Dr. Clifford Weil on carbohydrate partitioning in maize focusing on gene discovery and sink tissues.



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 earn a Ph.D. degree and working on determining the properties of selected proteins on different interfaces. Xiaoyu continues at Whistler Center as a Post-Doctoral Research Associate.



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.

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Project Summaries Table of Contents

1. Impact of the Order of Addition of Reagent and Catalyst in Starch Modification: Wheat Starch

P.I.: J.N. BeMiller

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: USDA-AFRI

Objective: To investigate the impact of allowing rapidly reacting reagents to infiltrate the matrix of wheat starch granules prior to initiation of reaction by adjustment of pH, in contrast to adjusting the pH before adding the reagent as is normally done.

Progress: Examined were reactions of commercial (C) and laboratory-isolated (LI) normal wheat starch (NWS) and laboratory-isolated waxy wheat starch (LI-WWS). The 3 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. Two different derivatization methods were used: 1) the starches were reacted with the reagents in the conventional way, i.e., using standard derivatization reaction procedures (SDR method), and 2) the reagents were given the opportunity to impregnate granules for 3 h prior to adjusting the pH to the required value so that reactions with the rapidly reacting reagents might be more uniform throughout the granules (IRF method = infusion of reagent first method). The products were characterized by RVA and DSC analysis. To compare results from products made by the 2 methods, the values for the products made by the IRF method were divided by the values for the products made by the SDR method.

Crosslinking: Preliminary analysis of the RVA data for the reactions with the 3 crosslinking reagents gave the following indications. The IRF method did not appear to produce products with improved properties in the case of reactions with AAMA and STMP, although the properties were somewhat different. In fact, it was indicated that granules reacted by the IRF method were more lightly crosslinked and remained swollen throughout the RVA analysis, but less swollen than those reacted by the SDR method. The properties of the products of the $POCl_3$ reaction appeared to be the same regardless of which method was used, suggesting that the reagent reacts with granule surfaces whether or not alkali is present. One of us (JNB) has proposed that, in some cases, when it appears that granules are less crosslinked, the reason may be that they were more swollen at the time of crosslinking. The results for LI-WWS reacted with $POCl_3$ could be interpreted that way, since the IRF/SDR values for peak and final viscosities were 0.81 and 0.66, respectively, but other results do not appear to provide evidence either way.

Stabilization: At least with SA and AA, products with different and perhaps more useful properties were made using the IRF method as compared to the SDR method. SA had the greatest effect on peak viscosity, breakdown, and setback IRF/SDR values, with the IRF method giving smaller RVA values, probably because of the ionic natures of the products.

Status: Active. Data still being analyzed. Manuscript in preparation.

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

P.I.: J.N. BeMiller

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: USDA-AFRI

Objective: To investigate the impact of allowing rapidly reacting reagents to infiltrate the matrix of corn starch granules prior to initiation of reaction by adjustment of pH, in contrast to adjusting the pH before adding the reagent as is normally done.

Progress: Laboratory-isolated (LI) and commercial (C) normal (NMS) and waxy (WMS) maize starches were each reacted with the same 3 crosslinking reagents and the same 3 stabilization reagents in the same ways described in Project 1, and the products were characterized and the data analyzed as described in Project 1. DS results indicated much less reaction efficiency for the infusion-with-reagent first (IRF) method as compared to the standard (SDR) method for reactions of the 4 starches with acetic-adipic mixed anhydride, acetic anhydride, and succinic anhydride, less reaction efficiency for reaction with succinic anhydride, about the same reaction efficiency for reactions with octenylsuccinic anhydride and STMP (WMS only), and greater reaction efficiency for reaction with $POCl_3$. However, RVA properties of the products indicated that there was a greater degree of crosslinking after reaction of the four starches with AAMA and little difference for products of reaction with $POCl_3$ (LI- and C-NMS) and STMP (all 4 starches) for products made by the IRF method. RVA properties of the products of reaction with the stabilizing reagents indicated a greater degree of substitution for SA and AA and a lesser difference in the product of reaction with OSA for products made by the IRF method (as opposed to the SDR method).

Status: Active. Manuscript in preparation.

3. Impact of Surface Protein Removal on Modification of Wheat Starch With Rapidly-reacting Reagents

P.I.: J.N. BeMiller

Researcher: Zhongquan Sui, Ph.D. Research Associate

Sponsor: USDA-AFRI

Objective: To investigate the impact of removing granule surface protein on wheat starch modification with rapidly reacting reagents that are believed to react at granule surfaces.

Progress: Examined were reactions of commercial (C) and laboratory-isolated (LI) normal wheat starch (NWS) and laboratory-isolated waxy wheat starch (LI-WWS) both before and after enzymic removal of granule-surface protein. The 6 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 anhydraide [OSA]), all of which are believed to be quite reactive. The products were characterized by RVA and DSC analysis. To compare results, the values for products of the protease-treated (PT) starches were divided by the values for the products made with granule surface protein intact.

Crosslinking: Preliminary analysis of the RVA data gave the following indications. Removal of protein made no difference in final viscosity for LI-WWS when either of the 3 crosslinking reagents were used. It made slightly more difference in RVA properties of the two NWS starches when they were crosslinked with AAMA or $POCl_3$, not necessarily for the same reason. Removal of surface protein increased peak and final viscosities of the two NWS starches, indicating either a greater degree of granule strengthening when granules were reacted after surface protein removal or a greater degree of granule swelling at the time of crosslinking because of protein removal.

Stabilization: The products of reaction with the stabilizing reagents differed little in their final viscosity values whether the reaction was done before or after protein removal. No difference in final viscosity was evident for PT-C-NWS as compared to C-NWS. For PT-LI-NWS and PT-LI-WWS, the greatest difference was given by SA (but only 1.05x and 1.2x, respectively) and AA (0.84x and 0.81x, respectively).

Status: Active. Data still being analyzed. Manuscript in preparation.

4. Experimental and Modeling of the Gelation Phenomenon

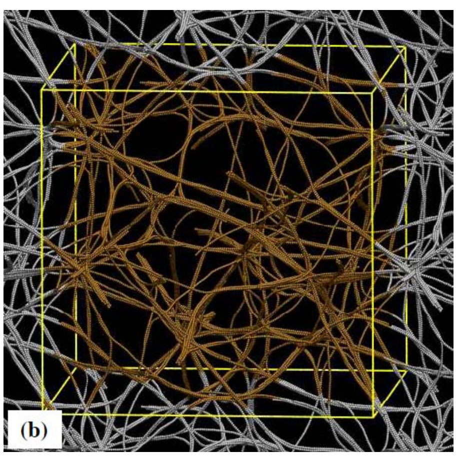
P.I.s: O.H. Campanella and M. Carignano (Northwestern University, Chicago)

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

Sponsor: Multidisciplinary Research Initiative (MURI)

Objectives: 1) Understand gelling mechanisms of particulate and polymeric systems, 2) Investigate the conditions in which these systems form a gel, 3) Obtain the constitutive equations that describe the rheological behavior of the gels, and 4) Perform molecular and computational modeling of gels to obtain a better understanding about the relation between microstructure and macroproperties.

Progress: Soft materials like gels have arisen as key components in a wide range of applications, ranging from rocket propellants to complex materials for biomedical devices and drug delivery. Experimental studies have focused on the characterization of a number of gels involving macromolecules such as proteins and polysaccharides; however the link between the microstructure of these systems with their resulting macroproperties is still lacking. From the experimental point of view, this research describes the rheological behavior of some complex systems using the appropriate rheological constitutive equations. Non-conventional rheological techniques are also considered to describe some fragile systems that are significantly disturbed during testing with conventional instruments. From the computational perspective, this research provides insights on how molecular conformation and interactions affect the rheological properties of colloidal and polymeric gels. Molecular and Brownian Dynamics simulations were performed to get a better understanding on gelation processes and to explore new applications for gelled materials.



Snapshot of simulated polymeric system with rigid branches leading the formation of a gel.

Status: Completed. Manuscripts in preparation.

5. Enhancing the Functional Properties of Hydrocolloids, Including Their Synergistic Action in the Presence of Other Hydrocolloids

P.I.s: O.H. Campanella

Researcher: Necla Mine Eren, M.S. Student

Sponsor: Government of Turkey

Objectives: 1) Characterize the physicochemical and molecular characteristics of hydrocolloids that have been subjected to high shear/pressure treatments, 2) Investigate the stability of physicochemical and molecular properties during storage at different pressures, and 3) Study changes in the synergistic properties of hydrocolloids that have been physically and enzymatically modified to enhance their functional properties.

Progress: Industrial and scientific interest related to the mechanical modification of biological polymers has increased in last two decades. Many polysaccharides have been subjected to high mechanical forces in order to modify the properties of solutions they can form. High pressure homogenization has been recognized as a convenient tool to provide those mechanical forces. However, the controlling parameters of this new process have not yet been studied in a great detail. Xanthan gum solutions that were subjected to high pressure homogenization showed a decrease in viscosity and elasticity upon treatment. This was attributed to an increase of maximum packing of molecules with a wider distribution in molecular weight and sizes created by the high pressure process. Treated samples were studied by rheological methods to measure shear viscosity and viscoelasticity including physicochemical properties of the polysaccharides, such as size-exclusion chromatography (SEC), multi-angle laser scattering (MALS), and circular dichroism (CD). Stress relaxation was a useful test to gain good insight on the characteristics of the treated samples, in particular when they are forming solutions and/or gels. Viscoelastic behavior was measured over a temperature range, showing that high pressure treatment also increases sensitivity of solution viscoelasticity with temperature. CD spectra of treated samples supported the hypothesis that a less structured and more disordered network occurs upon high pressure homogenization. Measurements of viscosity and viscoelasticity over a period of 11 weeks, at two different temperatures (4 and 25°C), showed that the rheological characteristics of the treated xanthan gum and control did not vary through the storage time. This indicated that the modifications in the structure of xanthan gum molecules were irreversible and not purely intermolecular. Interestingly, prolonged storage resulted in significant precipitation of the solutions mainly from the higher pressure-treated samples. SEC analysis of samples showed that precipitate had larger molecular weight than supernatant for highest pressure-treated samples. However, samples of the control group had the same average molecular weight independent of the location of the test tube, which indicates that the applied shear created a new dispersion that was able to sediment naturally from the solution. Overall, the results demonstrated a new way of modifying xanthan gum properties and are may be helpful in developing new value-added functional foods.

Status: Active

6. Novel Development for Assessing Texture of Foods

P.I.s: O.H. Campanella

Researchers: Jinghu Yu, Visiting Faculty, Jiangnan University, P.H.S Santos, Ph.D. Student

Sponsor: Jiangnan University, Wuxi, China

Objective: To 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.

Progress: Food texture is considered a key quality parameter in the development and acceptance of foods as well as in their grading and quality control. The purpose of many food processing operations is to create and improve textural and sensorial properties of foods. In this context, measurement of the mechanical and rheological properties of foods is extremely important to incorporate the elements that play a role in human perception and to better understand the complex relationship between these elements and texture.

The rheological properties of food materials under compression, especially at large deformations, are of interest for the food industry since they can be used to imitate human chewing. The stress-strain relationship during compression is closely related to the texture and the final mouth feeling that is perceived from the food material. The present research is aimed to establish and validate rheological models that can be used to characterize viscoelastic properties of food gels during compression under small and large deformations. Transient creep and standard compression tests were performed to characterize agar gels of different concentrations under small and large deformations in a texture analyzer. The Burger model and a modified Generalized Linear Viscoelastic (GLVE) models were used to describe the behavior of gels in the linear and non-linear viscoelastic regions, respectively. Results obtained are being applied in the design of novel instruments that mimic the mastication action to assess the texture of semi-solid foods.

Status: Active

7. Development of Edible Materials for Food Packaging

P.I.s: O.H. Campanella

Researchers: Ligang Wang, Visiting Faculty, Northeast Agriculture University, Bhavesh Patel, Ph.D. Research Associate

Sponsor: Available for sponsorship

Objective: To develop edible packaging material with good mechanical properties.

Progress: Sodium alginate-based edible films were prepared from blends containing sodium alginate, different amounts of plasticizer, and other biomaterials such as carboxymethyl cellulose and gelatin. Rheological properties of the blend solutions were studied at 25°C using steady shear and dynamic oscillatory measurements. The intrinsic viscosities of solutions formed with pure sodium alginate (SA) solution, pure sodium carboxy-methyl-cellulose (CMC), pure gelatin, and a blend of these materials were studied. Solutions of the blends exhibited shear-thinning behavior over a range of shear rates between 0.1 and 1000 s^{-1}. The effect of temperature on viscosities of all solutions was also determined. Results from viscoelastic tests showed that the blend solutions with a total solid content of

4.5% (w/w) exhibited viscoelastic behavior. Films from these solutions were prepared and characterized for tensile strength, percent elongation, creep compliance, relaxation modulus, and glass transition temperature. An optimization of the formulation involved the screening of 17 blending SA/SCMC/gelatin ratios, using glycerol as the plasticizer. Work is being carried out to incorporate cinnamaldehyde and nisin in different proportions with the aim of preparing controlled-release carriers of natural antimicrobials. The release of these antimicrobials, along with scanning electron microscopy and infrared analysis, will be assessed for biodegradability and controlled-release property of the formulated films (Project 11)

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

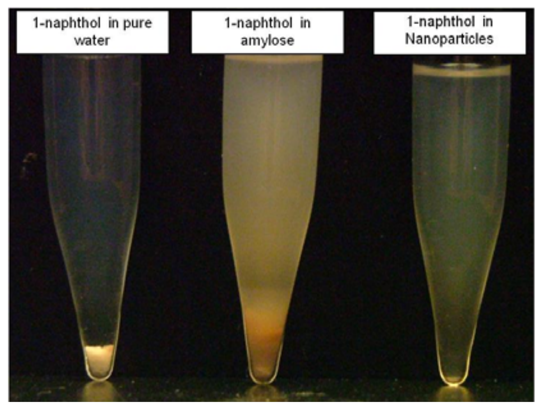
Researcher: Deepak Bhopatkar, Ph.D. Student

Sponsor: Available for sponsorship

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

Progress: Interaction among normal corn starch, whey protein, and fatty acid and their ability to produce a self-assembled water soluble three-component nanoparticle has been studied by our group. Amylose from high amylose corn starch was used along with ß-lactoglobulin and linoleic acid to form the nanoparticle. Transmission electron microscopy showed that the nanoparticle is assembled in the form of discrete rod shaped particles with dimension of ~20 x 50 nm. The nanoparticles from such interaction are thermodynamically stable, unlike nanoemulsion systems (both o/w and w/o emulsions). The molecular size, conformation, and thermal behavior of the nanoparticle were found to be affected by type and concentration of salt present in the mixture. A significant feature of this nanoparticle is its ability to carry sparingly soluble small compounds. Sparingly soluble guest compounds for food and non-food applications, including limonene, 1-naphthol, 5-fluorouracil, were used to evaluate the carrying ability of the nanoparticles.

Potentiometric titration indicated that guest compounds were incorporated in the hydrophobic cavity of amylose helices of the nanoparticle, leading to conformational changes. Thermal and X-ray diffraction studies of guest molecule-loaded nanoparticles further confirmed their incorporation. Caco-2 BBe MTT cytotoxicity studies showed that release of guest molecules can be attained in a controlled manner. It was demonstrated that the soluble, soft nanoparticle, made from simple food components, has the capacity to carry sparingly soluble small molecules with ultimate applications ranging from flavor delivery or masking to drug delivery.



Demonstration of the solubilization of 1-naphthol in the nanoparticle compared to mixing with pure water or solubilized amylose.

Status: Active. Manuscripts in preparation.

9. Cereal Arabinoxylan Properties Related to Incorporation into Processed Products

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

Researchers: Madhuvanti Kale, Ph.D. Student

Collaborator: Liqiang Zhang, Visiting Faculty

Sponsor: Available for sponsorship

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

Progress: Arabinoxylans (AXs) obtained from cereal brans have a large potential for the production of healthy foods and pharmaceuticals. They are obtained by treatment cereal brans with alkali. One of the objectives in line with the overall objective of the project was to determine the effect of alkali treatment conditions on oxidative gelling of corn bran AXs. AXs extracted through mild alkali treatment formed strong gels through ferulic acid (FA) crosslinking. Increasing harshness of alkali treatment caused a decrease in average FA content of AXs and elasticity of gels formed with them. It was found that the average FA content in the sample is not a good indicator of gelling capacity. It was hypothesized that this could be due to the presence of molecules with different FA contents within a sample. Molecules rich in FA can form crosslinks and participate in the network, while those with low FA contents cannot. Different alkali treatments result in preparations with some molecules richer in FA than others. The former can form crosslinks and participate in the gel network. A gel is formed only if there is a sufficiently large proportion of participating arabinoxylans with capacity to crosslink.

Status: Active. Manuscript in preparation.

10. Dietary Fibers and Colonic Fermentation

P.I.: B.R. Hamaker and B.L. Reuhs

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); O. Campanella

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

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

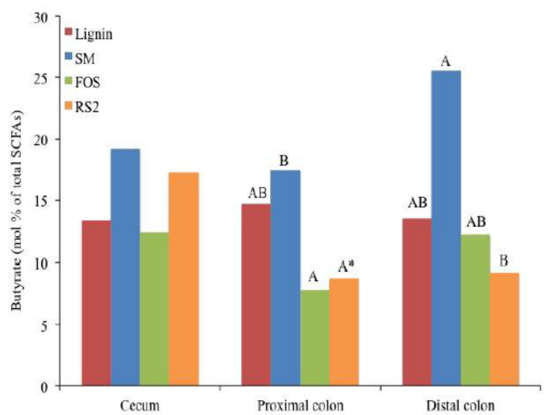
Progress: In 2011, our research on dietary fibers and colon health focused on two areas: 1) arabinoxylan structures and their fermentation rate properties, and 2) *in vivo* study on resistant starch form and affect on SCFA profiles and microbiota changes.

1) In the past year, we reported on a relationship between cereal bran arabinoxylan structures and fecal fermentation properties, including rate of fermentation and SCFA profiling. Soluble arabinoxylan substrates from both native polymers and hydrolyzates were produced with single HPSEC molecular size peaks that had a range of fermentation rates as indicated by gas and total SCFA production. Proposed consensus structures were determined by monosaccharide profiling by the GC-alditol acetate method and linkages through methylation-GC-MS analysis. Density and complexity of branches in the polymers drove fermentation rate with structural fractions high in single terminal xylose, and with other more complex branched linkage patterns, were slower fermenting.

Further study on alkali-soluble corn arabinoxylan showed it to have structural repeating segments varying in both branch density around the xylan backbone and branch complexity. This information was obtained through a step-wise procedure of hydrolyzing the native polymer with different combinations of an endoxylanse and two arbinofuranosidases. Twelve partially purified fractions were obtained and proposed consensus structures were determined. Interestingly, when a panel of a total of 21 arabinoxylan structures were fed to various strains of Bacteroides, through our collaborator E. Martens, differing abilities to ferment different substrates was apparent. Colonic bacteria seem to have specificity to compete for substrates down to regions within dietary fiber polysaccharides. This is providing our collaborative group direction as to how fiber substrates might be used for more specific changes in the colon environment.

2) A fermentable starch substrate fabricated in our laboratory, termed starch-entrapped microspheres, has been shown to have promising properties such as slow and extended rate of fermentation, unusually high levels of butyrate production, and positive influence on the gut microbiota of inflammatory bowel disease patients. Starch-entrapped microspheres were examined in healthy C57BL/6J mice for extended rate of fermentation in the distal gut, in vivo butyrate levels, and effect on microbiota. It was hypothesized that physically inaccessible

resistant starch (starch-entrapped microspheres) compared to accessible resistant starch (RS2 raw potato starch) would promote growth of different bacterial groups. FOS, an established prebiotic, was used as a fast fermenting fiber, and lignin was the non-fermentable control. Results showed that starch-entrapped microspheres appeared not to ferment completely, and likely need to be tweaked to obtain a full extended rate of fermentation into the distal colon. Nevertheless, starch-entrapped microspheres resulted in 2.4 times higher mole percent butyrate in the distal gut compared to RS2. FOS resulted in high SCFAs but caused abdominal distress due to marked cecal hypertrophy. Bacterial tag-encoded pyrosequencing revealed discrete differences in the bacteria that fermented the physically inaccessible starch-entrapped microspheres versus the accessible RS2 starch. Overall, the data indicates that both starches have the ability to improve distal colonic health, though in different ways, through altering mucosa-associated microbiota, and that specific substrates for gut microbiota modulation can be designed from a similar starting material, raw starch in this case.



Molar proportion of butyrate out of the total short-chain fatty acids after the fermentation of dietary fiber in the diet as seen in the intestinal contents collected at the end of the mouse feeding trial. Letters indicate significant differences between the treatments at each respective site and * indicates significant difference in mol % butyrate from the previous site of fermentation. Abbreviations: SM, starch-entrapped microspheres; FOS, fructooligosaccharides; RS2, resistant starch type 2.

Status: Active. Manuscripts published (A.8) and in preparation.

11. Methods to Obtain Slowly Digestible Glycemic Carbohydrates

P.I.: B.R. Hamaker

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

Collaborators: B. Nichols (Baylor College of Medicine, Houston); R. Quezada-Calvillo (University of San Luis Potosi, Mexico); M. Pinto (Simon Fraser University, Canada); D. Rose (University of Waterloo, Canada)

Sponsor: USDA-AFRI

Objective: To understand better the four mammalian α-glucosidase enzymes related to manipulating starch digestion rate.

Progress: For digestion of starch to glucose in the body, starch molecules are first broken down to α-limit dextrins, similar to a maltodextrin, by salivary and pancreatic α-amylases. These are the substrates for glucogenesis which takes place at the location of the small intestine enterocytes through maltase-glucoamylase (MGAM) and sucrase-isomaltase (SI) which have two subunits each (C- and N-terminal). In this study, hydrolysis properties of the four individual recombinant mucosal α-glucosidases on the major components of α-limit dextrins (linear and branched maltooligosaccharides) were determined to elucidate possible ways for extending glucose release at the mucosal α-glucosidase level. Study with starch-based materials showed that the amount of glucose released was increased as starch molecules were degraded by α-amylase. Partially hydrolyzed WCS by α-amylase (maltodextrin DE 10 and 5218) was predominately hydrolyzed by ctMGAM, while fully α-amylolyzed WCS (α-limit dextrins) was hydrolyzed by all mucosal α-glucosidases. Considering the fact that initial high glycemic responses are due to rapid conversion of starch to glucose in the duodenum, and that initial α-amylolysis of starch creates partially hydrolyzed maltodextrin-sized molecules, the high glycemic spikes might be effectively controlled by inhibition of ctMGAM activity.

In a second related study, we applied the concept of "toggling", developed by our collaborative group, through differential inhibition of subunits and to specifically inhibit the ctMGAM mentioned above. Recombinant mucosal α-glucosidases were individually reacted with α-limit dextrins as substrates with acarbose to elucidate its inhibitory effects. After enzyme reactions, released glucose amounts were analyzed for calculating IC50 values. Notably, the various α-glucosidase subunits were differently inhibited by acarbose during hydrolysis of the α-limit dextrins. Acarbose showed selective inhibitory effects on C-terminal subunits. This approach could conceivably be used to address Type II diabetes by extending postprandial blood glucose delivery to the body with partial inhibition with acarbose and similar C-terminal α-glucosidase inhibitors, and may apply as well to other metabolic syndrome-associated diseases and conditions.

Status: Active. Manuscripts in preparation.

12. 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: To study physiologic responses to slowly digestible carbohydrates with controlled digestion profiles.

Progress: Following our work, reported last year, showing a dose response effect of slowly digestible starches and reduction in gastric emptying time, in 2011 we initiated a long-term feeding study using our controlled starch digestion microbeads. The study, though not yet completed, is designed to compare feeding responses (food intake, satiety index, meal frequency) in rats consuming diets differing in starch digestion rate property. The study will be completed in June 2012.

Status: Active. Manuscripts in preparation.

13. Rheological Investigation of Alginate Chain Interactions Induced by Concentrating Calcium Cations

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

Researcher: Ying Yang, Visiting Scholar

Collaborators: G. Zhang, Z. Gu

Sponsor: Available for sponsorship

Objective: To develop a self-gelling alginate solution for coating.

Progress: Sodium alginates are widely applied in food and pharmaceutical industries related to their gel-forming properties in the presence of Ca^{++}. Common methods for gelling sodium alginates use excessive calcium salts or other chemicals besides alginate and calcium. In this study, an innovative gelling method based on concentrating Ca^{++} in a sodium alginate solution through water evaporation (termed as Ca^{++}-concentrating gelling process (CCGP)) was developed, and alginate chain interactions during the gelling process were investigated without influence of other materials.

Two commercially available sodium alginate samples (low viscosity (LA), medium viscosity (MA), both from the same brown algae) and CaCl2 were used to develop CCGP. The structure of LA and MA were characterized using gel permeation chromatography and ^{1}H nuclear magnetic resonance analyses, and their chain interactions during the gelling process were investigated using an oscillatory rheometer. For LA and MA with an initial concentration of 1%, the critical Ca^{++} concentrations for gelation were found to be 4.63 and 4.45 μmol/mL, respectively, after water evaporation. Under the above conditions, the combination of LA and MA at different ratios of 0/4, 1/3, 2/2, 3/1 and 4/0 showed variable flow properties and gelling trends before water evaporation and gel properties after water evaporation. Molecular weight distributions of sodium alginates had dramatic influence on alginate chain interactions mediated by Ca^{++}. Thus, desirable alginate products can be expected to be produced by modulating alginate chain interactions induced by concentrating Ca2+ through manipulating the mixing ratios of sodium alginate with different molecular weights while retaining the same composition distributions.

Status: Completed. Manuscript submitted.

14. 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, Ph.D. Student, Stephanie Tandazo, M.S. Student, Morgan Goodall, M.S. Student

Collaborator: L. Mauer

Sponsor: USDA-AFRI, Purdue fellowship, USAID INTSORMIL project

Objectives: 1) To create gluten-free bread dough mainly composed of corn or other non-gluten proteins to address the celiac problem, 2) To study how different co-proteins interact with zein in order to create improved quality dough, 3) To study the interaction between protein (zein) and carbohydrates (starch) to have a better understanding its effect on dough formation and baking characteristics, and 4) To determine applicability of using high digestibility/high-lysine sorghum flour for high incorporation composite breads for Africa.

Progress: Advances were made in objectives 2, 3 and 4.

2) An hypothesis was tested that the prolamins, gliadin and zein, have similar roles in dough formation whereby glutenin protein can enhance their viscoelasticity through a co-protein effect. While viscous-like, though tough, doughs were observed for zein samples mixed at room temperature, glutenin addition increased the elasticity. Still higher elastic properties of the sample were determined for zein dough samples with glutenin at 50% addition level and mixed at 35°C. Glutenin addition to zein appears to change its viscoelastic property beyond that of the glutenin protein alone. We are interested how co-proteins, in general, can be used to improve functionality of generally non-functional food proteins.

3) In this project, three properties of dough were investigated, glass transition temperature, extensional viscosity, and viscoelastic properties. The dough composites were made of zein + co-proteins (casein, sodium caseinate, gliadin, glutenin) + three different isolated starches (corn, wheat, rice). Starch type had a large effect on rheological properties, and co-proteins, to different degrees with different starches used, improved viscoelasticity above the glass transition temperature of zein.

4) High digestibility/high-lysine sorghum, with kafirin proteins freed from protein bodies, were shown to effectively participate in dough formation in sorghum:wheat composite breadmaking systems. Our goal in this project is to find a way to increase levels of sorghum incorporation into breads for use in Africa to better utilize local crops and to reduce wheat imports.

Status: Active. Manuscripts published (A.9) and in preparation.

15. Hydrocolloid-Based Stable Nutraceutical Carriers

P.I.: S. Janaswamy

Researcher: Patrick Polowsky, Undergraduate Student

Sponsor: Available for sponsorship

Objective: Nutraceuticals are utilized due to their inherent ability to provide health benefits, especially for the prevention and treatment of chronic diseases such as diabetes, obesity, cardiovascular disease and cancer. Their incorporation into food formulations (food supplements, functional foods and medicinal foods) can be a technological challenge mainly due to low water solubility and stability during processing and storage conditions. To circumvent these problems, carriers that can effectively protect and release nutraceuticals during product formulation, consumption and actual delivery are needed. Hydrocolloids stand out as worthy candidates for such carriers due to their unique functional properties and versatility.

Progress: Eugenol was encapsulated in the sodium and calcium forms of iota-carrageenan fibers. Complexation experiments were performed at 4, 25, 35 and 45°C to understand the effect of temperature on the loaded amounts and release profiles. Results demonstrate that the binary complexes possess stable organization. Encapsulated eugenol molecules were released from the complex in a controlled manner and complexation temperature indeed determines the loaded amounts.

Status: Active.

16. Trivalent Iron Induced Gelation of Lambda-Carrageenan

P.I.: S. Janaswamy

Researcher: Cordelia Running, M.S. Student

Collaborator: R. Falshaw, New Zealand

Sponsor: Available for sponsorship

Objective: Kappa-, iota- and lambda-carrageenans are sulfated polysaccharides used extensively in food, pharmaceutical and medical applications. While kappa- and iota-carrageenans show gelation in the presence of mono- and divalent ions, lambda-carrageenan yields only viscous solutions. The inability of lambda-carrageenan to gel has been attributed to electrostatic repulsion between highly charged polysaccharide chains. Herein, we show that gelation in lambda-carrageenan indeed is possible with trivalent iron ions.

Progress: X-ray fiber diffraction patterns of iron(III)-lambda-carrageenan (Fe-lambda) are characteristic of highly oriented and polycrystalline fibers, and contain well resolved Bragg reflections that correspond to a trigonal unit cell with dimensions a = 19.30(1) and c = 25.08(4) Å. The elastic modulus (G') of Fe-lambda is far greater than the loss modulus (G") signifying the thermal stability of lambda-carrageenan in the presence of iron (III) ions. Overall, the trivalent nature of iron appears to be responsible for inducing an organized gel network in lambda-carrageenan by stabilizing the charges on the polysaccharide chain. This novel finding has potential to expand lambda-carrageenan's current utility beyond a viscosifying agent.

Status: Active. Manuscript in preparation.

17. Effect of Rebiana and Salt on the Functional Behavior of Iota-Carrageenan

P.I.: S. Janaswamy

Researcher: Cordelia A Running, M.S. Student

Sponsor: Available for sponsorship

Objective: Several epidemiological studies suggest that overweight and obesity are the main cause factors for type 2 diabetes mellitus, cardiovascular disease and cancer. Consumption of high amounts of sucrose and sucrose-sweetened beverages is thought to a key contributor to these chronic diseases. Utilization of non-nutritive sweeteners in lieu of sucrose might be helpful to combat these ailments. However, exploitation of sweeteners in developing novel food products is sometimes hampered by the lack of precise understanding about structure-property relationships, especially in the presence of hydrocolloids and other ingredients.

Progress: We studied the influence of rebiana (10, 30, and 50 mg/mL), a natural non-nutritive and high intense sweetener derived from the stevia plants, in conjunction with NaCl (2 and 4 mg/mL) on the structural and viscoelastic properties of iota-carrageenan (1% w/w). Rebiana addition affects the gel-to-solution transition temperature (Tg). Larger unit cell dimensions - doubling in the basal net values and tripling in the layer line spacings - deduced from X-ray fiber diffraction analysis suggest the involvement of multiple iota-carrageenan helices and rebiana molecules in the junction zone formation. Overall, unlike sugar, which competes for water and substantially modifies the functional behavior of hydrocolloids, rebiana by itself has a subtle effect, but with salt significantly alters the solid-state structure and Tg of iota-carrageenan gels.

Status: Active.

18. Effect of Salt and Sucrose on the Gelation Behavior of Kappa-Carrageenan

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

Researcher: Bhavesh K. Patel, Ph.D. Research Associate

Sponsor: Available for sponsorship

Objective: In food formulations, polysaccharides are used to modify solution properties such as water binding, viscosity, thickening and stability of dispersions. Addition of co-solutes, notably sugars and salts, significantly alter 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 highlight the underlying molecular mechanisms that govern structure-function relationships and macroscopic behavior in food systems.

Progress: We have undertaken a systematic investigation at dilute hydrocolloid conditions so as to represent their practical applications, e.g. beverage thickeners, where strong gel formation is highly undesirable. Our test hydrocolloid system comprised kappa-carrageenan at 0.25, 0.5, 0.75 and 1.0 % w/w concentrations. Effect of sucrose (0.1, 0.5 and 1.0 M) and salt (0.1 and 0.2 M) on viscoelastic behavior was studied. Gel strength was found to increase dramatically for carrageenan concentrations above 0.75%. Salt addition improved the gelling ability and, for a given salt concentration, sucrose incorporation further augments gelation. Overall, sucrose has large influence on the salt induced kappa-carrageenan gelation.

Status: Active.

19. Effect of Urea on the Structure-Function Relationships of Iota-carrageenan

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

Researcher: Bhavesh K. Patel, Ph.D. Research Associate

Sponsor: Available for sponsorship

Objective: Generally urea addition to biopolymer systems breaks hydrogen bonds leading to structural destabilization. In the case of hydrocolloids, urea is reasoned to impact gelation. Detailed information, however, about its role towards influencing the structure-function relationships is still elusive. The present investigation is aimed at delineating hydrocolloids structural behavior in the presence of urea employing iota-carrageenan as a model system.

Progress: X-ray fiber diffraction, viscoelastic and thermal properties at two iota-carrageenan concentrations (4.5 and 6.0% w/w), and two urea amounts (0.5 and 2.0 M) with and without heat treatments were analyzed. X-ray analysis suggests that the canonical double helical structural arrangement of iota-carrageenan is maintained even after urea addition. However, improved crystallinity, ordering and altered unit cell dimensions especially with heat treatments of binary mixtures indicate promotion of favorable interactions among urea molecules and carrageenan helices. Increased elastic modulus and onset temperature of melting endotherm with boiled treatment compared to cold addition further attests the X-ray observations. Overall, results suggest that urea molecules synergistically promote iota-carrageenan interactions and stabilize structure of junction zones. These findings will be helpful in understanding the additive roles on food components leading to novel non-food applications of hydrocolloids.

Status: Active.

20. Time-resolved X-ray Fiber Diffraction Studies on Iota-carrageenan

P.I.: S. Janaswamy

Collaborators: Irina Koshelev, Robert Henning, Zhong Ren (Center for Advanced Radiation Sources, The University of Chicago)

Sponsor: Available for sponsorship

Objective: Functional properties of polysaccharides rely greatly on their structural organizations as well as their time dependent structural transformations. Hence, precise knowledge about polysaccharide architectures and their preferred structural organizations is necessary to develop novel functional foods.

Progress: Our initial focus has been to delineate structural transformations in iota-carrageenan during cation exchange. Time-resolved X-ray diffraction studies have been conducted on sodium iota-carrageenan fibers and intensity data collected at time resolutions of 100 ms during cation exchange from mono- (Na^+) to divalent (Ca^{2+}). Singular value decomposition (SVD) analysis coupled with modeling suggests that the overall process of replacement of sodium ions by calcium ions is rather slow, ~200 seconds. However, there are at least two metastable states associated with different rate constants before the completion of ion exchange suggesting greater functional diversity of iota-carrageenan.

Status: Active.

21. Specific Ion Effects on Electrostatic Complex Formation and Macromolecular Development Between Whey Proteins and Pectin

P.I.: O.G. Jones

Researcher: Stacey Hirt, M.S. Student

Sponsor: USDA-Hatch MRF

Objective: Determine attractive physical forces and macromolecular interactions between milk proteins and carboxylated polysaccharides in the presence of specific ion effects.

Progress: Initial light scattering and atomic force microscopy investigations have been performed on mixtures of β-lactoglobulin and pectin at neutral and low-acid conditions. Conditions of low ionic strength have verified the system from literature.

Status: Active.

22. Stabilization of Flavor Oil Emulsions by β-Lactoglobulin/Pectin Heated Complex Structures

P.I.: O.G. Jones

Researcher: Laura Zimmerer, M.S. Student

Sponsor: USDA-Hatch MRF, Industry Associates Fellowship

Objective: Determine the interfacial activity and interfacial structuring at multiple flavor oil interfaces using heated complexes between β-lactoglobulin and pectin; determine oxidative stability and evaporative loss of flavor oils from the stabilized interfaces; gauge physical stability of an emulsified flavor oil system using the heat-treated complexes.

Progress: Emulsions with heat-treated β-lactoglobulin particles have been created using a flavor oil. Light scattering studies indicate that stable droplets are created with diameter under 1 micrometer. These droplets are unstable after several days. Current research involves studying interfacial activity of the biopolymer particles and resolving stabilized droplets by atomic force microscopy techniques.

Status: Active.

23. 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.

24. Molecular Dynamics Simulation of Polypeptides Tethered to Surface

P.I.: G. Narsimhan

Researchers: Xiaoyu Wu, Ph.D. 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, and 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. In the presence of Cecropin P1 C in the vicinity of silica surface, there is a shift in the location of two peaks in H-O-H density profile to larger distances (2.95 Å and 7.38 Å compared to 2.82 Å and 4.88 Å in the absence of peptide) with attenuated peak intensity. This attenuation is found to be more pronounced for the first peak. H-bond density profile in the vicinity of silica surface exhibited a single peak in the presence of Cecropin P1 C (at 2.9 Å) which was only slightly different from the profile in the absence of polypeptide (2.82 Å) thus indicating that Cecrpin P1 C is not able to break the H-bond formed by the silica surface. Water density and H-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 SKTAKKLEN and ISEGI). 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 ISEGI at higher ionic strength of 0.12 M. The conformation of Cecropin P1 C tethered to silica surface with either (PEO)6 or (PEO)3 linker exhibited two regions of high α helix probability (residues SKTAKKLENSA and EGIAI); the conformation of Cecropin P1 C in solution is closer to that of 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 (19.5% 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.

Status: Active.

25. Investigation of the Conformation of Model Polypeptides Using Molecular Dynamics Simulation

P.I.: G. Narsimhan

Researcher: Xiaoyu Wu, Ph.D. Research Associate

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, and 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 conformation of SKKKKKKKKS in the vicinity of a titania surface was determined by molecular dynamics simulation using explicit solvent for three different crystal forms (rutile, brookite and anatase); the polypeptide was initially located parallel to the surface with its center of mass at a distance of 20 Å and its initial structure was either linear or native. For initial native structure of the polypeptide, its conformation after interaction with the rutile surface for 10 ns exhibited higher α-helix content. The hydrogen bond formed between water and the surface is difficult to break and thus prevents direct contact of the polypeptide with the surface. There are two water layers formed near the surface. The presence of the polypeptide has no effect on the first water density peak while it does reduce the density of the second peak. Polypeptide on three different types of TiO2 surfaces (rutile, brookite and anatase) experienced different conformational change during the simulation. The anatase surface induced much more turns in the conformation of the polypeptides compared to other two surfaces. The density peak was at smaller distance from the surface for rutile, whereas the peak was at the largest distance for anatase. The conformation of SKKKKKKKKS in the vicinity of an anatase surface as determined by molecular dynamics simulation using explicit solvent with the molecule initially located at different positions from the surface (center, edge and corner) showed that the differences in conformation of polypeptide for different initial locations are not significant. The conformation of SKKKKSSKKKKS and SSKKKKKKKK in the vicinity of anatase crystal surface was determined by molecular dynamics simulation using explicit solvent for different initial locations of the peptide from the surface (center, edge and corner). The initial conformation of polypeptide for these simulations was taken to be native conformation in solution. The presence of a serine at the two ends of the polypeptide resulted in a bend whereas two serines in one end leads to a structure without a bend and with increased α helix in aqueous medium. When SKKKKSSKKKKS from the solution was placed at the center of the anatase surface, the total helix did not decrease. However, there was a decrease in the total helix for SSKKKKKKKK.

Status: Active.

26. Pore Formation in DMPC Liposomes by Antimicrobial Peptides

P.I.: G. Narsimhan

Researchers: Lu Zhou, Ph.D. student**,** Xiaoyu Wu, Ph.D. Research Associate

Sponsor: Available for sponsorship

Objectives: 1) Preparation of liposomes with fluorescent dye of different sizes inside. Characterization of size, shape and charge of liposomes, 2) Experimental measurement of leakage of fluorescent dye from the liposome into the aqueous medium when exposed to different concentrations of antimicrobial peptides, and 3) Experimental measurement of kill rate of gram negative microorganism *E. Coli* that is exposed to antimicrobial peptide of different concentrations.

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 Mellittin. Liposomes were negatively charged (zeta potential of -25 to -30 mV) and have two different sizes of 150 nm and 600 nm, respectively. 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 monitored by fluorescence of the external phase. Circular dichroism results showed that insertion of Mellitin 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) for both small and large size of liposome. Also, the lag time was larger for larger size of liposome. 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. Fluorescence confocal image assay indicated that the fluorescence intensity decayed faster for higher peptide/liposome ratio compared to control (90 s and 8 minutes respectively). The fluorescence intensity zone distribution zone showed that the pore was only formed at certain regions on the surface. Furthermore, the fluorescence intensity deceased with time at the region close to liposome center, while at the regions close to the surface, the intensity increased with time, indicating that the dye leaked from the center to the surface.

Status: Active

27. 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. We are examining the basis for the different viscosities in the two products, particularly as it relates to potential pectin degradation.

Progress: Many past 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 more intact pectic polymers were solubilized by HB. We have 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 overall 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 showed 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. We will continue to examine the particle size, shape, and chemical makeup to determine the exact physical properties that play such a significant role in fruit viscosity.

Status: Active.

28. High-Value Corn Starch

P.I.: C. Weil

Collaborators: L. Mauer, Y. Yao

Researchers: Patrick Breen, M.S. Student, Kaylie Fritts, B.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 corn mutants can produce starch in the kernel that has some of the same properties currently obtained by chemical modification. These mutants would, therefore, reduce processing time, cost, and variability. A second objective is to screen mutants for more digestion-resistant cooked starch, and a third is to screen for more rapidly digesting starch for use as a biofuel feedstock. Large populations of mutagenized seeds have been developed in the inbred maize lines W22 and B73.

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

Status: Active.

29. Genes Controlling Starch Channelization

P.I.: C. Weil

Collaborator: J.N. BeMiller

Sponsor: Available for sponsorship

Objective: In the past, in conjunction with Yenny Widya and Dr. BeMiller, we have analyzed genetic changes associated with differences in the number of channels formed in starch granules. 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. Our goal now is to test their specific roles in forming channels in maize starch granules.

Progress: An even 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. These RILs have now been phenotyped in the BeMiller lab. We are performing association analyses on these RILs 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.

30. Genetic Interactions That Impact Starch Quantity and Quality

PI: C. Weil

Researchers: Project currently available

Sponsor: Available for sponsorship

Progress: Vijay Chaikam has moved on to CIMMYT in Mexico, so this project is awaiting a new researcher. Many mutations show differences in the phenotypes they cause when they are moved into various genetic backgrounds. The starch mutants *ae1, su2* and *wx* have been crossed to 27 highly diverse inbreds to identify interacting genes that affect starch quantity and quality. We now have F2 progeny of these crosses and are analyzing differences in starch content and quality. Once the effects have been determined, we will use association mapping to quickly identify and isolate novel genes that alter starch characteristics.

Status: Active

31. Genetics of Carbohydrate Transport and Partitioning in Maize

PI: C. Weil

Researchers: T. Wojciechowski, Ph.D. Research Associate, J. Woodcock, Technician, J. Wedow, Undergraduate

Sponsor: NSF

Progress: We have begun to map four new mutations impacting carbohydrate transport and distribution in maize, have identified ~100 more and have developed mapping populations for these for analysis this summer.

Status: Active

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

PI: C. Weil

Collaborators: J. Woodcock, N. Carpita, D. Szymanski (Purdue University)

Sponsor: USDA

Progress: Sugar accumulating grasses store sucrose in the vacuoles of stem (stalk) cells in preparation for remobilizing that sugar to developing seeds. In grasses such as sugarcane and sweet sorghum, that remobilization is reduced, and the stalks are harvested to collect the sugar. In maize, remobilization to the developing ear has been selected for as a part of the domestication process, and is under genetic control. Some tropical maize varieties flower late in temperate climates and do not make ears (although they still set seed normally under shorter day lengths in the tropics). Some of these continue to accumulate sugar as though they were going to make ears while others do not and we are trying to understand and make use of this variation. In the past year we have tested our preparation of vacuoles both in sugar accumulating and non-accumulating lines to determine the time course of sugar accumulation in each. We also developed populations that will allow us to map sugar accumulation genes from two tropical inbreds. We are focusing on increasing the processes loading sugar into the vacuoles of stalk cells and decreasing its remobilization out of those vacuoles.

Status: Active

33. Impact of Genetic Background on Starch Structure: a Single-kernel Approach

P.I.: Y. Yao

Researcher: Yiming Wang, Visiting Scientist

Sponsor: Available for sponsorship

Objectives To understand the impact of *wx*, *su1*, and *ae* genes on starch structure

Progress: This work is part of our long-term effort in the area of genetic starch modification for improved functionality. In the past years, we have been working to introgress selected mutant alleles together to yield maize mutants. From this work, we have obtained a number of ears with segregating kernels theoretically containing all dosage combinations of *wx*, *su1*, and *ae* alleles. Thereafter, we use single kernel sampling method to characterize the starch structure of individual kernels, including amylose content and amylopectin branch structure. Meanwhile, each kernel is preserved for germination test in the future. This methodology will allow us to establish the relationship between starch structure and genetic background associated with *wx*, *su1*, and *ae* mutant alleles.

Status: Active.

34. Carbohydrate Nanoparticle-Based Colloidal Assemblies to Adsorb and Deliver Antimicrobial Peptides

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

Researchers: Preetam Sarkar, Ph.D. Student

Objective: To study the adsorption of antimicrobial peptides with carbohydrate nanoparticle-based colloidal assemblies.

Progress: Phytoglycogen octenyl succinate (PG-OS) materials with different degree of substitution (DS) are prepared. The nanoparticles or the nanoparticle-stabilized emulsions are used to complex with antimicrobial peptide nisin. The adsorption behaviors of peptide are determined using equilibrium dialysis. This study allows us to understand the impact of PG-OS properties on its interaction with peptide molecules, which will lead to the rational design of delivery system for food.

Status: Active.

35. Branch Structure of Phytoglycogen Nanoparticles

PI: Yuan Yao

Researchers: Hua Chen, Ph.D. Student

Objective: To study the branch structure of phytoglycogen in comparison with amylopectin.

Progress: In our early work, we have revealed the particulate structure of phytoglycogen nanoparticles compared with amylopectin. In general, phytoglycogen has high dispersed molecular density due to its dendrimer-like structure. Currently, we are using beta-amylolysis to probe the branch structure of phytoglycogen. During beta-amylolysis of phytoglycogen and amylopectin, we monitor the maltose release and the chain length distribution of dextrins produced. This work is particularly important for understanding glucan branching in the biosynthesis of phytoglycogen. It also benefits 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. **J.N. BeMiller**. Pasting, paste, and gel properties of starch-hydrocolloid combinations. *Carbohydrate Polymers* 86: 386-423.
2. **Z. Sui**, **A. Shah**, **J.N. BeMiller**. Crosslinked and stabilized in-kernel heat-moisture-treated and temperature-cycled normal maize starch and effects of reaction conditions on starch properties. *Carbohydrate Polymers* 86: 1461-1467.

Campanella

3. **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* 105: 444-452.
4. **G. Chen**, **O.H. Campanella**, M. Peleg. Calculation of the total lethality of conductive heat in cylindrical cans sterilization using linear and non linear survival kinetic models. *Food Research International* 44: 1012-1022.
5. A. Dechelette, **O.H. Campanella**, C. Corvalan, P. Sojka. An experimental investigation on the breakup of surfactant-laden non-Newtonian jets. *Chemical Engineering Science* 66: 6367-6374.
6. P. Takhar, D.E. Maier, **O.H. Campanella**, **G. Chen**. Hybrid mixture theory based moisture transport and stress development in corn kernels during drying: Validation and simulation results. *Journal of Food Engineering* 106: 275-282.
7. **O.H. Campanella**, H. Sumali, **B. Mert**, **B. Patel**. The use of vibration to characterize the mechanical properties of biomaterials, *in* Biomaterials Physics and Chemistry, R. Pignatello, ed., Intech, Open Access Publisher, pp. 299-328.
8. **M. Kale, D. Pai, B.R. Hamaker, O.H. Campanella**. Incorporation of fibers in foods, a food engineering challenge, in Food Engineering Interfaces, J. Aguilera, G.V. Barbosa-Canovas, J. Welti, R. Simpson, eds., Springer-Verlag, chapter 4.
9. **M. Fevzioglu, B.R. Hamaker, O.H. Campanella.** Gliadin and zein show similar and improved rheological behavior when mixed with high molecular weight glutenin. *Journal of Cereal Science* On-line DOI: 10.1016/j.jcs.2011.12.002.

See Hamaker papers 18, 19.

See Reuhs paper 37.

Hamaker

10. **A. Kaur**, D. Rose, **P. Rumpagaporn**, J. Patterson, **B.R. Hamaker**. In vitro batch fecal fermentation comparison of gas and short-chain fatty acid production using “slowly fermentable” dietary fibers. *Journal of Food Science* 76: H137-H142.
11. **M. Benmoussa**, **B.R. Hamaker**. Rapid small-scale starch isolation using a combination of ultrasonic sonication and sucrose density separation. *Starch/Stärke* 63: 333-339.
12. D.J. Rose, **B.R. Hamaker**. Overview of dietary fiber and its influence on gastrointestinal health, *in* Nondigestible Carbohydrates and Digestive Health, T.M. Paeschke, W.R. Aimutis, eds., pp. 185-221.

13. **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* 46: 2344-2350.

14. **V. Espinosa-Solis**, S.L. Sanchez-Ambriz, **B.R. Hamaker**, L.A. Bello-Pérez. Fine structural characteristics related to digestion properties of acid-treated fruit starches. *Starch/Stärke* 63:717-727.

15. E.G. Kean, **N. Bordenave**, G. Ejeta, **B.R. Hamaker**, M.G. Ferruzzi. Carotenoid bioaccessibility from whole grain and decorticated yellow endosperm sorghum porridge. *Journal of Cereal Science* 54:450-459.

16. **R. Mufumbo**, Y. Baguma, S. Kashub, E. Nuwamanya, P. Rubaihayo, S. Mukasa, **B.R. Hamaker**, S. Kyamanywa. Amylopectin molecular structure and functional properties of starch from three Ugandan cassava varieties. *Journal of Plant Breeding and Plant Science* 3:195-202.

17. **R. Mufumbo**, Y. Baguma, S. Kashub, E. Nuwamanya, P. Rubaihayo, S. Mukasa, **B.R. Hamaker**, S. Kyamanywa. Functional properties of starches on the East African market. *African Journal of Food Science* 5:594-602.

18. **D.P. Erickson**, **O.H. Campanella**, **B.R. Hamaker**. Functionalizing maize zein in viscoelastic dough systems through fibrous, β-sheet-rich protein networks: An alternative, physicochemical approach to gluten-free breadmaking. *Trends in Food Science and Technology* (on-line) http://dx.doi.org/10.1016/j.tifs.2011.10.008.

19. **R. Rumpagaporn**, **A. Kaur**, **O.H. Campanella**, J.A. Patterson, **B.R. Hamaker**. Heat and pH stability of alkali-extractable corn arabinoxylan and its xylanase-hydrolyzate and their viscosity behavior. *Journal of Food Science* (on-line) http://dx.doi.org10.1111/j.1750-3841.2011.02482.

20. **P. Zhang, B.R. Hamaker**. Banana starch and its digestibility. *Carbohydrate Polymers* 87 (on-line) http://dx.doi.org/10.1016/j.carbpol.2011.09.053.

See Campanella paper 3.

Janaswamy

21. **Y. Yao**, **S. Janaswamy**. Gene dosage effect on starch structure studied using maize polygenic model containing ae and su1 mutant alleles. *Food Chemistry* 125: 1153-1159.

22. P. Senthivel, **S. Janaswamy**, J. Gopalakrishnan, M.N.S. Rao. Single crystal X-ray structure and reactivity of a Triphenylphosphinazine, (C6H5)3P=N-N=C(H)(C6H4NO2-p). *Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry* 4: 1315 1323.

Jones

23. **O.G. Jones**, S. Handschin, J. Adamcik, L. Harnau, S. Bolisetty, R. Mezzenga. Complexation of β-lactoglobulin fibrils and sulfated polysaccharides. *Biomacromolecules* 12: 3056-3065.

24. A. Matalanis, **O.G. Jones**, D.J. McClements. Structure biopolymer-based delivery systems for encapsulation, protection, and release of lipophilic compounds. *Food Hydrocolloids* 25: 1865-1880.

25. C. Bengoechea, **O.G. Jones**, A. Guerrero, D.J. McClements. Formation and characterization of lactoferrin/pectin electrostatic complexes: impact of composition, pH and thermal treatment. *Food Hydrocolloids* 25: 1227-1232.

Lin

26. **A. Lin,** Y.H. Chang, W.B. Chou, T.J. Lu. Interference prevention in size-exclusion chromatographic analysis of debranched starch glucans by aqueous system. *Journal of Agricultural and Food Chemistry* 8:59: 5890-8.

Mauer

27. **A. Hiatt**, L. Taylor, **L. Mauer**. Effects of co-formulation of amorphous maltodextrin and deliquescent sodium ascorbate on moisture sorption and stability. *International Journal of Food Properties* 14: 726-740.
28. **M. West**, **L. Mauer**. Development of an integrated approach for the stability testing of flavonoids and ascorbic acid in powders. *Food Chemistry* 129: 51-58.
29. **N. Li**, L.S. Taylor, **L. Mauer**. Degradation kinetics of catechins in green tea powder: effects of temperature and relative humidity. *Journal of Agricultural and Food Chemistry* 59: 6082-6090.
30. W. Tongdeesoontorn, **L. Mauer**, S. Wongruong, P. Sriburi, P. Rachtanapun. Effect of carboxymethyl cellulose concentration on physical properties of biodegradable cassava starch-based films. *Chemistry Central Journal* 5:6.
31. **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* 14:996-1006.
32. **R. Lipasek**, L.S. Taylor, **L.J. Mauer**. Effects of anticaking agents and relative humidity on the physical and chemical stability of powdered vitamin C. *Journal of Food Science* 76: C1062-1074.
33. **R. Davis**, **L.J. Mauer**. Subtyping of Listeria monocytogenes at the haplotype level by Fourier transform infrared (FT-IR) spectroscopy and multivariate statistical analysis. *International Journal of Food Microbiology* 150:140-149.
34. **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* 14: 1330-1348.
35. **M.E. West**, **L.J. Mauer**. Development of an integrated approach for the stability testing of flavonoids and ascorbic acid in powders. *Food Chemistry* 129: 51-58.

See Reuhs paper 39.

Narsimhan

36. **L. Bi**, **L. Yang**, **G. Narsimhan**, A. Bhunia, **Y. Yao**. Designing carbohydrate nanoparticles for prolonged efficacy of antimicrobial peptide. *Journal of Controlled Release* 150: 150-156.

Reuhs

37. Y. Zhang, S. Simsek, **O. Campanella**, J.B. Ohm, H. Chang, **B.R. Reuhs**, M. Mergoum. Rheological changes in refrigerated dough during storage in relation to proteins. *Journal Food Process Engineering* 34: 639-656.
38. **A. Deering**, R. Pruitt, **B. Reuhs**. Examination of the internalization of salmonella serovar typhimurium in peanut, arachis hypogaea, using immunocytochemical techniques. *Food Research International.* Available online 4 February 2011.
39. **A. Deering**, R. Pruitt, **L. Mauer**, **B. Reuhs**. Identification of the cellular location of internalized *Escherichia coli* O157:H7 in Mung Bean, *Vigna radiata*, using immunocytochemical techniques. *Journal of Food Protection* 74: 1224-1230.

Weil

40. W. White, S.P. Moose, **C. Weil**, M. McCann, N. Carpita, F. Below. Tropical maize – Exploiting maize genetic diversity to develop a novel annual crop for lignocellulosic biomass and sugar production, *in* Routes to Cellulosic Ethanol, M.S. Buckeridge, G.H. Goldman, eds., Springer, New York, pp. 167-180.
41. **V. Chaikam**, A. Negeri, R. Dhawan, B. Puchaka, S. Chintamanani, E. Gachomo, A. Zillmer, T. Doran, **C. Weil**, P. Balint-Kurti, G. Johal. Use of mutant-assisted gene identification and characterization (MAGIC)

to identify novel genetic loci that modify the maize hypersensitive response. *Theoretical and Applied Genetics* 123: 985-99.

42. N. Huefner, Y. Mizuno, **C. Weil**, I. Korf, A. B. Britt. Breadth by depth: expanding our understanding of the repair of transposon-induced DNA double strand breaks via deep-sequencing. *DNA Repair* 10:1023-1033.

Yao

43. **L. Huang**, **Y. Yao**. Particulate structure of phytoglycogen nanoparticles probed using amyloglucosidase. *Carbohydrate Polymers* 83: 1665-1671.

44. **L. Bi**, **L. Yang**, A. Bhunia, **Y. Yao**. Carbohydrate nanoparticle-mediated colloidal assembly for prolonged efficacy of bacteriocin against food pathogen. *Biotechnology and Bioengineering*, 108: 1529-1536.

See Janaswamy paper 21.

See Narsimhan paper 36.

B. 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, keynote speaker, St. Joseph College, Trichy, India.

March

2. **C. Weil**. TILLING and point mutations. International Workshop on Plant Genomic Technologies, Vienna, Austria.

3. N.B Best, **C. Weil**, B.P. Dilkes. Isolation of defective kernel mutants from an open-pollinated EMS population to identify maternal effects on seed developmental processes in maize. *Maize Genetics Conference*, St. Charles, IL.

4. **K. Lau**, J. Palmer, **C. Weil**. Using natural variation to identify gene modifiers of three developmental mutations in maize. *Maize Genetics Conference* , St. Charles, IL.

5. **P. Breen**, **C. Weil**. Genetic control of starch digestion: better food and fuel. *Maize Genetics Conference ,* St. Charles, IL.

April

6. **Y. Yao**. Carbohydrate nanoparticles for improved food safety and quality. University of Illinois Distinguished Speaker Series, Urbana, IL.

7. **S. Janaswamy**, I. Koshelev, R. Henning, Z. Ren. Time-resolved X-ray fiber diffraction studies on polysaccharide matrices. BioCARS NIH Advisory Committee meeting, Advanced Photon Source, Chicago, IL.

8. **A. Lin**, B.L. Nichols, R. Quezada-Calvillo, D. Rose, **B.R. Hamaker**. A potential control point of glucose delivery from starchy foods: intestinal mucosal {alpha}-glucosidase digestion. Experimental Biology annual meeting, Washington, D.C.

9. **B.R. Hamaker**. Evolution of carbohydrate digestibility. Experimental Biology annual meeting, Washington, D.C.

10. R. Quezada-Calvillo, B. Nichols, S. Avery, M. Rocha, **B.R. Hamaker**. Ct-MGAM activity adapts to various botanical food starch intakes by alternative splicing. Experimental Biology annual meeting, Washington, D.C.

11. **B.-H. Lee**, R. Quezada-Calvillo, B. Nichols, D.R. Rose, **B.R. Hamaker**. Alpha-glucogenic activity of mammalian mucosal enzymes on different disaccharides. Experimental Biology annual meeting, Washington, D.C.

12. **L. Yan**, R.J. Phillips, K. Kinzig, T.L. Powley, **B.R. Hamaker**. Slow release glucose in small intestine via dietary approach slows gastric emptying in vivo in a dose response fashion. Experimental Biology annual meeting, Washington, D.C.

May

13. **S. Janaswamy**, I. Koshelev, R. Henning, Z. Ren. Time-resolved X-ray fiber diffraction at BioCARS demonstrated the dynamic process of ion exchange in crystalline polysaccharide matrices. 2011 Advanced Photon Source, Center for Nanoscale Materials and Electron Microscopy Center Users Meeting, Argonne National Laboratory, Chicago, IL.

14. **C. Weil**. Mining the Diversity of Zea mays: biomass and sugar in the temperate zone. Purdue Bioenergy Symposium, West Lafayette, IN.

June

15. **B. Patel**, **O.H. Campanella**, **S. Janaswamy**. Structural changes in iota-carrageenan induced by urea. 42nd American Chemical Society Central Region Meeting, Indianapolis, IN.

16. **C. Weil.** Plants: archetypes of reversion. International Workshop on Genetics of EB, Barcelona Spain.

17. **B.R. Hamaker**. Designer carbohydrates and glucose control. 42nd American Chemical Society Central Region Meeting, Indianapolis, IN.

18. **B.R. Hamaker**, **P. Rumpagaporn**, **H. Xu**. Fine structural features of cereal arabinoxylans that determine fermentation rate properties. Gums & Stabilizers Conference, Wageningen, Netherlands.

19. **L. Bi**, L. Yang, A. Bhunia, **Y. Yao**. Emulsion-based colloidal systems for prolonged efficacy of epsilon-polylysine. Institute of Food Technologists annual meeting, New Orleans, LA.

20. **S. Janaswamy**. Puzzling polysaccharides-demystifying their three-dimensional structures. Carbohydrate Division Luncheon, Institute of Food Technologists annual meeting, New Orleans, LA.

21. **C. Running**, **B. Patel**, **S. Janaswamy**, **O.H. Campanella**. Effect of salt and sucrose on the functional behavior of iota-carrageenan. Institute of Food Technologists annual meeting, New Orleans, LA.

22. **V. Espinosa-Solis**, **B.R. Hamaker**. Digestion properties of acid-treated mango and plantain starches., Institute of Food Technologists annual meeting, New Orleans, LA.

23. **B.R. Hamaker**. Internationalization of graduate student education in food science Institute of Food Technologists annual meeting, New Orleans, LA.

24. **B.R. Hamaker**. Structure-function modification of cereal arabinoxylans. Institute of Food Technologists annual meeting, New Orleans, LA.

25. **B.R. Hamaker**. Enzyme modification of starch to affect its digestibility. Institute of Food Technologists annual meeting, New Orleans, LA.

26. **B.R. Hamaker**, **B.H. Lee**, **L. Yan**, R. Phillips, T. Powley, K. Kinzig, M. Kushnick. Functional foods containing novel carbohydrates for energy balance and improved health. USDA PI annual meeting, New Orleans, LA.

27. **B.R. Hamaker**, **O.H. Campanella**, **L.J. Mauer**, **M. Fevzioglu**, **M. Goodall**, **D.P. Erickson**. Use of non-wheat cereal proteins as functional viscoelastic polymers. USDA PI annual meeting, New Orleans, LA.

28. **Y. Yang**, G. Zhang, **B.R. Hamaker**, **O.H. Campanella**. Synergistic interaction between alginate and pectin for improved delivery of bioactive food components. Institute of Food Technologists annual meeting, New Orleans, LA.

29. **A. Lin**, B.L. Nichols, R.L. Quezada-Calvillo, D.R. Rose, H.Y. Naim, **B. Hamaker**. Do gut mucosal α-glucosidases participate in native gelatinized starch digestion? Institute of Food Technologists annual meeting.
30. **A. Lin**. An update on starch digestion. Institute of Food Technologists annual meeting, New Orleans, LA.
31. **A. Lin.** Marion G. Priebe. Human and rat studies on carbohydrate digestion and its metabolic consequences. Institute of Food Technologists annual meeting, New Orleans, LA.
32. P.Y. Phoon, M.F. San Martin-Gonzalez, **G. Narsimhan**. Soy protein hydrolysate as emulsifier in retarding oil oxidation in an oil/water emulsion. Institute of Food Technologists annual meeting, New Orleans, LA.
33. **P.H. Santos**, **N.M. Eren**, **O. Campanella**. Rheology of high-pressure homogenized xanthan and locust bean gum solutions. Institute of Food Technologists annual meeting, New Orleans, LA.
34. **Y. Yao**. Designing carbohydrate nanoparticles for food. Institute of Food Technologists annual meeting, New Orleans, LA.
35. **Y. Yao**. Carbohydrate nanoparticle-mediated colloidal assemblies to deliver antimicrobial peptide. Institute of Food Technologists annual meeting, New Orleans, LA.
36. **R. Chandrasekaran**. "Puzzling polysaccharides – De-mystifying their three-dimensional structures" Institute of Food Technologists annual meeting, New Orleans, LA.

August

37. **X. Wu**, **L. Zhou**, C. Mello, R. Nagarajan, **G. Narsimhan**. Conformation of antimicrobial peptide and its role in pore formation. American Chemical Society fall meeting, Denver, CO.
38. **B.R. Hamaker**, **A.H.M. Lin**, **L. Yan**, **B.H. Lee**. Control of glucose delivery to the body and potential physiologic effect. Seoul National University Center for Agricultural Biotechnology Food Science Symposium, Seoul, South Korea.
39. **B.R. Hamaker, A. H-M. Lin, B-H. Lee**, Small intestine a-glucosidases as a control point of glucose delivery to the body. Sejong University, Seoul, South Korea.
40. **B.R. Hamaker**, Imagining new healthy carbohydrate (and protein) food products. Daesang Corporation, Seoul, South Korea.
41. **B.R. Hamaker**, Carbohydrates and health research. CJ Corporation, Seoul, South Korea.

September

42. **T. Wojciechowski**, **C. Weil**. Modifiers of carbohydrate partitioning in maize. Dow Symposium on Biotechnology, West Lafayette, IN.
43. **P. Breen**, J. Palmer, A. DiGiacomo, E. Cotant, **A. Chernyshova**, **R. Davis**, **B.R. Hamaker**, **L. Mauer**, **C. Weil**. Genetic control of starch digestion: better food and fuel. Dow Symposium on Biotechnology, West Lafayette, IN.
44. **O.H. Campanella**. Mechanical properties of materials and their role on the processing of pharmaceuticals and foods. Joseph Fourier University, School of Pharmacy, Grenoble, France.
45. **O.H. Campanella**. Extrusion of biomaterials and pharmaceuticals. Ferring, Lausanne, Switzerland.
46. **O.H. Campanella**. Keynote Speaker, Novel Technologies and Innovation for Food Safety. Saltillo, Mexico.
47. **B.R. Hamaker**. Recent advances on functional carbohydrates for improved health. Conference on Functional Foods, Jiao Tong University, Shanghai, China.
48. **L.J. Mauer**. Center for Food Safety Engineering: overview of research activities. The Sixth International Forum on Food Safety and 2011 Annual Meeting of MOST-USDA Joint Research Center for Food Safety. Shanghai, China.

49. **L.J. Mauer**. Research progress at the Center for Food Safety Engineering, Purdue University. Huazhong University, Wuhan. China.

October

50. **B.R. Hamaker**. Starch digestion – the complexity of structure, digestion rate and physiologic consequence. Starch Roundtable, Palm Springs, CA.

51. **B.R. Hamaker**. Structural features of slow fermenting soluble fibers. Science Café: Carbohydrates and Colonic Health. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

52. **A. Lin**, **B-H Lee**, **B.R. Hamaker**. Small intestinal mucosal α-glucosidases: A missing feature of in vitro digestion models. Science Café: In Vitro Digestion Models for Cereals and Cereal-Based Ingredients. American Association of Cereal Chemists International Annual meeting, Palm Springs, CA.

53. **A. Lin**, B. Nichols, **B.R. Hamaker**. Small intestinal mucosal α-glucosidases have a rate limiting role in starch digestion. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

54. **H. Xu**, **B.L. Reuhs**, **A. Kaur**, E.C. Martens, **B.R. Hamaker**. Structural evidence for the slowly-fermented property of corn arabinoxylans at the human colonic *Bacteroides* level. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

55. **M. Goodall**, **O.H. Campanella**, G. Ejeta, **B.R. Hamaker**. High digestibility, high lysine (HDHL) sorghum grain contains kafirins which participate in the protein network of composite dough and bread. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

56. **B.-H. Lee**, **L. Yan**, R. Phillips, T. Powley, **B.R. Hamaker**. Slow digestion of synthesized highly branched starch-based structures at the mucosal α-glucosidase level suggest slow glucose delivery to the body. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

57. **M. Fevzioglu**, **O.H. Campanella**, **B.R. Hamaker**. Comparison of the secondary structural changes in zein and gliadin with addition of high molecular weight subunits of glutenin (HMW-GS). American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

58. **Z. Sui**, **J.N. BeMiller**. Relationship of the average number of channels per granule of maize starch to the properties of modified starch products. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

59. **A. Kaur**, B. Martin, P. Gillevet, J.A. Patterson, A. Keshavarzian, **B.R. Hamaker**. Effects of variable rate fermenting fibers on luminal and mucosa-associated microbiota in different segments of the large intestine. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

60. **D. Bhopatkar**, **O.H. Campanella**, **B.R. Hamaker**. Solubilization of a hydrophobic component in a soft nanocomplex from starch protein and lipid. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

61. **M. Kale**, **C. Yang**, **O.H. Campanella**, **B.R. Hamaker**. Conformation and aggregation of cereal arabinoxylans in water. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

62. **M. Rahimi**, **O. Campanella**, **B.R. Hamaker**. Extract of *Cephalaria syriaca* is a powerful agent to strengthen wheat dough. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

63. **P. Rumpagaporn**, **B. Reuhs**, **B. Hamaker**. Major determinants of slow fermentation rate in alkali-extractable arabinoxylans and their hydrolyzates from corn, rice, wheat, and sorghum brans. American Association of Cereal Chemists International annual meeting, Palm Springs, CA.

64. **O.H. Campanella**. Keynote Speaker development of physicochemical methods for the study of biomaterials. XIII Argentine Food Science and Technology Congress, Buenos Aires, Argentina.

65. L.A. Wegiel, **L.J. Mauer**, L.S. Taylor. Evaluation of intermolecular interactions in solid dispersions of polyphenols. Federation of Analytical Chemistry and Spectroscopy Societies (FACSS) annual meeting, Reno, NV.

66. L.A. Wegiel, **L.J. Mauer**, L.S. Taylor. Evaluation of intermolecular interactions in solid dispersions of polyphenols. The Ninth Annual Garnet E. Peck Symposium in Industrial Pharmacy, West Lafayette, IN.

November

67. **B.R. Hamaker**, **A. Lin**. Update of Whistler Center Carbohydrate Research related to human health. National Taiwan University, Taipei, Taiwan.

68. **B.R. Hamaker**, **P. Rumpagaporn**, **H. Xu**. Polysaccharide structures to control colonic fermentation rate. International Conference on Food Factors (ICoFF), Taipei, Taiwan.

69. **A. Lin**. Are small intestine mucosal-glucosidases the final control point of dietary glucose production from starchy foods? International Conference on Food Factors (ICoFF), Taipei, Taiwan.

70. **B.R. Hamaker**, **A. Lin**, **L. Yan**, **B.-H. Lee**, **P. Rumpagaporn**, **H. Xu**. Carbohydrates and health – a perspective from the Whistler Center. International Conference on Food Factors (ICoFF), Taipei, Taiwan.

71. **B.R. Hamaker**, **A. Lin**, **L. Yan**, **B.-H. Lee**, **P. Rumpagaporn**, **H. Xu**. Controlling digestion rate of dietary glycemic carbohydrates for improved health outcomes. SLACA biennial meeting, UNICAMP, Campinas, Brazil.

72. **B.R. Hamaker**. Nanocomplex-based delivery systems. Joint NIH and USDA Workshop on Using Nanotechnology to Improve Nutrition Through Enhanced Bioavailability and Efficacy, Bethesda, MD.

73. **O.H. Campanella**. Only speaker - international course. International Conference in Rheology and Extrusion, Universidad de la Molina, Lima, Peru.

December

74. **B.R. Hamaker**. Control of starch digestion. 50 Years of congenital sucrase-isomaltase deficiency disease. Starch Digestion Consortium Workshop: 50 Years of Progress since Congenital Sucrase Isomaltase Deficiency (CSID) Recognition, USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, Texas..

75. **A. Lin**. Digestion of limit dextrin. Starch Digestion Consortium Workshop: 50 Years of Progress since Congenital Sucrase Isomaltase Deficiency (CSID) Recognition, USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, Texas.

76. **B.-H. Lee**, R. Quezada-Calvillo, B. Nichols, D. Rose, **B.R. Hamaker**. Inhibition of maltase-glucoamylase activity to hydrolyze α-1,4 linkages by the presence of undigested sucrose. Starch Digestion Consortium Workshop: 50 Years of Progress since Congenital Sucrase Isomaltase Deficiency (CSID) Recognition, USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, Texas.

E. GRADUATE DEGREES AWARDED

1. **Pinthip Rumpagaporn, Ph.D.,** Structural Features of Cereal Bran Arabinoxylans Related to Colon Fermentation Rate, May.

2. **Mirwais Rahimi, M.S.,** Dynamic Rheological Properties of Wheat Dough Supplemented with Extract of Cephalaria syriaca and Characterization of Active Components Responsible for Wheat Dough Strengthening, May.

3. **Bicheng Wu, M.S**., Tomato Product Viscosity, August.

4. **Cordelia Running, M.S.**, Structural and Functional Changes in Iota-Carrageenan Upon Addition of Salts and Sweeteners, December.

5. **Dawn Dahl, M.S.**, Maize Starch Cross-Linked With Sodium Trimetaphosphate, December.
6. **Lin Bi, Ph.D.**, Carbohydrate Nanoparticle-Based Delivery System as Carrier to Prolong the Efficacy of Antimicrobial Peptides, December.
7. **Paulo H.S. Santos, Ph.D.,** Mechanical Characterization and Computational Modeling of Gels, December.

F. RECOGNITIONS, AWARDS, AND HONORS

1. **Amanda Deering**, **Brad Reuhs**, and **Lisa Mauer's** work was highlighted in the August 17, 2011 weekly newsletter from IFT.
2. **Amy Lin,** Outstanding Volunteer Award, IFT Carbohydrate Division.
3. **Amy Lin,** Young Investigator Award, International Conference on Food Factors (ICoFF), Taipei, Taiwan.
4. **Paulo Santos**, M.A. Carignano, **Osvaldo Campanella,** Best Paper Award in the International Conference in Engineering and Foods 2011 (ICEF11), Greece May 2011.
5. **Osvaldo H. Campanella.** Agricultural and Biological Engineering Best Teacher Award in Engineering, 2011.
6. **Lisa Mauer**, appointed interim director of the Center for Food Safety Engineering, Purdue University.
7. **Rebecca Lipasek** among the graduate students teaching assistants honored at the 13th Annual Celebration of Graduate Student Teaching Excellence. Rebecca received one of the "Committee for the Education of Teaching Assistants Excellence in Teaching" awards.
8. **Byung-Hoo Lee** attended "Discover Novozymes" workshop. Did a team project on how to optimize the enzyme combination for increasing product yield.
9. **Yuan Yao,** granted tenure and promoted to Associate Professor
10. **Lisa Mauer,** promoted to Professor
11. **Byung-Hoo Lee's** presentation "Slow digestion of synthesized highly branched starch-based structures at the mucosal α-glucosidase level suggest slow glucose delivery to the body" was awarded third place in the 2011 American Association of Cereal Chemists International Best Student Research Paper Competition.
12. **Madhuvanti Kale**, Spring 2011 Food Science Outstanding Teaching Assistant Award.
13. **C. Weil,** Purdue University "Millionaire's Club" for grant awards over $1 million.
14. **C. Weil,** Chair, American Society for Plant Biology, Midwest Section.

Whistler Center Short Course, October 10-12, 2011

The Center offered a three-day Short Course October 10-12, 2011. 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.

Monday Sessions:

1. Introduction to structures and properties of polysaccharides, J. BeMiller
2. Polysaccharide architecture, S. Janaswamy and 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

Tuesday and Wednesday Breakout Sessions:

8. Advances in modification of starch properties, J. BeMiller
9. Beverage emulsions, G. Narsimhan and S. Janaswamy
10. Carbohydrate nutrition 101, B. Hamaker
11. Rheology of hydrocolloids, M. Kale and O. Campanella
12. Fine structure analysis and genetic modification of starch, Y. Yao, C. Weil
13. Water relations: mechanisms, approaches, and applications, S. Schmidt, L. Mauer
14. Dietary fiber/prebiotics and colon function, A. Kaur and B. Hamaker
15. Hydrocolloids as thickeners, gelling agents and emulsifiers, P. Williams
16. Glycemic carbohydrates, B. Hamaker, A. Lin
17. Polysaccharide architecture and functionality including starch, S. Janaswamy and R. Chandrasekaran
18. Complex carbohydrate-structure analysis (non-starch), B. Reuhs

BELFORT LECTURE

2011 Belfort Lecturer
Dr. Geoff Fincher

Dr. Geoff Fincher gave his May 2011 presentation "Fine structure of polysaccharides from plant cell walls: from human health to biofuel production". He received his Ph.D. in Biochemistry at the University of Melbourne, and is the Professor of Plant Science at the University of Adelaide and the Director of the newly established Australian Research Council Centre of Excellence in Plant Cell Walls. The CoE has additional nodes at the University of Melbourne and the University of Queensland, together with several overseas partner organizations (http://www.adelaide.edu.au/plant-cell-walls/). Dr. Fincher is also the leader of a new CSIRO Food Futures Flagship Cluster on 'High Fibre Grain". He was Director, Waite Agricultural Research Institute and Deputy CEO, Australian Centre for Plant Functional Genomics (2003-2010); Director, GRDC Program on Functional Genomics in the Growth and End-use Quality of Cereals (2000-2004); Deputy Dean, Faculty of Sciences (2002-2003); Professor of Plant Science, University of Adelaide, Head of Department of Plant Science (1993-2011)