WHISTLER CENTER
for Carbohydrate Research

ANNUAL REPORT

2013

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

In Memoriam

Struther Arnott

The scientific world and the field of fiber crystallography have lost a major figure with the passing of a respected and beloved colleague, Professor Struther Arnott, aged 78, on April 20, 2013, at his residence in Doncaster, a small market town in south Yorkshire, England. Motivated by curiosity, drive, and enthusiasm, Dr. Arnott was internationally acclaimed for his meticulous research projects and scrupulous contributions to the three-dimensional structures of nucleic acids, polypeptides, and polysaccharides. He also took up challenging administrative positions of increasing complexity—Department Head, Dean of Graduate School, Vice President for Research, and University Principal—throughout a rich professional career.

Dr. Arnott was born on September 25, 1934, in Larkhall, Scotland. He received exemplary high school education at the Hamilton Academy during 1945-1952, where he earned top honors, including the Academy's Gold Medal for General Scholarship and Silver Medal in Chemistry and Mathematics. He was also the winner of the first science place in the University of Glasgow Open Bursary Competition in 1952. Subsequently, he graduated from the University of Glasgow with a B.Sc. in Chemistry and Mathematics in 1956 and a Ph.D. in Chemistry in 1960. His doctoral dissertation examined the x-ray structure of limonin – the bitter principle of citrus fruits, a complex molecule by any means – under the tutelage of the renowned Dr. John Robertson.

In the early 1950s, x-ray diffraction patterns from the genetic material obtained at King's College, London, were staples for assiduous scientists striving to decipher DNA morphology. Along these lines, the young and enthusiastic crystallographer Dr. Arnott moved on to King's College in 1960 to join Dr. Maurice Wilkins. In the following 10 years there, Dr. Arnott formulated the required methodology and established for the first time the precise atomic details of the DNA double helix. The groundbreaking results were published in a series of scientific articles between 1965 and 1968.

Dr. Arnott then came to the U.S. in 1970 with a professorship in the Department of Biological Sciences, Purdue University. He was appointed Department Head in 1975. With admirable administrative skills that paralleled his scientific abilities, it is no surprise he was appointed Vice-President for Research and Dean of the Graduate School - a dual position – from 1980 to 1985. He served as a mentor for many graduate students and post-doctoral researchers. At the same time, he expanded the scope of fiber diffraction from nucleic acids to gelling polysaccharides and was recognized as the most scrupulous fiber diffractionist in the field.

In 1986, Dr. Arnott returned to the United Kingdom as Principal and Vice-Chancellor at St. Andrews University, Scotland, where he served until the end of 1999. (His departure from Purdue University coincided with the establishment of the Whistler Center for Carbohydrate Research. Two scientists from his fiber diffraction group – R. Chandrasekaran and Rick Millane – were the first to be hired into faculty positions by the Center's Director – J.N. BeMiller.) During his tenure at St. Andrews University and beyond, Dr. Arnott retained strong ties with the Whistler Center as Adjunct Professor and participated in joint research that led to seminal journal publications. Even after his "retirement" he fervently continued tackling certain longstanding problems by collaborating with scientists at London's Imperial College as well as the University of London's School of Pharmacy.

In appreciation of a remarkably rich professional career, Dr. Arnott was honored with accolades: Fellow of the Royal Society in 1985, Royal Society of Edinburgh in 1988, Commander of the British Empire in 1996, and an Honorary Doctorate from Purdue University in 1998, amongst others. Throughout his professional life, Dr. Arnott inspired his colleagues and pupils with enthusiasm for the subject and the academic world in general. With his unfailing impeccable suit and smiling face, he was always a vivid person blessed with a knack for engaging in intelligent conversations with peers, students and children of all ages; the pleasant get-togethers over the years have left indelible impressions and inspirations forever.

Dr. Arnott is survived by his lovely wife Dr. Greta Arnott, their two sons and grandchildren. He is sorely missed.

R. Chandrasekaran

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DIRECTOR'S STATEMENT

Welcome to our 2013 Whistler Center annual report. From our perspective, we continue to see big interest in food carbohydrates and how they can be used in foods for improved quality involving nutrition and health, as texturants, and carriers and functional agents. We are pleased to be part of the action in this area. Our 12 faculty members with expertise ranging from fundamental carbohydrate science to the applied sciences interface with nutrition and clinical disciplines, engineering, pharmaceutical sciences, and with over 80 total scientists and staff in the Center last year, we feel well positioned to generate meaningful and translational science to the carbohydrate-utilizing industry, to other disciplinary communities, and to the consuming public. We have reached out and formed the beginnings of partnerships in South Korea at Sejong University, in China at Shanghai Jiao Tong University and Jiangnan University, in Taiwan at National Taiwan University; and continue our partnership with the International Complex Carbohydrate Consortium that is affiliated with the new Elsevier journal "Bioactive Carbohydrates and Dietary Fibre". Our vision of such partnerships is to complement what we lack in expertise and skill and to address larger and more complex problems in the carbohydrate area. We would like to be the place where companies and other entities come for carbohydrate problems to be solved, and with our partners, to work towards their solution.

We are an industry member-based university center and in 2013 were pleased to have Kraft Foods join. As usual, we had a variety of activities over the year. In May at our Technical Conference following our annual Board Meeting, we were honored to have Prof. Jay-Lin Jane give the Belfort Lecture containing highlights of her long and distinguished work in the starch chemistry and application field. With the help of faculty member Dr. Amy Lin, we organized and participated in a number of symposia at national and international meetings. In the area of carbohydrates, nutrition and health, there is growing interest in both how glycemic carbohydrates can be made healthier and how dietary fibers might be used to improve colon and related whole body health. We are active in these research areas and have become a part of the dialogue going on about them.

In the fall, we put on our yearly 3-day Short Course which is free for our member company participants. After a first day review of carbohydrate chemistry, structure, function and nutrition; in-depth half-day sessions are provided that in 2013 spanned 13 topics ranging from starch modification to water relations, extrusion rheology, nutrition and health, and others. Our intent is to provide state-of-the-art information and a view, where applicable, of where we see an area is going. We had two guest speakers, John McCrorie from Proctor & Gamble Co. who spoke on gastrointestinal tract physiology, movement and digestion; and John Keller on hydrocolloids and functionality. After many years now of conducting the Short Course, we continue to have high attendance. We seek for ways to improve content and delivery.

As we look ahead, there are continued challenges facing the Whistler Center, and other like Centers. Research funding continues to be sparse at the federal and state levels, and we need to find new ways to build alliances to gain important research advances. Whether that comes from industry or through avenues such as foreign partners remains to be seen. We undoubtably will continue to be successful at the federal funding level, but we must be more innovative in finding resources than before.

Please take a look at our 2013 Whistler Center Annual Report and see what we do. If you have questions of would like to know more about our Center, feel free to contact either myself of Marilyn Yundt, Center Coordinator.

Sincerely,

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

Starches, Non-Starch Polysaccharides, and Cereals:

Dr. BeMiller and his Visiting Faculty and Scientists continued studies of the impacts of the presence of hydrocolloids on the pasting, paste, and gel characteristics of starches by focusing on any effects of the presence of a hydrocolloid on granule swelling (Project 1).

Drs. Campanella and Hamaker have initated a new project to better understand the structural properties of branched starches and their functional properties, relevant to processing as well as their digestion (Project 5).

In another project of **Dr. Hamaker**, fibers from amaranth, quinoa and three cereals were pre-treated to increase soluble fiber content that resulted also in higher *in vitro* fecal fermentation. Improved fermentative property appeared to be dependent not only on the solubility of the fiber, but also the state of the insoluble fiber portion.

Drs. Hamaker and Campanella's group continued to work on fundamental approaches to functionalize non-wheat cereal storage proteins, with a focus on corn zein. In 2013, D. Erickson completed a study systematically examining change in structure and function of zein in the presence of a plasticizer versus a co-protein. A project was also initiated with collaborator S. Keten at Northwestern University using molecular dynamics simulation to understand zein peptide segments that may participate in viscoelastic fibril formation (Project 9).

Dr. Yao's work in 2013 has mostly been on functional carbohydrate biomaterials, with particular focus on the stabilization and dissolution of active ingredients, including: antimicrobial compounds (Project 40), food nutrients and nutraceuticals (41, 42), and active pharmaceutical ingredients (43).

Carbohydrates, Nutrition and Health:

Dr. Hamaker's research activities have increased in recent years in the area of carbohydrates and health. His group's two main focal areas are: 1) glycemic carbohydrates and physiological response (Projects 12, 13) and 2) dietary fiber and colon and related whole body health (Projects 10, 11). These address large questions of how carbohydrate foods can be designed, or identified, that deliver better health and, as such, involve extensive collaborations. Close to home, collaborators in the Whistler Center are Brad Reuhs for fiber structural analysis and Osvaldo Campanella for rheological considerations; and, in the Department of Food Science, Mario Ferruzzi for an expanding area of phytochemicals and their impact on glucose delivery to the body. In animal studies related to slowly digestible starch materials and effect on the ileal brake and gut-brain axis, they have had collaborators at Purdue: T. Powley, R. Phillips, and K. Kinzig at the Department of Psychological Sciences; and M. Kushnick at Ohio U. Elsewhere, they work with a multi-disciplinary group called "Starch Digestion Consortium" consisting of A. Lin at Purdue, B. Nichols at Baylor College of Medicine, R. Quezada-Calvillo in Mexico, D. Rose and M. Pinto in Canada, and H. Naim in Germany. In the area of dietary fiber and colon health, they work with A. Keshavarzian and group at Rush Medical School, Chicago, and E. Martens at U. Michigan Medical School, Ann Arbor.

In their glycemic carbohydrate research, they last year finished a long-term rat study examining the effect of consumption of slowly digestible starch over an 8-week period on food intake habits and appetite regulating neuropeptides in the hypothalamus. They found that slow digestion with distal glucose release in the small intestine resulted in smaller meals and ultimately by week 11, lower food intake. This coincided with a significant drop in appetite-stimulating hormones. Since then, they have been working on limited funds to begin new collaborations to identify location in the small intestine of glycemic carbohydrate digestion and glucose release. This is of interest, as they wish to determine the optimal location and amount at location for a notable positive physiological response. They also continued our work in 2013 using the α-glucosidases on: 1) alpha-linked disaccharides and their digestion kinetics on the four enzymes, where they found that maltase has a broader range of ability to digest other alpha-linked Glc-Glc and Glc-Fru disaccharides, and 2) polyphenols that they found selectively inhibit different of the α-glucosidases (Project 12).

In dietary fiber research related to the colon and microbiota, they continued work on discrete structural parts of fiber polymers to understand specificity to bacterial strains, and towards understanding of preference of colonic bacteria for different fibers (Project 11). Also, they have begun work towards using dietary fiber mixtures to address barrier function problems.

In a Bill and Melinda Gates Foundation funded project, they completed, with co-PIs B. Nichols (Baylor College of Medicine) and A. Rahmanifar (nutrition advisor), a study on stunted children in Bamako, Mali showing that the α-glucosidases function at a somewhat higher level in stunted than normal children and correspondingly allow them to digest local thick sorghum porridges well (Project 14).

Dr. Lin's research focuses on starch chemistry and its nutritional aspects, with the emphasis on glycemic response management from the food science perspective. In 2013, the second year of Lin's faculty appointment, she established a small research group with one Master's student, four undergraduate students (different time periods), and three visiting scientists (different time periods). She continues collaboration with other members of the Starch Digestion Consortium as mentioned above. The long-term goal of her research is to improve human health and prevent diseases of the general population related to glycemic carbohydrates by providing solutions for problems related to starch digestion rate and location of delivery from the starch chemistry prospective.

In 2013, they finished a study examining the relationship between branch pattern of α-amylase hydrolysates and α-glucogenesis (Project 23), and moved on to characterize the branch fraction, which may release glucose slowly and provide sustained energy (Project 24). They are also studying the α-amylase hydrolyzates obtained from commonly used starches (Project 25) in order to provide the food industry a database for selecting proper starchy materials for producing starchy foods. Lin's group also continues studying starch digestion *in vivo* (Project 26), with collaborators using both healthy and Mgam-null mice. They published part of their findings showing that maltase-glucoamylase contributes to high efficiency activity on *ad libitum* intakes and modulates gluconegogenesis, while sucrase-isomaltase dominates starch digestion glucogenesis on *ad libitum* diets (Figure 1). The current goal of that project is to elucidate the structure of a slowly digestible fraction from granular starch in mice, and to examine the individual digestion roles of maltase-glucoamylase and sucrase-isomatase *in vivo*. Lin's group also improved methodology on quantification of α-amylase hydrolysates (Project 27) and are working on improvement of the measurement of starch digestibility *in vitro* (Project 28).

Polysaccharide Structures:

Dr. Janaswamy's research demonstrates the use of food grade polysaccharide fibers toward the design and development of cost-effective carriers of nutraceuticals, drugs and antimicrobial compounds. The research idea is about solubilizing active molecules in organic solvents and then encapsulating them in the water pockets of fiber networks. Their study on the effect of organic solvents (ethanol, acetone, triacetin, propylene glycol and isopropanol) on encapsulation efficiency and release profiles of nutraceuticals employing sodium iota-carrageenan and eugenol as representatives of a polysaccharide and nutraceutical, respectively, revealed the influence of organic solvents on iota-carrageenan network arrangement and associated encapsulated amounts (Project 15). Sustained release of eugenol is noticed from the complexes prepared using acetone. In another study, they showed that iota-carrageenan fibers encapsulated with eugenol are effective in controlling the proliferation of foodborne pathogens *e. g. Escherichia coli* and *Listeria monocytogenes* (Project 16). Their systematic study on the structure-function relationships of sodium kappa-carrageenan in the presence of NaI, NaBr and NaCl shows (Project 17) that iodine ions are effective in controlling the aggregation of kappa-carrageenan helices towards yielding organized and crystalline networks. This novel finding indeed aids in solving the three-dimensional structure and gaining knowledge about the kappa-carrageenan junction zone architecture that were absent for several decades.

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-bond, 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. Current research is also being done to investigate the relationships between the nanoscale mechanical properties of biopolymer structures and their macroscale attributes, which will contribute a greater understanding of structure-function relations. Ultimately, the aim of this research is to understand both fundamental physical interactions and improved methods for the formation of functional, food-compatible structures. Currently investigated structures include protein fibrils (Projects 18, 19) and block ionomer complexes assembled from modified polysaccharides (Project 22).

Protein fibrils assembled from β-lactoglobulin show excellent promise for improved mechanical properties and as scaffolds for controlled release or enzymes. The greatest challenge in β-lactoglobulin fibril research is the production of stable fibrils in non-acidic conditions and the production/isolation of fibrils in an industrially relevant mechanism. Project 18 is currently investigating means to isolate fibrils in either acidic or neutral conditions so as to improve their relevance to the industry. Project 19 involves the production of an improved gel or film using the fibrils and polysaccharide. Funding is currently being sought to facilitate these investigations.

Protein microgels (particulate agglomerates with diameter between 50 and 600 nm) may be formed from whey protein using thermal treatment; alternatively, protein nanoparticles are crafted from poorly soluble proteins, such as zein, using solvent nanoprecipitation techniques. Control of formation using specific ions in solution is being currently investigated within Project 20. Microgels are proposed to impart textural control in fractal networks or to serve as particle-based stabilizers of interfaces susceptible to Ostwald ripening (Project 21).

Rheology:

Dr. Campanella's projects involve physicochemical characterization of biomaterials including food and non-food materials. They include properties associated with the formation of structures, e.g. during gelling, interaction of polymeric molecules with colloidal particles, self-assembling of biomolecules, and the structure of fiber and their relevance for the incorporation of fibers into foods. The role of these physicochemical properties is also analyzed in regards to material processability. Changes in proteins structures and their functions by changes in temperature, addition of other macromolecules such as co-proteins are being studied using rheological and spectroscopic techniques (e.g. circular dichroism, FTIR) and microscopy. Properties of these composite systems such as glass transition, and their structures, and how they affect the material's functional properties are being studied. Results of this research have an impact on the area of development of new materials and improved foods with good nutritional and textural quality (Projects 2-8).

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 food ingredients. Given the complex nature of biomaterials composition and the various conditions to which they are exposed during processing and storage, stability, functionality and quality under different external and processing conditions are key attributes that deserve attention and are being investigated by Dr. Campanella's group. Glass transition is a phenomenon of significance in the area of food engineering and science, thus methodologies used to accurately characterize this property are essential to understand how composition affect glass transition. In these projects rheological, thermophysical, spectrocopical and microscopical methods are also being developed to study the effects and use of ingredients that can improve the functionality of some cereal proteins, like for example zein and small particles polymeric molecules in solutions. Model systems are 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 mechanistic frameworks for approaching these systems by highlighting structure/function relationships.

With B. Hamaker, novel physicochemical and rheological methods are being developed to monitor the formation and stability of nanocomplex formed by the interaction of starch, protein and fatty acids (Project 3). Thermodynamic analysis performed on data obtained with differential scanning calorimetry (DSC) demonstrated that the formation of the three-component nanoparticle is a thermodynamically possible process leading to a thermodynamically stable system. Dispersion of these nanoparticles in suitable solvents are stable non-emulsion systems. Physicochemical data, complemented with microscopy studies clearly showed the presence of nanostructures with regular rod shapes. Molecular modeling to study the formation of amylose-like molecules with fatty acids, in the presence and without the presence of proteins, the three component system (amylose, fatty acid and protein) and the three component binding a four hydrophobic component have been studied using molecular modeling.

Rheological characterization of nano-systems and the effects of colloidal particles on formation and properties of these systems are being studies using experimental methods (rheology, dynamic laser scattering (DLS), atomic force microscopy (AFM)) and molecular simulations. Results are showing a significant interaction between the particles forming the suspension (silica) and the polymeric sytems (e.h proteins) which in general results in increases of their viscoelasticity and viscosity (Project 2).

Rheology of food ingredients are also investigated. Pectin is one major component of plant cell walls and is used extensively as a functional food ingredient in a large number of products. The molecular structure and sugar composition of pectins affect their functionality, thus limiting commercial pectin production to a few plant sources. Specifically degree of methoxylation, degree of acetylation, pattern of methyl esterification, and molecular size determine the functional properties of pectins. Rheological measurements are of primary concern due to the importance of texture in assessing quality attributes of food products containing pectin. Analyzing the rheological profile of juice, serum, and particulate of these different varieties is helping to elucidate the impact of pectin methoxylation on the viscoelastic properties of many foods (Project 4).

Methods to characterize properties that are relevant to the texture of viscoelastic materials are being developed (Project 6). Related to this project and also to Project 5 is Project 8, which is aimed on the characterization on single polysaccharides molecules.

Interfacial Phenomena:

Dr. Narsimhan's group continues to work on fundamental aspects of formation and stability of emulsions (Project 33) and foams. To complement the previous experimental and theoretical studies on unfolding of model proteins on nanoparticle surfaces, they are investigating pore formation in microbial cell membranes by antimicrobial peptides (Projects 31, 32).

Chemical Structures and Functions of Polysaccharides:

Dr. Reuhs and A. Terekhov run an analytical core facility at the Whistler Center dedicated to complex carbohydrate structural analysis. With O. Campanella and B. Hamaker, the group studies non-starch polysaccharide structures and their function related to physical functionality (described under Rheology), as well colon fermentation also described above (Project 11). Analysis typically involves monosaccharide profiling using the alditol acetate GC method, and linkage analysis by partial methylation using GC-MS and using NMR. Chromatography methods are used to profile molecular size and as a preparative technique.

Genetics:

Dr. Weil's lab now has a mutant population (~12,000 lines) of the important staple crop Sorghum bicolor. ~600 of these lines have been fully resequenced to cataolgue all the mutations present in each. This database and seed for each mutant line are available to breeders worldwide. Novel mutations are already emerging from these data. The mutants in these lines include those that improve the digestibility of the cooked sorghum flour and they are characterizing these further (Project 34).

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 38). 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 lines they have identified three QTL for increased sugar content and they are now focused on identifying the genes underlying these QTL that impact sugar accumulation. In addition, they are pursuing a reverse genetic strategy to knock out specific invertase enzymes to increase stalk sugar.

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. The Weil lab has now identified over 300 new mutants that impact carbon partitioning in maize. Mapping populations have now been made for these mutants, over 50 of them are mapped to candidate intervals in the maize genome and the genes are being pursued. The remaining mutants will be mapped this summer (Project 37).

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

The Weil lab has continued to characterize mutant lines of corn that show altered starch digestion (Projects 34, 35) 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. Another inbred has a more rapidly digested uncooked starch, which has potential as an improved poultry feed ingredient. They are identifying the genes responsible for both these changes 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.

STAFF DIRECTORY

Faculty

James N. BeMiller	Professor Emeritus	bemiller@purdue.edu
Osvaldo H. Campanella	Professor	campa@purdue.edu
R. Chandrasekaran	Professor	chandra@purdue.edu
Bruce R. Hamaker	Professor/Director	hamakerb@purdue.edu
Srinivas Janaswamy	Research Assistant Professor	janaswam@purdue.edu
Owen G. Jones	Assistant Professor	jones@purdue.edu
Amy Hui-Mei Lin	Research Assistant Professor	amylin@purdue.edu
Lisa J. Mauer	Professor	mauer@purdue.edu
Ganesan Narsimhan	Professor	narsimha@purdue.edu
Bradley L. Reuhs	Associate Professor	breuhs@purdue.edu
Clifford F. Weil	Professor	cweil@purdue.edu
Yuan Yao	Associate Professor	yao1@purdue.edu

Visiting Professors

Edith Agama Acevedo	Hamaker	eagamaac@purdue.edu
Tao Feng	Campanella/ Hamaker/BeMiller	(January – August)
Li Guo	BeMiller/Lin	guo237@purdue.edu
Yuzhi Jiao	Lin	(January – July)
Kyeongyee Kim	Hamaker/Campanella	kim1673@purdue.edu
Xiaolei Li	Hamaker	li1545@purdue.edu
Xiaoxi Li	Hamaker/Campanella	li1493@purdue.edu
Miao Ming	Hamaker	miao20@purdue.edu
Luis Arturo Bello Perez	Hamaker	lbellope@purdue.edu
Yang Wang	Weil	wang1875@purdue.edu
Guangfeng Wu	Hamaker	wu511@purdue.edu
Genyi Zhang	Hamaker	(June – August)

Visiting Scientists

Mustapha Benmoussa	Hamaker	mbenmous@purdue.edu
Wei-Jen (William) Chang	Lin	chang267@purdue.edu
Wonjun Jung	Hamaker	(January – April)
Juliane H. Lamarino	Campanella	(February – August)
Sunyoung Lee	Hamaker	lee1695@purdue.edu
Alejandra Mencia	Yao	amguevar@purdue.edu
Xiang Ning	Narsimhan	xiangn@purdue.edu
Livia Ostroschi	Campanella	(January – June)
Filipe M. Piccinelli	Campanella	(Feburary – August)
Carolina Bassi Samel	Campanella	(February – August)
Karine Scharanck	Campanella	(Janauary – March)
Yu-Ting Tseng	Yao	(January – April)
Lan Yao	Yao	yao66@purdue.edu
Chengrong Wen	Janaswamy	wen46@purdue.edu
Haining Zhuang	BeMiller	(January – August)

Ph.D. Students

Mohammad Chegeni	Hamaker	mchegeni@purdue.edu
Hua Chen	Yao	(January – December)

Tingting Chen	Hamaker	chen921@purdue.edu
Fatima Cisse	Hamaker	fcisse@purdue.edu
Juan Du	Jones	du2@purdue.edu
Marwa El Hindaway	Hamaker	melhinda@purdue.edu
Necla Mine Eren	Campanella	neren@purdue.edu
Daniel Erickson	Hamaker/Campanella	derickso@purdue.edu
Fang Fang	Campanella/Hamaker	ffang@purdue.edu
Mehtap Fevzioglu	Campanella/Hamaker	(January – July)
Madhuvanti Kale	Hamaker/Campanella	(January – May)
Like Hasek	Hamaker	yan@purdue.edu
Lisa Lamothe	Hamaker	llamothe@purdue.edu
Kin Lau	Weil	lau3@purdue.edu
Na Li	Mauer	li416@purdue.edu
Yuan Lv	Narsimhan	lv10@purdue.edu
Ryan Murphy	Jones	murph170@purdue.edu
Xin Nie	Hamaker/Reuhs	nie3@purdue.edu
Preetam Sarkar	Yao	psarkar@purdue.edu
Leigh Schmidt	Hamaker	lcrschmidt@purdue.edu
Meric Simsek	Hamaker	msimsek@purdue.edu
Rándol J. Rodríguez	Yao	rodrigrj@purdue.edu
Yunus Tuncil	Hamaker	ytuncil@purdue.edu
Xi Wu	Narsimhan	wu403@purdue.edu
Ying Xie	Yao	xie96@purdue.edu

M.S. Students

Matthew Allan	Mauer	mallan@purdue.edu
Seda Arioglu	Mauer	sarioglu@purdue.edu
Belinda Christiana	Mauer	bchristi@purdue.edu
Jay Gilbert	Jones	gilber26@purdue.edu
Stacey Hirt	Jones	(January – December)
Carl Littrell	Campanella	clittrel@purdue.edu
Krystin Marrs	Mauer	marrsk@purdue.edu
Anbuhkani Muniandy	Lin	amunian@purdue.edu
Lohit Myneedu	Janaswamy	lmyneedu@purdue.edu
Beth Pletsch	Hamaker	epletsch@purdue.edu
Julia Ana Steen	Campanella/Hamaker	jsteen@purdue.edu
Stephany Tandazo	Campanella/Hamaker	atandazo@purdue.edu
Laura Zimmerer	Jones	(January – December)

Ph.D. Post-Doctoral Research Associates

Choon Young Kim	Hamaker	kim410@purdue.edu
Byung-Hoo Lee	Hamaker	lee9@purdue.edu
Xiqing Ma	Weil	ma244@purdue.edu
Bhavesh Patel	Campanella/Hamaker	patel46@purdue.edu
Xiaoyu Wu	Narsimhan	xwu@purdue.edu

Staff

Anton Terekhov	Managing Director of NMR /Carbohydrate Specialist	aterekho@purdue.edu
Marilyn K. Yundt	Administrative Coordinator	yundt@purdue.edu

James N. BeMiller

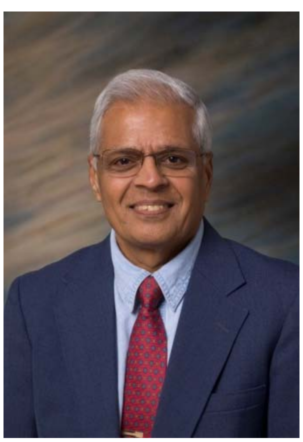
GENERAL RESEARCH AREAS
- Starch
- Carbohydrate chemistry

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

Osvaldo H. Campanella

GENERAL RESEARCH AREAS
- Process modeling
- Rheology of Biomaterials
- Structure and Physico Chemical of Materials and their relations with functional properties
- Extrusion

SPECIFIC RESEARCH AREAS
- Application of rheology to food science and food engineering
- Mathematical modeling of food process operations
- On-line rheological techniques
- Rheology of biomaterials
- Dough rheology
- Rheology of dairy products
- Characterization of material structure and texture; relationship to rheological properties
- Effect of glass transition on product texture
- Extrusion; role of rheology in the extrusion process



R. Chandrasekaran

GENERAL RESEARCH AREAS
- X-ray diffraction
- Molecular architecture of biopolymers

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

Bruce R. Hamaker

GENERAL RESEARCH AREAS
- Carbohydrates and health
- Starch
- Cereal chemistry and functionality

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

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 G. Jones

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

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

Amy Hui-Mei Lin

GENERAL RESEARCH AREAS
- Starch chemistry
- Carbohydrates and human health

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

Lisa J. Mauer

GENERAL RESEARCH AREAS
- Food chemistry
- Water-solid interactions

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

Ganesan Narsimhan

GENERAL RESEARCH AREAS
- Emulsions and foams
- Biopolymer interactions

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

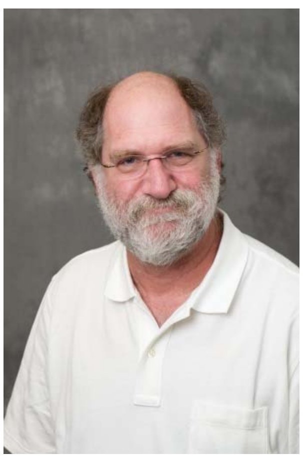
Bradley L. Reuhs

GENERAL RESEARCH AREAS

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

SPECIFIC RESEARCH AREAS

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



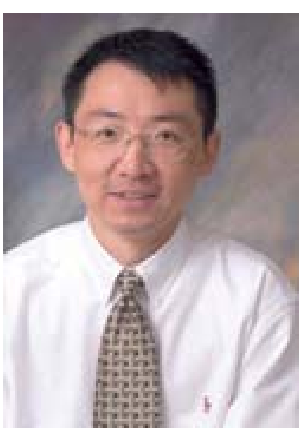
Clifford F. Weil

GENERAL RESEARCH AREAS

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

SPECIFIC RESEARCH AREAS

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



Yuan Yao

GENERAL RESEARCH AREAS

- Biomaterials and carbohydrate chemistry
- Food nanotechnology

SPECIFIC RESEARCH AREAS

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

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

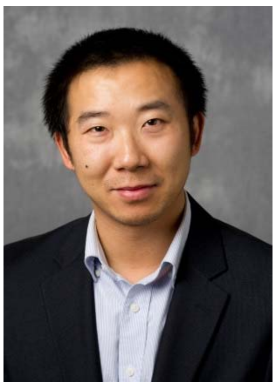
GENERAL RESEARCH AREAS
- Polymers, colloids and surfactants
- Self-assembly biopolymers
- Nanotechnology

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.

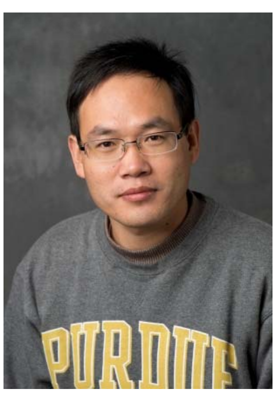
Sakharam K. Patil, Ph.D. is President of S.K. Patil and Associates. Dr. Patil was awarded a Ph.D. degree in Cereal Science by Kansas State University in 1973. He held several positions at American Maize Products Co., later Cerestar, from 1978 until his retirement in 2002. The positions included VP Marketing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

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



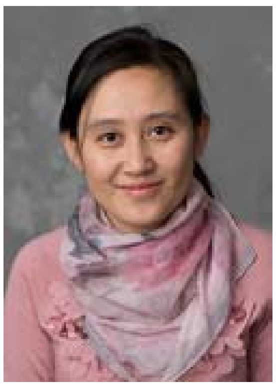
Tao Feng earned his Ph.D. in Food Science from Jiangnan University of China in June 2007. He is an Associate Professor at Shanghai Institute of Technology in China and has returned there. He arrived at Purdue University May 2012 as a visiting faculty in Food Science and worked with Drs. Hamaker, Campanella, and BeMiller. His research focused on molecular dynamics simulation of soluble nanoparticles self-assembled by amylose, beta-lactoglobulin (dimer) and free fatty acids and the effects of hydrocolloids on the pasting, paste, and gel properties of crosslinked starch.

Li Guo received a Ph.D. degree (2010) in the Key Laboratory of Tea Biochemistry and Biotechnology, Anhui Agricultural University, studying primarily tea polysaccharides, and is currently an Associate Professor in the School of Tea and Food Sciences of the same university. She is assisting Dr. BeMiller.

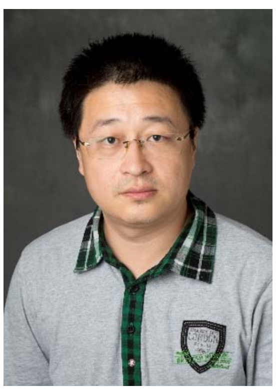


Yuzhi Jiao earned his M.S. in Food Science from Jiangnan University of China in June 2004. He is currently an Associate Professor at Jiangsu Food Science College in China. Yuzhi was a visiting faculty in the Food Science Department and was advised by Dr. Amy-Lin. His research focused on polysaccharide modification.

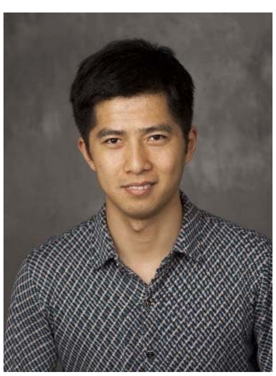
Kyeongyee Kim is a Professor in the Department of Food Science and Biotechnology of Seoil University in South Korea. Her research focuses on the rheological properties of polysaccharides and hydrocolloids and fractionation to evaluate chemical heterogeneity with varying structural parameter. Dr. Kim is a visitor in the labs of Drs. Hamaker and Campanella. She will remain at Whistler Center as a visiting faculty for a year until August 2014.



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

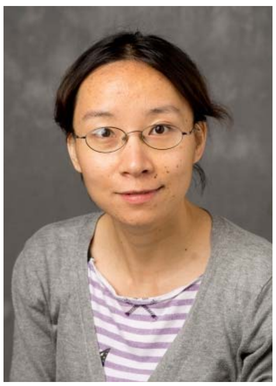


Xiaoxi Li is an Associate Professor at South China University of Technology (SCUT; PR China). He received his Ph.D. degree from SCUT in 2004 and has been employed as a faculty member at SCUT since then. His research focuses on the starch modification and the application of controlled release carriers. He joined Drs. Hamaker and Campanella's group as a visiting faculty for a year from August 2013.

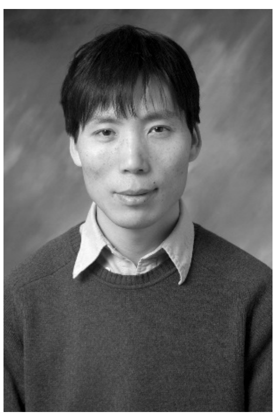


Ming Miao is an Associate Professor at the State Key Laboratory of Food Science and Technology in Jiangnan University. He received his Ph.D. in Food Science from Jiangnan University in June 2009. He joined Dr. Hamaker's group as a visiting faculty from April 2013. His research focuses on the modification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

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

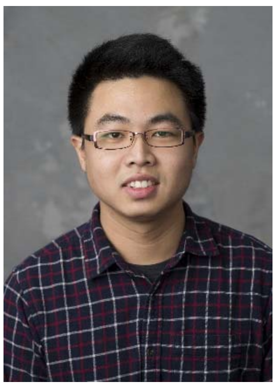


Guangfeng Wu earned her Ph.D. in Food Science from Jiangnan University in June 2002. She is an Associate Professor at the China Agricultural University. She arrived at Purdue University August 2012 as a visiting faculty sponsored by the Chinese government and was co-advised by Drs. Hamaker and Campanella. Her research focused on fine structure and rheological properties of alkali-extracted corn araboxylan.

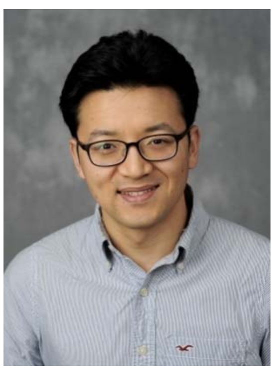


Genyi Zhang earned a B.S. degree in biology from Lanzhou University and a M.S. degree in genetics from the Institute of Genetics, Academia Sinica, Beijing. He obtained a second M.S. degree at Purdue investigating sorghum starch digestibility and a Ph.D. researching a three-component nanocomplex. He joined the Whistler Center as a Visiting Professor from Southern Yangtze University in December 2004, where he researched alternative ways to achieve, and fundamental structures of, slowly digestible starches. Dr. Zhang is a Professor of Food Science at Jiangnan University, mainly focusing on the carbohydrate chemistry and nutritional properties of starch, and related to this, nutritional interference to prevent or delay the incidence of chronic diseases (diabetes) using functional food components. He also works on soft matter nanotechnology for functional component encapsulation and delivery.

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.

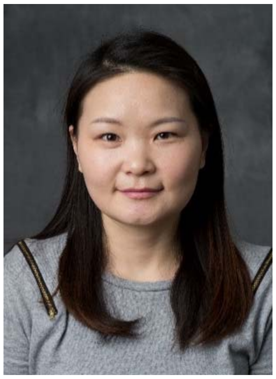


Wei-Jen Chang received his B.S. degree in the Department of Food Science from Tunghai University, Taiwan June 2011. He is in the M.S. program in the Department of Food Science, National Pingtung University of Science and Technology, Taiwan. Wei-Jen was awarded a government scholarship by the Ministry of Education in Taiwan to join Dr. Lin's group as a visiting scientist.



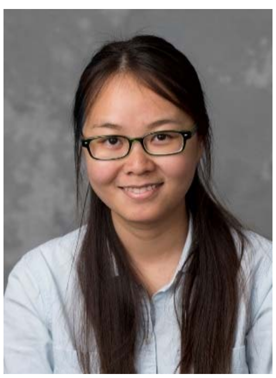
Wonjun Jung is a senior researcher of the Food Starch and Sweetener Laboratory at the R&D Center, Daesang Corporation, South Korea. He received his B.S. and M.S. degrees in Food Engineering from Korea University in Korea. In 2005, he joined Daesang Corporation. He is in charge of development of food grade modified starches. He Joined Dr. Hamaker's group in May 2012 and his research project focused on effective development of xylose from corn bran. Wonjun returned to Daesang in April 2013.

Juliane Hossri Lamarino joined the Rheology lab as an undergraduate research assistant in February 2013. During her 6 months stay she worked on the incorporation of β-lactoglobulin fibrils into hydroxypropyl cellulose films to improve their mechanical and barrier properties and correlate those properties to the film forming solution rheology. Juliana is working on her bachelor's degree in Food Engineering at the University of Sao Paulo, Brazil.



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

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



Xiang Ning earned her B.E. degree from the Department of Food Engineering of Hunan Agricultural University in July 2011. She obtained her M.S. degree from the Department of Food Science of Wageningen University in the Netherlands in June 2013. The research topic of her M.S study is "The relation between structure of globular proteins and their cross-linking activity with microbial transglutaminase". She joined Dr. Narsimhan's group as a visiting student in July 2013 to study the function of homogenization on soy β-conglycinin and pectin stabilized encapsulation system. She will continue her Ph.D. under Dr. Narsimhan with the research of pore formation in lipid bilayers by antimicrobial peptides.

Lívia Ostroschi joined the Food Rheology lab as an undergraduate research assistant in January for a six-month internship within the Department of Agricultural and Biological Engineering. During her stay at Purdue, Lívia became involved in an interdisciplinary project between the Food Engineering and Food Science Departments through the Whistler Center for Carbohydrate Research. The objective of the study was to understand the self-assembly of cereal protein systems into β-sheet rich aggregates and assess the influence of these events on system rheology. Lívia aided in all aspects of the project including experimental design, sample preparation, instrument use, and data interpretation. As part of her laboratory responsibilities, Lívia gained hands-on experience with several useful techniques including circular dichroism spectroscopy for secondary structural analysis of proteins and oscillatory rheometry for physical property tests.

Luis Filipe Maringolo Piccinelli joined the Rheology lab as an undergraduate research assistant in February 2013. During his 6 months stay he helped to develop one of the projects that has a great potential to be conducted in the near future in the Whistler Center. The objective of the study was to optimize the production of fibril network formation through crosslinking with iota carrageenan. Filipe has focused on the characterization of the fiber solutions and the formed fibers by using atomic force microscopy and rheology. Luis is still working on his bachelor's degree in Food Engineering at University of Sao Paulo, Brazil.

Carolina Bassi Samel joined the Rheology lab as an undergraduate research assistant in January 2013. During her 6 months stay she helped to develop one of the projects that has a great potential to be conducted in the near future in the Whistler Center. The objective of the study was to incorporate the alumina nanoparticles into hydroxypropyl cellulose films to improve their mechanical and barrier properties and correlate those properties to the film forming solution rheology. Carolina is still working on her bachelor's degree in Food Engineering at University of Sao Paulo, Brazil.

Karine Scharanck joined the Food Rheology lab as an undergraduate research assistant in October 2013 for a five-month internship within the Department of Agricultural and Biological Engineering. During her stay at Purdue, Karine became involved in an interdisciplinary project between the Food Engineering and Food Science Departments through the Whistler Center for Carbohydrate Research. Karine's project was centered on identifying *in vitro* conditions that simulate these interactions and to investigate the role of intermolecular β-sheets in this event.

Yu-Ting Tseng received a B.S. degree in Food Science from National Taiwan Ocean University in 2010. She studied as a M.S. student in Institute of Bioscience and Biotechnology, National Taiwan Ocean University in 2011. Yu-Ting came to Purdue as a visiting scientist in 2012. She worked with Dr. Yao on analysis of starch and has returned to Taiwan.

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

Lan Yao completed her B.S. in Food Quality and Safety from Shenyang Agricultural University in 2010 in China. She joined Dr. Yao's Lab in 2012 as a visiting student. Lan's research focused on the effect of modified starch on drug encapsulations.

Haining Zhuang earned her Ph.D. in Food Science from Jiangnan University in June 2011. She is a lecturer in Shanghai Institute of Technology. She was advised by Dr. BeMiller. Her research focused on interactions between crosslinked starch and various hydrocolloids.

Matthew Allan graduated from Washington State University in May 2012 with a B.S. in Food Science. He joined Dr. Lisa Mauer's lab in 2012 and will beand is pursuing a M.S. degree in Food Science. His main research focuses are in methods to measure deliquescence and the effects of capillary condensation on the deliquescent point.

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

Mohammad Chegeni completed his B.S. in Biology from Ferdowsi University in 2002 in Iran. After that, he did his master Master degree in Public Health at Ball State University. He joined Dr. Hamaker's group on January 2010 and started his Ph.D. on work in August 2010. His Ph.D. research focuses on maltose sensing of the small intestine enterocytes and sucrose-isomaltase maturation and trafficking.

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 has been a Ph.D. student through 2013. Her thesis focused on the structure of carbohydrate nanoparticles and their functional properties such as digestibility and compound adsorption.

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

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

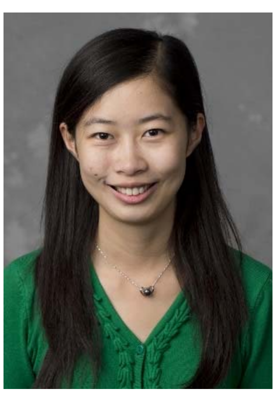
Fatimata Cisse received her M.S Degree in Food Science and Technology from the Department of Technology and Management of Production, Academy of State of Food Products of Moscow, Russia in 1997. After that she worked in the Food Laboratory of Rural Economic Institute of Mali. In January 2010 she joined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

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

Marwa El Hindaway is from Cairo, Egypt and is pursuing her Ph.D. degree with Dr. Hamaker. She was formerly in biochemistry and studies dietary carbohydrate sensing, glucose release and feedback responses.

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 August 2010 as a M.S. student and completed her degree in May 2010. She is currently working on her Ph.D. with Dr. Campanella on physical-chemistry of colloidal nano-particle interactions with a focus on micro-microstructure relationship.

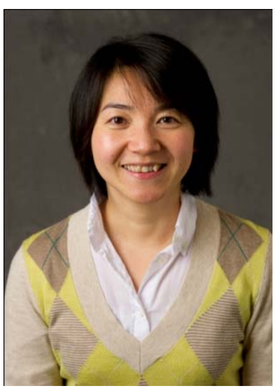
Daniel Erickson earned his B.S. in Chemical Engineering from Iowa State University in May 2010. He arrived at Purdue University in August 2010 in pursuit of an M.S. degree in Food Science and is co-advised by both Dr. Hamaker and Dr. Campanella. His research focuses on functionalizing non-wheat cereal proteins to behave as viscoelastic aggregates for breadmaking and other applications within the gluten-free and functional protein areas.



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

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 and completed her PhD in December 2012 and continued as a Post-Doctoral Research Associate. Her research focuses on the structure and function of corn zein protein. Mehtap left the Center in July to work for Frito Lay in Plano, TX.

Jay Gilbert received his B.S. degree in Food Science and Technology from the University of Massachusetts Amherst in May 2013. He joined the research group of Dr. Owen Jones and started in August 2013 to pursue a Ph.D. degree. His Ph.D. research focuses on the stability and potential functionality of protein fibrils with a concentration in atomic force microscopy techniques.

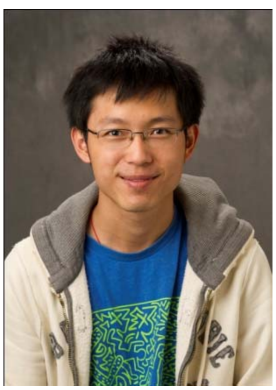


Like Hasek graduated from Shanghai University of Science and Technology with a B.S. in Food Science and Technology, and from Iowa State University with M.S. degrees both in Food Science and Nutrition. Her food science thesis was on shelf life of toasted soyflakes and their application in breadmaking, tofu color prediction from the soybeans and soyflakes color. She joined Dr. Hamaker's lab for her PhD. and is doing completing her 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.

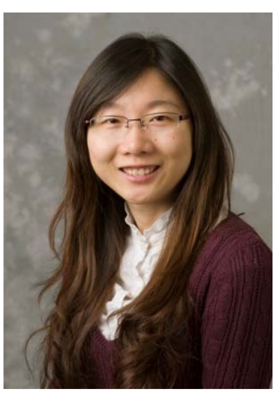
Stacey Hirt received a B.S. in Food Science from Purdue University in 2011. She is continuing her M.S. research with Dr. Jones. Her research focuses on stability of beta-lactoglobulin and pectin systems to the Hofmeister series of salts. Stacey graduated in December and is now working at Kraft.

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 and Campanella'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. Madhuvanti is now a Post-doctoral research scientist, working for Z-Trim Technologies, Inc. (Mundelein, IL) but located at the USDA-ARS Eastern Regional Research Center in Philadelphia, PA.

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

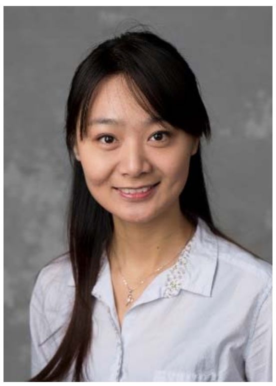


Kin Lau earned his B.S. degree in Biology from Davidson College in May 2010 where he conducted research in synthetic biology using *E. coli* as a model organism. He is currently pursuing a Ph.D. in Plant Breeding and Genetics in the lab of Dr. Weil. His main project is to identify modifiers of certain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



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

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



Yuan Lyu (Yuan Lv) earned her B.S. degree in College of Life Science from Henan Normal University in July 2010, and M.S. degree in School of Life Science from East China Normal University in JulY 2013. Her M.S. research was mainly about development of soybean product, including isolated soybean protein and dietary soybean fiber. Yuan joined Dr. Ganesan Narsimhan's lab in Aug 2013 in pursuit of a Ph.D. degree. Her current research focuses on verifying a strategy of getting obtaining antimicrobial peptide from soybean protein.

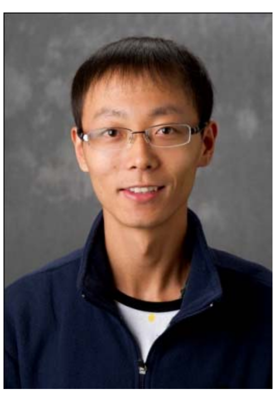
Krystin Marrs received a B.S. in Food Science and a BSAB in applied biotechnology from the University of Georgia in May 2010. She arrived at Purdue University in August 2011 in pursuit of an M.S. degree in Food Science under Dr. Lisa Mauer. Her research focuses on the physical and chemical stability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

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

Anbuhkani Muniandy is an M.S. student with Dr. Amy Lin. She received her B.S degree from the Department of Food Science at Purdue University in May 2013. She joined the Whistler center in August 2011 when she was a Junior. Muniandy's research focuses on the structure of slowly digestible dextrin.

Ryan Murphy earned his B.S. in Food Science from the University of Manitoba in May 2013. He arrived at Purdue University in August 2013 in the direct entry Ph.D. program. Ryan received an Andrews Fellowship and is co-advised by Dr. Jones and Dr. Farkas. His research focuses on emulsion stabilization using protein and polysaccharide-based microparticles (Pickering stabilizers). He interned with Kraft Foods and previously started and ran a small agribusiness focused on the production, light processing and sale of local agricultural products.

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



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 through an awarding from the China Scholarship Council government scholarship. Xin's research project mainly focuses on dietary fiber's structure-function relationships related to for colon and whole body health.

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

Rándol J Rodríguez was an undergraduate student in the Food Science Department of Zamorano University, Honduras. In the graduate program at Purdue Food Science, he works under Dr. Yao on the structure and function of carbohydrate nanoparticles.

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 antimicrobial compounds and carbohydrate biopolymers 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.

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

Ana Steen received her B.S. in chemical Chemical engineering Engineering from Bucknell University. She began her M.S. in August 2013 co-advised by Drs. Campanella and Dr. Hamaker. Her research focuses on a food- based nano-scale, soft particle.

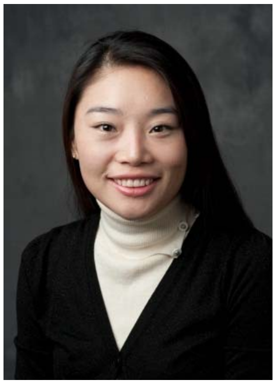
Stephany Tandazo graduated from Texas A&M University in May 2010 with a B.S. in Chemical Engineering and a minor in chemistry. Stephany is working with Drs. Campanella and Hamaker. She joined the group in August 2010 to pursue her M.S. in Agricultural and Biological Engineering. Her research focused on corn zein protein functionality in doughs. Stephany completed her degree in 2013 and is currently employed by Frito Lay.

Yunus Emre Tuncil got his B.S. in Food Engineering at Ataturk University in Turkey in 2008. He was awarded a scholarship for his M.S. and Ph.D. degree in the USA by the Turkish Government. He joined Texas A&M University Food Science and Technology Department as a M.S. student in 2010 in where he studied on the effects of wheat proteins on dough rheological properties. He arrived at Purdue University in August 2012 in pursuit of a Ph.D. and is advised by Dr. Hamaker. His research mainly focuses on dietary fiber structure and their effects on colon health. At the same time he is conducting a research on the function of sorghum kafirin proteins.

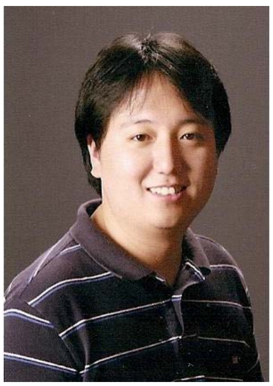
Xi Wu earned her B.S. degree in the Department of Applied Chemistry from China Agricultural University in July 2011. She joined Dr. Narsimhan's group in January 2012 to pursue a Ph.D. degree in the Department of Agricultural and Biological Engineering and is working on investigation of pore formation in cell membrane by synthetic antimicrobial peptides.

Ying Xie received her M. S. degree in Processing and Storage of Agriculture Products from China Agricultural University. She joined Dr. Yao's group and started her Ph. D study in August 2012 with a governmental scholarship from China Scholarship Council. Her Ph.D. research focuses on modified carbohydrate nanoparticles and their functional properties.

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 worked with Dr. Jones on the encapsulation of flavor oils utilizing beta-lactoglobulin and pectin systems. Laura graduated in December and is working at General Mills.

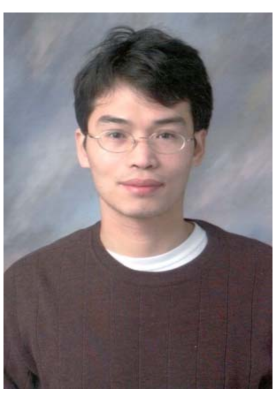


Choon Young Kim received her Ph.D. in Food Science from Purdue University in December 2011. Her Ph.D. research was identification of anti-obese dietary components and characterization of their molecular mechanisms. She joined Dr. Hamaker's group as a Post-Doctoral Research Associate in August 2012. Her research focuses on physiological responses to slowly digestible carbohydrates.



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

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 worked on fiber rheology and incorporation into processed foods and gel formation kinetics. Currently Dr. Patel is working in a project related to enzymatic conversion of complex polysaccharides into ethanol in collaboration with Dr. Campanella.



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.

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

PROJECT SUMMARIES

1. Effect of Controlling the Swelling of Starch Granules via Crosslinking on Starch-Hydrocolloid Interactions

P.I.: J. BeMiller

Researchers: Tao Feng, Ph.D., Visiting Faculty; Haining Zhang, Ph.D., Li Guo, Ph.D., Visiting Scientists

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

Progress: Normal corn and waxy maize starches were crosslinked with $POCl_3$ to make products with higher RVA viscosity profiles (granules in paste more swollen than those of the native starch) and products with lower RVA viscosity profiles (granules in paste less swollen than those of the native starch). The native and the 4 crosslinked starches were subjected to RVA analysis in the presence of 9 hydrocolloids (xanthan [in water and in 1% NaCl], guar gum, sodium alginate, CMC, methylcellulose, HPMC, and kappa-, iota-, and lambda-type carrageenans), sodium nitrate (a swelling promoter), sodium sulfate (a swelling inhibitor), poly(ethylene glycol) (PEG; a non-polysaccharide, water-soluble polymer), and water (control). Following RVA analysis and cooling of the pastes, the resulting gels were subjected to dynamic rheological analysis to determine loss and storage moduli, loss tangent, and complex viscosity values and to steady shear analysis to determine K', n', K'', n'', and η^* values.

Analysis of the RVA data placed the 13 solutions into 6 categories: (1) Those (xanthan in water, guar gum) that increased peak viscosity, % breakdown, and % setback [as compared to the control (water)]; (2) those (xanthan in 1% NaCl, sodium nitrate) that increased peak viscosity and % breakdown, but decreased % setback; (3) those (CMC, sodium alginate) that increased peak viscosity, but decreased % breakdown and % setback; (4) that (HPMC) which increased % setback (to the greatest extent of all solutions), but decreased peak viscosity and % breakdown; (5) those (κ- and ι-carrageenans, PEG, and sodium sulfate) that increased % breakdown and % setback, but decreased peak viscosity; (6) that (λ-carrageenan) which increased % setback, did not change % breakdown, and decreased peak viscosity.

Underway: Tentative mechanisms have been proposed for the 6 behaviors. To gain corroborating evidence, swelling powers, leached amylose, and total solubilized starch in the 13 solutions at different temperatures are being determined. Epichlorohydrin-crosslinked normal and waxy maize starches with properties similar to those of the $POCl_3$-crosslinked starches are being prepared so that the starches with neutral crosslinks can be compared to those with surface, anionic crosslinks.

Status: Active.

2. Physical Chemistry of Colloidal-Nanoparticle Interactions

P.I.: O. Campanella

Researcher: Necla Mine Eren, Ph.D. Student

Collaborator: O. Jones

Objectives: 1) Understanding the effect of colloidal nanoparticle interaction on physicochemical properties of soft materials, 2) Application of the colloidal nanoparticle interactions to obtain soft materials with targeted material properties.

Objectives: The objective of the current project is to investigate colloidal nanoparticle interactions with a view on both macroscopic and microscopic scales. In the macroscopic approach, model systems are exposed to different flow patterns using a rotational rheometer and an acoustic device to mimic the deformations that they can encounter during processing or application. In the microscopic approach, the dynamics and kinetics of model systems are investigated via spectrometric techniques such as dynamic light scattering, electrophoretic light scattering, and ultraviolet visible spectroscopy. The microstructure of the colloid-nanoparticle complex and direct measurement of the related forces are investigated by atomic force microscopy on contact and non-contact mode, respectively. Upon completion of the fundamental studies performed on model systems that use proteins, the work will focus on development of novel materials using polysaccharides as major ingredients, e.g. maltodextrins.

Progress: Incorporation of nanosize (below 100 nm) particles into polymer/colloidal hosts imparts unique mechanical, electrical, thermal and optical properties to the host. Understanding the physicochemical behavior of these colloidal-nanoparticle systems is essential to gain the functional advantage that safe nanoparticles brings to both non-biological and biological engineering applications. Even though interactions are much more complicated at the nano-bio interface, starting from basic model systems by questioning well-known fundamentals of classical colloidal science, current unknowns in the nano-scale word can be explored to design and develop new biomaterials with targeted properties such as carriers for molecular transport and drug delivery, bioplastics, biosensors, etc.

The model systems are composed of a nanoparticle (silica based particles with different size and charge) and a biopolymer (proteins with different charge, size and structural stability and polysaccharides with different electrochemical charges). As expected, the interactions of the nanoparticle and biopolymer were found to play an important role in the macrostructure of the system that was observable with the methods mentioned earlier. As the bridge between macroscopic structure and microscopic interactions is built, not only the scientific gaps are expected to be filled but also industrial applications are expected to be found.

Status: Active, two manuscripts are being submitted for publication.

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

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

Researcher: Ana Steen, M.S. Student

Objective: The overall goal of the current research is to scale up lab production of our previously researched soft nano-sized particle to increase yield while maintaining control over particle parameters such as size and shape. One parameter that will be investigated is cooling rate during formation. Differential scanning calorimetry will be used to determine thermodynamic stability of particles formed under different cooling conditions. Size exclusion chromatography using refractive index (RI) and multi-angle laser scattering (MALS) detectors will be used to evaluate changes in nanoparticle molecular weight and size.

Progress: A major hurdle to deliver drug, color, and flavor compounds is their solubility. In this regard, a water-soluble, self-assembling, soft particle consisting of amylose, β-lactoglobulin, and linoleic acid with the capacity to bind a fourth component was identified by our group. Cryo-TEM was employed to estimate the particle dimensions as approximately 20 x 50 nm. Differential scanning calorimetry showed the formation of the particles to be a spontaneous process. The binding ability of a fourth component by the nanoparticle was demonstrated using three hydrophobic molecules, limonene, 1-naphthol, and 5-fluorouracil. Caco-2 BBe MTT cells treated with 5-FU bound nanoparticles demonstrated release of the small, hydrophobic molecule in a controlled manner. Size exclusion chromatography coupled with a refractive index detector was used to determine that shear rate during preparation, protein content, and temperature have an effect on particle formation and properties. To characterize the release kinetics of the added hydrophobic compound, a dye will be incorporated into the nanoparticle core and confocal microscopy will be used. It is hypothesized that, unlike metal-based nanoparticles that tend to destroy cell membranes during passage of the nanoparticles into the cells, the soft particle will be able to diffuse into cells without affecting their membranes. The encapsulated dye in combination with confocal microscopy will also be used to evaluate cell uptake.

Current research into the effect of cooling rate on particle properties has shown that increasing cooling rate results in an increase in peak viscosities during particle formation, perhaps due to formation of larger nanoparticles. It also appears that the magnitude increase in peak viscosity is affected by the the type of corn starch. While normal corn was used in all cases, different batches of corn starch vary in amylose and amylopectin content and degree of branching. Nanoparticles have been isolated and separated from excess starch and protein by size exclusion chromatography and a fraction collector. Particles were dialyzed to remove sodium azide present after passing through the column and then freeze-dried. Quantification of pure nanoparticles gave an approximate concentration of 3.1 mg/mL in the supernatant isolated from the final paste.

The current preparation process yields the desired particles mixed with smaller amounts of contaminating protein and a trace of amylopectin.

Improvement of particle purity is now focused on removal of unbound β-lactoglobulin through use of filtration membranes for purity of > 80%. In addition, isothermal calorimetry (ITC) will be used to evaluate the binding energies of a fourth component into the particle core. This will initially be investigated with naphthol, shown previously to bind to the nanoparticle. Evaluation of binding energies will later be extended to other small, hydrophobic molecules.

Status: Active.

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

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

Researcher: Carl P. Littrell, M.S. Student

Collaborator: B. Reuhs

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

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

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

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

Status: Active

5. Structure-Function Relationship of Highly Branched Starch

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

Researcher: Fang Fang, Ph.D. Student

Collaborators: B. Reuhs, J.M. Bemiller

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

Progress: The shear-thickening behavior exhibited by dispersion of 10% waxy corn, waxy potato, waxy rice and waxy wheat starches between 0.01-100s^{-1} shear rates was investigated. After gelatinization, waxy potato starch dispersion exhibited shear-thickening behavior from 10 to 50°C at 20 s^{-1}shear rate, while this behavior was observed on waxy corn starch only at a temperature lower than 15°C, and was not observed on waxy wheat and waxy rice starches at any test temperature. At 2 h, and 1, 2, and 7 d storage at 4°C, dispersions of waxy corn starch still showed the shear thickening behavior, while the behavior disappeared for waxy potato starch at 7d storage. Differences in shear-thickening behavior might be caused by entanglement of polymers and related to the flexibility of different molecular structures of the starches. Results of the dynamic temperature ramp test indicated gradually increasing entanglement in waxy corn and waxy potato starch dispersions; however, the entanglement changed less in waxy wheat starch dispersion and was hardly observed in the waxy rice starch dispersion. Further near-term studies will focus on the relationship between rheological properties and digestion characteristics of concentrated starch dispersions.

Status: Active.

6. A Relationship Between Rheology and Texture of Foods Having Complex Rheological Properties

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

Researcher: Dongdong Ma, M.S. Student

Collaborator: O. Jones

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

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

Status: Active

7. Rheological Characterization of Small Particles (Micro And Nano Level) and The Effects on Mesocale And Macroscale Structures

P.I.s: O. Campanella and O. Jones

Researcher: Xing Fei, Ph.D. Student

Collaborator: S. Wereley (Mechanical Engineering, Purdue University)

Objectives: Rheological techniques that allow the characterization of single particles (polymeric molecules, self-assembled systems) offer a novel way to study the nature of polymeric systems such as polysaccharides that have complex structures and have a key and a relevant influence on their bulk rheological properties, notably when they form solutions or dispersions. A system that has been successfully used in a large scale to characterize the shear and extensional properties of solutions and dispersions of polymeric liquids will be scaled down to perform mechanical measurements of single particle systems as well as image characterization of these systems using a variety of microscopic systems.

Progress: A literature review is being conducted to evaluate the type of research that has been carried out to characterize polysaccharide-based single particles. The literature review includes the different methods and complex rheological models used to characterize general polymers.

Status: Active, a review manuscript will be submitted August 2014.

8. Amyloid-Like Protein Fibril Networks Using Variable Charged Polysaccharide Cross-Linking

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

Researcher: Mine Eren, Ph.D. Student

Objectives: Identify structural and mechanical improvements to semi-dilute fibril suspensions through the use of electrostatically-interacting polysaccharides and to establish correlations between mechanical attributes of their microstructure and macrostructure.

Progress: β-Lactoglobulin is the major whey protein in the milk of ruminants. High temperature thermal treatment of β-lactoglobulin in acidic conditions has been shown to lead to formation of fibrils that are biodegradable and strong. Preliminary studies have shown that the crosslinking of β-lactoglobulin fibrils via iota- carrageenan has a potential to improve the structural and mechanical properties of fibril networks. The objective of the present study is to optimize the production of fibril network via a crosslinking phenomena by investigating fiber solutions and fibers with classical rheology and atomic force microscopy (AFM). The long term objective of the project is to incorporate β-lactoglobulin fibers and cross-linked fibers into biofilms for packaging applications. Preliminary studies have shown that with incorporation of fibers it is possible to improve both the barrier and mechanical properties of hydroxyl propyl methyl cellulose based films.

Status: Active.

9. Use of Corn Zein Proteins as Functional Viscoelastic Polymers

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

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

Collaborators: S. Renzetti, A. Jurgens (TNO Netherlands); L. Mauer (Purdue)

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

Progress: Using resins formed via precipitation from aqueous ethanolic environments, this study presents a framework for understanding how state transition and viscoelastic properties of zein can be controlled through interactions with plasticizers and co-proteins. Resins plasticized with oleic acid exhibited reduced water absorption and glass transition temperatures and formed low elasticity/high extensibility resins. Incorporation of small amounts of casein, as a co-protein, increased water absorption and glass transition temperatures and imparted a four-fold increase in material strength/elasticity, as compared to zein alone. Plasticizers and co-proteins influenced zein secondary structure in the resin systems by decreasing and increasing low-frequency β-sheet structures. This work demonstrates that specific protein/plasticizer and protein/co-protein interactions are capable of promoting fundamental differences to zein's behavior in viscoelastic systems and could serve as a basis for improving the functional properties of this underutilized material in various food and biomaterial applications. Main highlights of the work are :

- Glass transition temperatures can be controlled by plasticizers and co-proteins
- Oleic acid plasticizers improve extensibility at the expense of material strength
- Co-protein interactions with casein increase the elastic properties of zein
- Differences in mechanical properties are related to changes in secondary structure

Status: Active. One manuscript submitted and two in preparation.

10. Dietary Fiber-Based SCFA Mixtures and Cell Monolayer Permeability

P.I.: B. Hamaker

Researcher: Tingting Chen, Ph.D. Student

Collaborator: A. Keshavarzian (Rush Medical School, Chicago)

Objectives: Maintaining good barrier function in the colon is important in good colonic health as well as health conditions arising from systemic inflammation. To obtain a better level of understanding of the role of short-chain fatty acids (SCFAs) and colon cell wall permeability, this project has begun with a study of the SCFA amount and composition that 1) provides protection to the enterocyte monolayer to tight junction disrupters, and 2) when applied after permeability has been induced to promote tight junctions. Different fiber source and structures will be studied to provide proper SCFA concentrations and composition.

Progress: Patients with HIV, obesity, and inflammatory bowel disease often have impaired gut barrier function. SCFAs, particularly butyrate, provide energy to the intestinal epithelium and improve barrier function. Our lab reported that various fibers have different fermentation profiles, generating SCFAs varying in total concentrations and proportions of acetate, propionate, and butyrate. To study the impact of SCFA profiles of various fibers on gut barrier function, SCFA mixtures with 5, 20, and 50% butyrate proportion were designed to correspond to SCFA profiles of tested fiber fermentations, and were subjected to healthy and LPS/TNF-α treated Caco-2 cell monolayers. Integrity of monolayers was indicated by trans-epithelial electric resistance and dextran flux. Total concentration of 40-60 mM SCFA with 20% butyrate improved barrier function without causing damage to the monolayer. Within this defined concentration range of SCFAs, butyrate proportion up to 50% further promoted tight junction function. Applying this result to dietary fiber selection, certain rapidly fermenting fibers may generate a high amount of SCFA that may negatively effect barrier function. Slow fermenting fibers that deliver appropriate concentrations of SCFAs to the epithelium with high proportion of butyrate might improve barrier function. These questions need to be investigated *in vivo*.

Status: Active. Manuscript in preparation.

11. Dietary Fibers and Colonic Microbiota

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

Researcher: Xin Nie, Ph.D. Student; Yunus Tuncil, Ph.D. Student

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

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

Progress: In the last 4-5 years, we have worked in collaboration with Prof. Eric Martens at UM Medical School on dietary fiber structures and how they are utilized by pure strain bacteria isolated from the human colon. Our interest is in better understanding how bacteria both utilize different structures and how they compete for them. We would like to create a more general knowledge base than is available regarding how dietary fibers and their mixtures can be used to favorably affect the colon microbiota. Last year, we reported on a study showing that the corn arabinoxylan polymer alone has different repeating structural components that favor different bacteria. This inferred that gut bacteria compete for the different regions of fiber molecules and are equipped with different enzyme degrading systems that target unique structural features.

In a study done this year by X. Nie, the relationship of different discrete structures of hydrolyzed/modified arabinoxylan products (termed here DBH_3, DBH_4 and modified pre-digested DBH_4 by *B. ovatus*) and bacterial growth behavior, including relative response on gene expression, were investigated. Growth curves were obtained from single culture of *B. ovatus* 3-1-23 and *B. cellulosilyticus* DSM 14838 on the different substrates for 120 h. Growth differences were shown between the two bacterial strains, particularly on the substrate predigested by *B. ovatus* 3-1-23. *B. cellulosilyticus* DSM 14838 still grew although the digestion ability was lower on the modified substrate (modified DBH_4) than that on other substrate; *B. ovatus* 3-1-23 did not grow indicating that it lost its ability to ferment the modified substrate. Substrates were purified by phenol extraction, dialysis and HPSEC. Their structures were analyzed by Smith degradation, HPSEC, NMR, methylation and GC/MS. The results showed structural similarity and difference between DBH_3 and DBH_4, and the structural change from DBH_4 and modified-DBH_4 that created different growth behaviors of the bacterial strains. The study implies high fiber substrate specificity at the colonic bacterial strain level.

A second study by Y. Tuncil tested hieratical patterns of dietary fiber usage by two strains of *Bacteriodes*, and will in the future examine hieratical preference when bacteria are competing for the same set of substrates. Responses of two human gut symbionts, *Bacteroides thetaiotaomicron* (Bt) and *B. ovatus* (Bo) during growth on a mixture of different dietary fibers were studied. The fibers used were rhamnogalacturonan I (RGI), arabinan (Ara), chondroitin sulphate (CS), amylopectin (AP), pectic galactan (PG), and polygalacturonic acid (PGA). Individual bacterial strains were inoculated in the soluble DF mixture. The growth of each was monitored for 17 h, and samples were collected every hour for the following analyses; monosaccharide composition and linkage disappearance of the remaining mixture using gas choromotography/mass spectrometry (GC/MS), and expression of DF utilization genes using qPCR. Our results demonstrate that the DF preferences of Bt and Bo are similar, though with some difference. The bacteria species can respond to more than one, but not all, fiber substrate simultaneously. They preferentially utilized AP and CS before others suggesting that these two human symbionts show hieratical preference to fibers. GC/MS analysis indicated that none of these fibers were completely used before going to the next substrate indicating that colonic bacteria have a strategy to sequester maximum energy from available substrates.

Status: Active. Manuscripts in preparation.

12. Investigations on Slowly Digestible Glycemic Carbohydrates

P.I.: B. Hamaker

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

Collaborators: A. H.M Lin (Whistler Center); S.H. Yoo (Sejong University, South Korea); G. Zhang (Jiangnan University); H. Naim (University of Veterinary Medicine Hannover, Germany); B. Nichols (Baylor College of Medicine, Houston); R. Quezada-Calvillo (University of San Luis Potosi, Mexico); M. Pinto (Simon Fraser University, Canada); D. Rose (University of Waterloo, Canada)

Objective: To design slowly digestible glycemic carbohydrates for ileal deposition of glucose in the small intestine for the purpose of testing and targeting physiologic response; and, related to ways to manipulate starch digestion rate, to better understand natural inhibitors and their effect on the four mammalian α-glucosidase enzymes.

Progress: We have, over recent years, taken a change in direction of our studies on slowly digestible glycemic carbohydrates to put a focus on location delivery of glucose to the small intestine ileum. This is because we have found that dietary consumption of materials that deposit at least a small amount of glucose to the ileum trigger the ileal brake mechanism and gut-brain axis physiological effect to slow gastric emptying and to reduce meal size, as well as daily food intake (in a long-term rat study). In this regard, we continue, with A. Lin, to work towards the development of glycemic carbohydrate materials that digest slowly and into the ileum. Here we report on two projects, both using recombinant mucosal α-glucosidases to study the possibility of control of glucose generation, or glucogenesis, for enterocyte uptake. In the first study by B.H. Lee, disaccharides (maltose isomers, sucrose isomers) with various possible α-linkages and compositional types (between glucose-glucose and glucose-fructose) were hydrolyzed by each recombinant enzyme to determine their specific α-hydrolytic kinetic properties. The individual α-glucosidases had various digestion activities on the disaccharides, however maltase showed the most versatile α-hydrolytic activity. The results indicate that the major hydrolysis activity differs based on linkages, structural conformations of disaccharides, and their composition. This study can be applied to establish a strategy for developing new carbohydrates for extended postprandial glucose response with low glycemic response profile.

In a second study, recombinant enzymes were used to investigate maltase inhibition assays using the polyphenols caffeic acid, gallic acid, (+)-catechin hydrate, chlorogenic acid and (-)-epigallocatechin gallate. Interestingly, it was shown that different polyphenol inhibitors show selective inhibition meaning that one of the four α-glucosidases might be inhibited by a given polyphenol more than others, and so on. Given the different roles of the four α-glucosidases, a strategy appears of possibly using a selective inhibitor with a particular structure of glycemic carbohydrate to "push" digestion down to the ileal region for stimulating potentially positive physiological effects.

In two other studies, hydrothermal treatment was applied to high-amylose starches and conditions were identified to generate good levels of slowly digestible starch (E. Agama-Acevedo), and gluten-free spaghetti was developed with banana flour and other components that has a slow digestion property (A. Bello-Perez).

Status: Active. Manuscripts in preparation.

13. Physiological Response Studies of Starchy Materials with Slow Digestion Profiles

P.I.: B. Hamaker

Researcher: Like Yan, Ph.D. Student; Beth Pletsch, M.S. Student; Mohammad Chegeni, Ph.D. Student; Choon Young Kim, Ph.D. Research Associate

Collaborators: T. Powley, R. Phillips, K. Kinzig (Department of Psychological Sciences); M. Kushnick (Ohio University); G. Zhang (Jiangnan University)

Objective: To understand the physiologic responses to slowly digestible carbohydrates with controlled digestion profiles.

Progress: We previously reported on a study showing that glucose deposited ileally in the small intestine promotes lower food intake which was regulated by hypothalamic response, and perhaps delayed gastric emptying. A follow-up study, the effect of slowly digestible starch on gastric emptying in the human was done showing that a pre-load of slowly digestible starch causes a slowing of gastric emptying of the subsequently given meal 10 or 20 min later. As funding is an issue, we are continuing these studies at a reduced pace.

We also have studied how the sensing of the digested products of α-amylase on starch by the small intestine enterocytes causes processing and maturation of sucrase-isomaltase (two of the four α-glucosidases). As the primary products of starch digestion by pancreatic α-amylase, maltose and malto-oligosaccharides are the dominant substrates for α-glucosidases at the intestinal brush border. Immunoblotting and biosynthetic labeling using [^{35}S]-methionine revealed maltose induces the formation of a higher molecular weight (HMW) sucrose-isomaltase species with a higher rate for early trafficking and maturation which is more associated with Triton X-100 lipid rafts, resulting in higher apical sorting of these species. As this finding is potentially indicative of a maltose sensing ability by enterocytes, our goal is to investigate the sensing mechanism on the small intestine enterocytes leading to the processing of HMW SI. A structural study using endoglycosidase treatment of HMW SI showed that the increased molecular weight of SI is a consequence of altered N- and O-glycosylation in the Golgi apparatus causing higher apical sorting of SI. In addition, metabolomics study on metabolites involved in differentiation along with transepithelial electric resistance and endoplasmic reticulum stress measurements revealed that cells maintain their differentiation through an adaptation to utilize maltose as an energy source. Thus, maltose sensing ability of enterocytes influences the intracellular processing of SI, apparently to enhance their digestive property. Further, this work suggests that processing and activation of the α-glucosidases occurs quickly, and perhaps in the same meal prepares the distal small intestine to fully digest slowly digestible glycemic carbohydrates to glucose and fructose for absorption.

Status: Active. Manuscripts submitted and in preparation.

14. Starch Digestion in Stunted Children in Mali

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

Researcher: Fatima Cisse, M.S. Student

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

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

Progress: This was a project funded by the Bill and Melinda Gates Foundation and was carried out in Mali, West Africa. Here, we hypothesized that moderately malnourished weaned stunted children have impaired ability to digest starch due to developmental pancreatic α-amylase insufficiency that impedes their normal growth with typical foods used at home. We used an innovative non-invasive modified ^{13}C-breath test developed at Baylor College of Medicine to assess the ability to digest starch in healthy (n=16) and moderately stunted infants (n=32) from 18–30 months in Bamako, Mali. Common or modified sorghum porridges and three different ^{13}C substrates (UL-algal starch, UL-algal limit dextrins, and greenhouse-enriched sorghum) were fed in five separate days. Serial breath samples (every 15 min for 3 hours) were collected and analyzed using a $^{13}CO_2$ infrared spectrophotometer. Contrary to our hypothesis, most subjects, whether stunted or normal, had pancreatic α-amylase insufficiency. Yet, nearly all children (stunted and normal children) digested starch from thick sorghum porridge and absorbed the released glucose well; and showed better digestion for normal sorghum porridge than in our modified "dispersed starch" porridge or the α-amylase-treated liquefied porridge. We concluded that Malian moderately malnourished stunted weaned children have higher mucosal α-glucosidase activities that allow them to digest well thick porridges. The implication of this work is that, contrary to conventional thought, thick energy dense porridges could be given in supplemental feeding programs to marginally malnourished children with good digestion of starch.

Status: Completed. Manuscripts in preparation.

15. Polysaccharide-Based Nutraceutical Carriers: Effect of Organic Solvents on the Encapsulation and Release

P.I.: S. Janaswamy

Researcher: Carlos Carter, Undergraduate Student

Objective: Nutraceuticals (NCs) are absorbed in the body during digestion and aid in preventing chronic diseases such as diabetes, obesity and cancer. Nutraceutical delivery, however, is often a problem of concern as they are water-insoluble and are susceptible to degradation from factors including temperature, enzymatic activity, pH, and light. More recently, we demonstrated that organized and crystalline polysaccharide fibers are effective towards encapsulation, thermal protection and control release of nutraceuticals and drugs. The central idea is about solubilizing NCs in the organic solvents and encapsulating in the water pockets of well-oriented and crystalline polysaccharide fibers. The objective of this study is to examine the effect of organic solvents on the encapsulation efficiency and release nature of NCs.

Progress: Ethanol, acetone, triacetin, propylene glycol and isopropanol were chosen as suitable organic solvents to solubilize eugenol (NC) and encapsulate it in sodium iota-carrageenan fibers. Complexation experiments were performed at room temperature. Results revealed that 3 μg/1mg eugenol/carrageenan can be embedded in the presence of triacetin, and only around 1 μg with propylene glycol. Interestingly, in the presence of acetone, the complexes showed sustained release that peak at approximately 80-90 mins as compared to 20-30 min with other solvents used in this study.

Status: Active.

16. Carbohydrate-Based Antimicrobial Carriers

P.I.s.: S. Janaswamy, A. Bhunia (Food Science Department, Purdue University)

Researchers: Lohit Myneedu, M.S. Student; Atul K. Singh, Ph.D. Research Associate

Objective: Food quality and shelf-life define the appearance and consumer acceptance of products. Owing to their perishable nature, protecting food products from spoilage and pathogens during preparation, storage and distribution is important. Microbial growth is one of the primary reasons why food loses its quality, becomes unsafe for consumption, and consequently raises concerns regarding food safety and public health. Packaging of food under modified atmosphere coupled with storage at low temperature can extend shelf-life and prevent pathogens. However, these processes alone are not sufficient to reduce foodborne outbreaks and public health concerns. Essential oils (EOs) possess antimicrobial properties. However, EOs are water insoluble and prone to oxidative degradation so that higher concentrations are needed to achieve desirable activity. The objective of this study was to protect EOs using GRAS carriers so as to gain balanced benefit of EOs for good food safety and food quality.

Progress: Eugenol and iota-carrageenan (IC) have been chosen as a model polysaccharide and EO. Antimicrobial activity was tested against two foodborne pathogens *Escherichia coli* and *Listeria monocytogenes*. Our results suggest that eugenol-encapsulated IC fibers are effective in controlling the microbial growth.

Status: Active.

17. Effect of NaCl, NaBr and NaI on the Three-Dimensional Structure and Viscoelastic Properties of Sodium Kappa-Carrageenan

P.I.: S. Janaswamy

Researcher: Lohit Myneedu, M.S. Student

Objective: Carrageenans are sulfated polysaccharides extracted from marine algae and are used in food and pharmaceuticals applications due to their ability to form thickeners, viscosifiers and gels. In particular, their food applications include bodying, gelling, thickening and emulsion stabilization in water- and milk-based systems. Depending on their source of extraction, and presence or absence of sulfated groups, as well as anhydro groups, fifteen carrageenans are known to date. However, only kappa-, iota-, and lambda-carrageenan have so far been exploited industrially and have been subjected to research studies toward delineating their structure-function relationships. In this set, information about kappa-carrageenan junction zone architecture and the effect of cations on their structure-function relationships were studied.

Progress: A systematic investigation about the effect of salts on the three-dimensional structure and viscoelastic properties of kappa-carrageenan has been carried out. Herein, the focus is on sodium salt form of kappa-carrageenan at two concentrations [1.5 and 2.0% (w/w)] in the presence of NaCl, NaBr and NaI (25, 50, 75 and 100 mM). X-ray fiber diffraction analysis suggests that the carrageenan fibers have uniaxially oriented crystallinity in the presence of NaI. The Bragg reflections on layer lines 0 through 6 are resolved well. Viscoelastic studies show that the elastic moduli increases as a function of salt content, and presence of NaCl yields stronger gels compared to use of NaBr and NaI.

Status: Active.

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

P.I.: O.G. Jones

Researcher: Jay Gilbert, M.S. Student (current); Monica Jiulianti, B.S. Student

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

Progress: Initial experiments have shown improved physical integrity of protein fibrils at higher pH values in the presence of chitosan. High concentrations of chitosan and methyl cellulose lead to a phase separation with fibril solution through an apparent thermodynamic incompatibility. These techniques are to be further developed for an improved method to selectively separate protein fibrils.

Status: Active.

19. Amyloid-Like Protein Fibril Networks Using Variable Charged Polysaccharide Cross-Linking

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

Researcher: O.G. Jones

Objective: Identify structural and mechanical improvements to semi-dilute fibril suspensions through the use of electrostatically-interacting polysaccharides and to establish correlations between mechanical attributes of their microstructure and macrostructure.

Progress: Initial experiments demonstrate the ability to form network cross-links using a charged polysaccharide. Mechanical analyses of the protein fibril networks are being currently developed using atomic force microscopy (nanoscale) and rheometry (macroscale).

Status: Active.

20. 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

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

Progress: Turbidimetry and light scattering were utilized to study the electrostatic interactions between β-lactoglobulin and pectin at neutral and low-acid conditions. A significant specific ion effect has been observed for the pH of complex formation and the pH of coacervation for unheated protein and pectin. Specific ion effects were also observed on the size of microgels formed from heated complexes.

Status: Active. Manuscripts in revision.

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

P.I.: O.G. Jones

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

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

Progress: Emulsions of corn oil or limonene were successfully prepared with β-lactoglobulin microgels using high pressure homogenization. Size of the microgels greatly influenced the capacity to stabilize emulsions, as larger microgels were poorly adsorbed to small droplet interface. The largest droplets flocculate rapidly and form a dense cream layer. Emulsions stabilized by zein nanoparticles were relatively prone to flocculation. Current research is developing discrete size populations from microgel and nanoparticle dispersions to determine the influence of size and swelling ratio on interfacial energy and rheology.

Status: Active. Manuscripts in revision.

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

P.I.: O.G. Jones

Researcher: Juan Du, Ph.D. Student

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

Progress: : Chitosan and dextran molecules have been successfully modified. Current research is pursuing separation techniques and further modification of dextran.

Status: Active.

23. Starch Internal Structure and Digestibility at Mucosal α-Glucosidase Level

P.I.: A. Lin

Collaborators: Z. Ao, R. Quezada-Calivillo, B. L. Nichols, C.-T. Lin, B.R. Hamaker

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

Progress: To produce sufficient amounts of glucose from starch, both α-amylase and mucosal α-glucosidases are required. We found previously that the digestion rate of starch is influenced by its susceptibility to mucosal α-glucosidases (Lin et al., 2012, Journal of Biological Chemistry 284 (44) 369170-369217). We hypothesized that the branch pattern of starch internal structure modulates the digestion by mucosal α-glucosidase. In this project, six starches and glycogen were pre-hydrolyzed by α-amylase for various time periods, and then further hydrolyzed with the mucosal α-glucosidase, the N-terminal subunit of maltase-glucoamylase (Nt-MGAM), to generate free glucose. Results showed that α-amylase amplified Nt-MGAM glucogenesis, and that the amplifications differed for various substrates. The amount of branches within α-amylase hydrolysate substrates was highly related to the rate of Nt-MGAM glucogenesis. After de-branching, the hydrolysates showed three fractions, Fraction 1, 2, and 3, in size exclusion chromatographs. We found that the α-amylase hydrolysates with higher quantity of the Fraction 3 (molecules with relatively short chain-length) and shorter average chain-length of this fraction had lower rates of Nt-MGAM glucogenesis. This study revealed that the branch pattern of α-amylase hydrolysates modulates glucose release by Nt-MGAM. It further supported the hypothesis that the internal structure of starch affects its digestibility at the mucosal α-glucosidase level. This project was partially sponsored by the Whistler Center Focus-

Group Generation project (to B. Hamaker) and USDA (to B.L.N.)

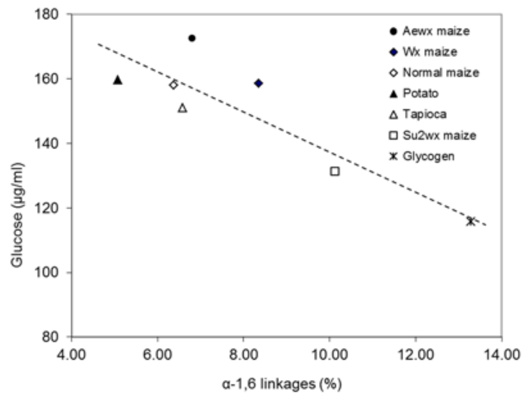


Figure. The relationship between glucose amount and the quantity of α-(1→6) linkages within α-amylolytic hydrolysate substrates

Status: Inactive. Manuscript was accepted for publication.

24. Starch Digestion in Vivo in Both Healthy and CSID (Congenital Sucrase-Isomaltase Deficiency) mice

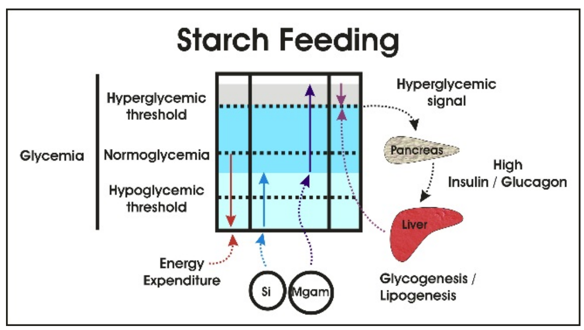
P.I.: A. Lin

Collaborator: B. Nichols (Baylor College of Medicine, Houston)

Researchers: Wei-Jen Chang, Visiting Scientist; Anbuhkani Muniandy, M.S.; Maricela Diaz-Sotomayor, Post-Doc, Baylor College of Medicine; S. Avery, Technician, Baylor College of Medicine

Objective: To understand the digestion role of individual mucosal α-glucosidases *in vivo* (both healthy and CSID mice); develop food-grade supplements for CSID's patients in order to receive enough carbohydrate-sourced energy with lower abdominal pain.

Progress: While luminal α-amylase (AMY) is recognized as a major starch digesting enzyme, the products require further digestion from the non-reducing ends of the oligosaccharides to produce glucose for absorption. Two mucosal enzyme complexes are required for glucogenesis: maltase-glucoamylase (MGAM) is a fast and sucrase-isomaltase (SI) is a slow α-glucosidase. Because of overlapping complex activities in vitro, Mgam was knocked-out in mice with the objective of determining the role of SI on *in vivo* starch digestion to glucose. The mice were fed chow containing normal maize starch 2 h before being euthanized. We quantified the carbohydrate amounts including glucose, oligomers, and residual starch in the lumen of each intestinal segment (total four). The wild type (WT) mice had a peak of residual starch in the distal jejunum (DJ), peak of oligomers in the proximal ilium (PI), and very little total CHO in the distal ilium (DI). The Mgam-nulls had significantly increased residual starch and total CHO in the DI. When expressed as oligomers/starch, there was an accumulation in the null DI. Compared with the null, the free glucose/oligomers in the WT were significantly increased in the proximal jejunum and both PI and DI. In conclusion, we have found that slower Si activity of the Mgam null mice could produce free glucose, but the precursor oligomers accumulate distally and the SB glucose production is significantly reduced compared to the WT mice. We continue to characterize the structure of residual starch of both WT and null mice to elucidate how starch granules are digested along the small intestine. Partly sponsored by USDA (to B.L. Nichols), NIH (Comprehensive Lab Animal Monitor system), Post-Doctoral Fellowship Program of Instituto Nacional de Perinatología (to M. Diaz); open for additional sponsorship for structure characterization.



Status: Active. Part of the data has published in J Pediatric Gastroenterology and Nutrition, 2013, 57(6) 704-712.

25. Structure of α-Limit Dextrin Influences the Rate and Quantity of Dietary Glucose Released by Small Intestinal α-Glucosidase

P.I.: A. Lin

Researchers: Anbuhkani Muniandy, M.S. Student

Objective: Elucidate the structure of the slowly digestible fraction of amylopectin molecules in order to design starchy foods or ingredients with enhanced slowly digestible property

Progress: Starch digestion in humans requires six digestive enzymes; salivary and pancreatic α-amylases, and N- and C-terminal subunits of both maltase-glucoamylase (MGAM) and sucrase-isomaltase (SI). We previously reported that mucosal enzymes digest α-amylolysis products differently and unequally (Lin et al., 2012, Journal of Biological Chemistry 284 (44) 369170-369217), and our Project 23 above confirmed that the branch pattern of starch internal structure modulates the digestion at the mucosal α-glucosidase level. The objective of this study is to elucidate what kind of starch structure is slowly digestible by human enzymes. Knowledge gained from this project could be utilized by the food industry to design slowly digestible ingredients or starchy foods to better manage glucose release in humans. This project is sponsored by the Whistler Center Focus-Group Generation Project.

Status: Active.

26. Structure of Slowly Digestible Dextrin From Various Botanical Sources

P.I.: A. Lin

Researchers: Li Guo, Visiting Professor (Anhui Agricultural University; Anhui, China); Anbuhkani Muniandy, M.S. Student

Objective: Characterization of the slowly digestible dextrin obtained from commonly used starches in order to provide the food industry a database for selecting proper starch materials for producing foods with slowly digestible property and providing sustained energy

Progress: We reported that mucosal enzymes digest α-amylolysis products differently and unequally (Lin et al., 2012, Journal of Biological Chemistry284 (44) 369170-369217), and the glucose generation at this level is associated with the branch pattern of the hydrolysates (Project 23 above). In this project, we characterized α-amylase hydrolysates of commonly used starches, which include all four structural types of amylopectin. The outcome will provide food industry the database for selected proper starch materials for producing foods with slowly digestible properties and/or providing sustained energy. This project is open for sponsorship.

Status: Active

27. Improving the Measurement of Alpha-Amylase Hydrolyzate Quantity

P.I.: A. Lin

Researcher: Yijing Shao, undergraduate student (junior)

Objective: To improve the accuracy and efficiency of measuring reducing sugars in α-amylase hydrolyzates at the microliter level.

Progress: There are several methods to measure reducing sugars, which are commonly used to present α-amylase hydrolysis degree. Those methods include dinitrosalicylic acid (DNS), Somogyi-Nelson (SN), Park-Johnson (PJ), and 2,2'-Bicinchoninate (BCA) assays. DNS was found not a proper method for correctly measuring reducing sugar due to the difference in responses to different sugars. SN assay has good sensitivity in a broad range of concentration; PJ and BCA was sensitive in detecting low concentrations of reducing sugar, but the operation of BCA is much easier and more efficient. We modified the SN assay and operated it in a 96-well microplate, which requires only 10 microliters of substrate. The modified SN assay is precise, sensitive, and efficient. This project was Shao's Junior Research Credit project and was sponsored by multiple gift funds.

Status: Inactive

28. Improving Measurement of Starch Digestibility *In Vitro*

P.I.: A. Lin

Researchers: Wei-Jen, Visiting Scientist; Anbuhkani Muniandy, M.S. Student

Objective: Provide the food industry with an improved method to evaluate starch digestibility *in vitro*.

Progress: We have been working on designing an *in vitro* assay based on digestive reactions *in vivo*, and developing a mathematical model to present the digestion information including changes in digestion rate, to show in a more precise way the slow or extended digestion period, and total releasable glucose amount. The outcome will be to provide the food industry an easy assay to evaluate the digestibility, and particularly the slowly digestible element, during the product development process. This project is open for sponsorship.

Status: Active.

29. Water-Solid Interactions

P.I.: L. Mauer

Researchers: Na Li, Ph.D. Student; Krystin Marrs, M.S. Student; Matt Allan, M.S. Student

Objective: To determine the effects of the 5 modes of water-solid interaction on the chemical and physical stability of multicomponent food systems.

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

Status: Active.

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

P.I.: L. Mauer

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

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

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

Status: Active.

31. Pore Formation in Bacterial Cells by Melittin

P.I.: G. Narsimhan

Researchers: Xi Wu, Ph.D. Student; Xiaoyu Wu, Ph.D. Research Associate; Atul Singh Ph.D. Research Associate
Objectives: 1) Characterization of kinetics of cell death for *Listeria monocytogenes* and *E coli* O157:H7 when exposed to melittin of different concentrations, 2) Inference of lag time for cell death, and 3) Comparison of cell death kinetics for Gram positive and Gram negative bacteris.

Progress: Antimicrobial peptides (AMP) belong to a large and varied class of relatively short peptides family that have the ability to penetrate the cell membrane, form pores which eventually lead to cell death. Melittin, an AMP with 26 amino acids (GIGAVLKVLTTGLPALISWIKRKRQQ), and its mutant (GIGAVLKVLTTGLPALKSWIKRKRQQ) with a higher charge and lower hydrophobicity, exhibited antimicrobial activity against eight strains of Listeria with this activity being highest against L. monocytogenes F4244 , completely deactivating when added at different times to a growing population. MIC values of wild type and mutant melittin against L. monocytogenes F4244 were 0.20 and 0.39 µg/well respectively whereas the MBC values were 3.12 and 6.25 µg/well respectively, which is further corroborated by epi-fluorescence studies using green fluorescent protein expressing L. monocytogenes F4244. Transmission electron microscopy images of deactivated L. monocytogenes F4244 exposed to high levels of melittin showed pores in the cell membrane, consistent with the proposed mechanism of deactivation by AMP. Plate count indicated existence of a lag time for deactivation against L. monocytogenes F4244 for wild type and mutant melittin concentrations of 0.25 µg/well and xxxx µg/well respectively. Wild type and mutant melittin both were found to exhibit cytotoxicity to Caco-2 cells in the concentration range of 2 to 10 µg/ml with the cell viability being less than 1.65%. Because of the predominant effect of decrease in hydrophobicity, mutant melittin was found to exhibit lower antiliterial activity as well as lower cytotoxicity.

Status: Active

32. Identification of Antimicrobial Peptides from Soy Protein

P.I.: G. Narsimhan

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

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

Progress: The usefulness of antibiotics is limited by the ability of pathogenic bacteria to develop resistance to them. As compared to the traditional antibiotics, AMPs kill bacteria rapidly and can target multiple pathogens. Naturally occurring AMPs are expensive and are of limited availability. Selection of synthetic AMP for specific activity would require screening of large number of potential candidates and is therefore prohibitively expensive. The long term objective of the proposed research is to produce antimicrobial peptides (AMPs) from soy protein for use in food safety and human health as a replacement for antibiotics. AMPs are usually cationic and amphipathic, and kill microbial cells through insertion and damage/permeabilization of the cytoplasmic cell membranes. Six helical peptides of 21-24 amino acid residues containing 4-6 positive charges were identified as potential antimicrobial peptides (AMPs) from soy β-conglycinin (7S) based on (i) number of amino acid residues, (ii) helical conformation in aqueous environment, (iii) positive charge and (iv) hydrophobic moment. Hydrophobic moment analysis indicated all the segments are able to form helical structure within the lipid bilayer, which agreed with Molecular Dynamics (MD) simulation result. However, the hydrophobicity of the selected peptides were found to be negative. The two of the selected synthetic peptides did not exhibit antimicrobial activity against the microorganisms L. listeria monocytogenesis and E. Coli which is believed to be due to their negative hydrophobicity. Therefore, the protocol for identification of AMP from 7S should be refined.

Status: Active

33. Soy Protein as Anti-Oxidative Encapsulant for Delivery of Fish Oil in Food Emulsions

P.I.: G. Narsimhan

Researchers: Ning Xiang, Visiting Scientist; Srishti Khurana, Undergraduate Student; Xiaoyu Wu, Ph.D. Research Associate

Objectives: To apply soy protein as anti oxidative encapsulant for delivery of fish oil in food emulsions

Progress: The acidic pH (around 3) of beverage emulsions causes 7S to precipitate and therefore not provide physical or oxidative stability to fish oil emulsions. This is a result of low solubility of 7S under acidic conditions since its isoelectric point is 4.5. To overcome this issue, a layer by layer deposition technique was proposed. In this technique, the fish oil droplets were first coated with 7S at pH 7 which is followed by formation of a second layer of high methoxyl pectin (HMP) at pH 3 by electrostatic interaction between positively charged 7S and negatively charged HMP under acidic conditions. A coarse emulsions of fish oil in phosphate buffer stabilized of 7S (0.5% w/v) at pH 7 was formed using a Virtishear; the emulsion was then centrifuged to obtain a cream layer which was added to citrate buffer pH 3 containing HMP (in the concentration range of 0.005 to 0.05% w/v) and homogenized (Panda plus 2000)at 3000 to 19000 psi to form a fish oil emulsion with a second HMP layer around the drops. The binding of thioflavin-T hydrophobic dye to amyloid fibril belonging to adsorbed 7S layer around the fish oil droplet was assessed using confocal laser scanning microscopy alongwith zeta potential measurements in order to probe the nature of second HMP layer. The detailed procedure is given in the attachment. Scanning electron microscopy was employed to investigate the structure of the adsorbed layers around fish oil droplets (see attachment for details). Layer by layer deposition technique was also employed for a beverage emulsion containing mixture of orange oil and fish oil as the dispersed phase using method described above. The final emulsions consisted of 11% (v/v) of orange oil and 2% (v/v) of fish oil. The evolution of drop size and peroxide value for these emulsions was monitored for 8 days.

Status: Active

34. High-Value Corn Starch

P.I.: C. Weil

Collaborators: L. Mauer, Y. Yao

Researchers: Nick Babcock, technician, Sean Tague, undergraduate student

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

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

Status: Active.

35. Genes Controlling Starch Channelization

P.I.: C. Weil

Collaborator: J. BeMiller

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

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

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

Status: Active.

36. Genetic Interactions That Impact Starch Quantity and Quality

PI: C. Weil

Researcher: Project currently available

Progress: This project is awaiting a new researcher. Many mutations show differences in the phenotypes they cause when they are moved into various genetic backgrounds. The starch mutants ae1, 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 need to analyze 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

37. Genetics of Carbohydrate Transport and Partitioning in Maize

PI: C. Weil

Researchers: Xiqing Ma, Ph.D. Research Associate; J. Wedow, Undergraduate Student; Yang Wang, Visiting Scientist

Progress: We have now mapped ten new mutations impacting carbohydrate transport and distribution in maize, have identified over 350 more and have now developed F2 mapping populations for 320 of these. In summer 2013 we will map another 40 mutations for detailed analysis this fall. In addition we are collaborating with Dr. Jenna Rickus of Purdue's Physiological Sensors group to develop fluorescent sensor measurements of sucrose levels at varying positions in field-grown plants.

Status: Active.

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

PI: C. Weil

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

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 mapped two QTL that impact sugar accumulation in maize stalks and the next steps will be to determine the genes underlying these QTL. We are focusing on increasing the processes loading sugar into the vacuoles of stalk cells and decreasing its remobilization out of those vacuoles. In addition, we are now in the fourth generation of breeding tropical maize varieties to increase a combination of biomass and sugar content.

Status: Active

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

PI: C. Weil

Researchers: Nick Babcock, Curtis Brackett, Mitch Tuinstra, Brian Dilkes, Eric Johnson, Hamadou Traore

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

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

Status: Active

40. Carbohydrate-Based Colloidal Assemblies to Adsorb and Deliver Antimicrobial

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

Researcher: Preetam Sarkar, Ph.D. Student

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

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

Status: Active.

41. Carbohydrate-Based Biomaterials to Improve Quercetin Water Solubility

P.I.: Y. Yao

Researcher: Hua Chen, Ph.D. Student

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

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

Status: Active.

42. Carbohydrate-Based Biomaterials to Improve Curcumin Water Solubility

PI: Yuan Yao

Researcher: Randol Jose Rodriguez Rosales, M.S. Student (bypass to Ph.D. program)

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

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

Status: Active

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

PI: Yuan Yao

Researchers: Ying Xie, Ph.D. Student

Objective: To improve the water solubility of APIs.

Progress: It is estimated that roughly 40% of new drug molecules present drug delivery challenges due to their low solubility. The Biopharmaceutics Classification System (BCS) was developed as a systematic approach to classify Active Pharmaceutical Ingredients (APIs) based on their solubility and permeability. Based on the BCS, drug solubilization is necessary for the delivery of APIs Class II (low solubility, high permeability) and Class IV (low solubility, low permeability). In particular, for compounds in Class II, solubilization technologies can solve the drug delivery problem. In this project, a number of carbohydrate-based biomaterials have been prepared and tested using model APIs. The results showed that both the stability and solubility of APIs can be improved through complexation with carbohydrate biomaterials.

Status: Active

PUBLICATIONS AND OTHER SCHOLARLY ACTIVITIES

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

BeMiller

1. **H.S. Kim**, **B. Patel**, **J. BeMiller**. Effects of the amylose–amylopectin ratio on starch–hydrocolloid interactions. *Carbohydrate Polymers* 98, 1438–1448.
2. **Z. Sui**, **J. BeMiller**. Relationship of the channels of normal maize starch to the properties of its modified products. *Carbohydrate Polymers* 92, 894-904.
3. **Z. Sui**, K. Huber, **J. BeMiller**. Effects of order of addition of reagents and catalyst on modification of maize starches. *Carbohydrate Polymers* 96, 8-130.

Campanella

4. **Y. Yang**, **O. Campanella**, **B. Hamaker**, B. Zhang, Z. Gua. Rheological investigation of alginate chain interactions induced by concentrating calcium cations. *Food Hydrocolloids* 30, 26-32.
5. **M. Kale**, **B. Hamaker**, **O. Campanella**. Alkaline extraction conditions determine gelling properties of corn bran arabinoxylans. *Food Hydrocolloids* 31, 121-126.
6. **B. Patel**, **O. Campanella**, **S. Janaswamy**. Impact of urea on the three-dimensional structure, viscoelastic and thermal behavior of iota-carrageenan. *Carbohydrate Polymers* 92, 1873-1879.
7. **P. Santos**, **O. Campanella,** M. Carignano. Effective attractive range and viscoelasticity of colloidal gels. *Soft Matter* 9, 709-714.
8. **S. Janaswamy**, **K. Gill**, **O. Campanella**, R. Pinal. Organized polysaccharide fibers as stable drug carriers. *Carbohydrate Poly*mers 94, 209-215.
9. **M.G. Abiad**, **O.H. Campanella**, M.T. Carvajal. Effect of spray drying conditions on the physicochemical properties and enthalpy relaxation of α-lactose. *International Journal of Food Properties*17, 1303-1316.
10. **I. Demirkesen**, **O. Campanella**, G. Sumnu, S. Sahin, **B. Hamaker**. Effects of chestnut flour on staling characteristics of gluten-free breads. *4th International Conference on Food Engineering and Biotechnology IPCBEE*, Volume 50.
11. S. Lee, **O. Campanella**. Impulse viscoelastic characterization of wheat flour dough during fermentation. *Journal of Food Engineering* 118, 266–270.
12. **I. Demirkesen, O. Campanella**, G. Sumnu, S. Sahin, **B. Hamaker**. A study on staling characteristics of gluten-free breads prepared with chestnut and rice flours. *Food and Bioprocess Technology* 10.1007/s11947-013-1099.
13. **I. Demirkesen**, S Kelkar, **O. Campanella**, G Sumnu. Characterization of structure of gluten-free breads by using X-ray microtomography. *Food Hydrocolloids*. Available online 12 September 2013.
14. J.D. Dennis, T.D Kubal, **O. Campanella**, S.F. Son, T.L. Pourpoint. Rheological characterization of monomethylhydrazine gels. *Journal of Propulsion and Power* 29, 313-320.

Hamaker

15. **X. Shen**, E. Bertoft, **G. Zhang**, **B. Hamaker**. Iodine binding to explore the conformational state of internal chains of amylopectin. *Carbohydrate Polymers* 98, 773-783.
16. **B. Lee**, **L. Yan**, R. Phillips, **B. Reuhs**, K. Jones, D. Rose, B. Nichols, R. Quezada-Calvillo, S.H. Yoo, **B. Hamaker**. Enzyme-synthesized highly branched maltodextrins have slow glucose generation at the mucosal α-glucosidase level and are slowly digestible *in vivo*. *PLOS ONE* 8(4):e59745; doi:10.1371/journal.pone.0059745.

17. G. Zhang, **B. Hamaker**. "Slowly digestible starch and health benefits" "*in*" esistant Starch Sources, Applications and Health Benefits, John Wiley & Sons, Inc.

18. **B.H. Lee, L. Bello-Pérez**, **A. Lin**, **C.Y. Kim**, **B.R, Hamaker**. Importance of location of digestion and colonic fermentation of starch related to its quality. *Cereal Chemistry* 90:4, 335-343.

19. **M. Kale**, **B. Hamaker**, **N. Bordenave**. Oat β-Glucans: Physicochemistry and nutritional properties, "*in*" Oats Nutrition and Technology, John Wiley & Sons, Inc., edited by YiFang Chu.

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

21. **G. Zhang**, **B. Hamaker**. Slowly digestible starch and health benefits, *"in"* Resistant Starch: Sources, Applications and Health Benefits, John Wiley & Sons.

See Campanella papers 4, 5, 10, 12

See Lin papers 24, 25

Janaswamy

22. **B. Patel**, **O. Campanella**, **S. Janaswamy**. Impact of urea on the three-dimensional structure, viscoelastic and thermal behavior of iota-carrageenan. *Carbohydrate Polymers* 92, 1873-1879.

23. **S. Janaswamy**, **K. Gill**, **O. Campanella**, R. Pinal. Organized polysaccharide fibers as stable drug carriers. *Carbohydrate Polymers* 94, 209-215.

See Yao paper 39

Lin

24. **S. Dhital**, **A. Lin**, **B. Hamaker**, M. Gidley, **A. Muniandy**. Mammalian mucosal alpha-glucosidases coordinate with alpha-amylase in the initial starch hydrolysis stage to have a role in starch digestion beyond glucogenesis. *PLOS ONE* DOI: 10.1371/journal.pone.0062546.

25. M. Diaz-Sotomayor, R. Quezada-Calvillo, S. Avery, S. Chacko, **L. Yan**, **A. Lin**, **Z. Ao**, **B. Hamaker**, B. Nichols. Maltase-glucoamylase modulates gluconeogenesis and sucrase-isomaltase dominates starch digestion glucogenesis. *Journal of Pediatric Gastroenterology and Nutrition* 57:704-712.

See Hamaker paper 18

Mauer

26. **M.K. Ghorab**, **K. Marrs**, L. Taylor, **L. Mauer**. Water-solid interactions between amorphous maltodextrins and crystalline sodium chloride. *Food Chemistry* 26-35. Published online Oct. 5, 2013.

27. L.A. Wegiel, **L. Mauer**, K. Edgar, L. Taylor. Crystallization of amorphous solid dispersions of resveratrol during preparation and storage - Impact of different polymers. *Journal of Pharmaceutical Sciences* 102(1), 171-184.

28. **M. West**, **L. Mauer**. Chemical and color stability of a variety of anthocyanins and ascorbic acid in solution and powder forms. *Journal of Agricultural and Food Chemistry* 61(17), 4169-4179.

29. **N. Li,** M. Ferruzzi, L. Taylor, **L. Mauer**. Kinetic study of catechin stability: Effects of pH, concentration, and temperature. *Journal of Agricultural and Food Chemistry* 26-35. Published online Oct. 5, 2013.

30. **N. Li**, M. Ferruzzi, L. Taylor, **L. Mauer**. Color and chemical stability of tea polyphenol (-)-epi-gallocatechin-3-gallate in solution and solid states. *Food Research International* 53:909-921.

31. **R. Lipasek**, **N. Li**, S. Schmidt, L. Taylor, **L. Mauer**. Temperature effects on deliquescence and deliquescence lowering. *Journal of Agricultural and Food Chemistry* 61(38):9241-9250.

Narsimhan

32. **P. Phoon**, **G. Narsimhan**, M. San Martin-Gonzalez. Effect of thermal behavior of beta-Lactoglobulin on the oxidative stability of menhaden oil-in-water emulsions. *Journal of Agricultural and Food Chemistry* 61, 1954-1967.
33. **X. Wu**, **H. Chang**, C. Mello, R. Nagarajan, **G. Narsimhan**. Effect of interaction with coesite silica on the conformation of Cecropin P1 using explicit solvent molecular dynamics simulation. *The Journal of Chemical Physics* 138, 045103-045114.
34. **G. Narsimhan**. A mechanistic model for baking of unleavened aerated food. *LWT - Food Science and Technology* 53, 146-155.

Reuhs

35. S. Simsek, T. Ojanen-Reuhs, K. Wood, **B. Reuhs**. Structural analysis of succinoglycan oligosaccharides from Sinorhizobium meliloti strains with different host compatibility phenotypes. *Journal of Bacteriology* 195, 2032-2038.
36. M. Ovando-Martínez, K. Whitney, **B. Reuhs**, D.C. Doehlert, S. Simsek. Effect of hydrothermal treatment on physicochemical and digestibility properties of oat starch. *Food Research International* 52, 17-25.
37. F. Mahmood, A. Hakimiyan, V. Jayaraman, S. Wood, S. Sivaramakrishnan, **B. Reuhs**, S. Chubinsicaya, S.H. Shafikhan. A novel human antimicrobial factor targets Pseudomonas aeruginosa through its type-three secretion system. *Journal of Medical Microbiology* 62, 531-539.

See Hamaker paper 16

Yao

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

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

February

1. **Lisa Mauer**. Fundamentals and consequences of water-solid interactions in blends of crystalline and amorphous ingredients. Department of Chemistry Biochemistry Division Seminar Series, Purdue University.

March

2. **Amy Hui-Mei Lin**. Starch digestion and slowly digestible dextrin. General Mills, Minneapolis, MN.

April

3. **Meric Simsek.** Different polyphenols have different affinities for c-terminal subunits of maltase-glucoamylase and sucrase-isomaltase for the modulation of glucose release. Experimental Biology annual meeting, Boston, MA.
4. **Meric Simsek.** Gallic acid modifies the expression of intestinal maltase-glucoamylase mRNA but not enzyme activity. Experimental Biology annual meeting, Boston, MA.
5. **Like Hasek.** Long-term feeding of dietary slow release glucose reduces daily caloric food intake *in vivo* 2. Experimental Biology annual meeting, Boston, MA.
6. **Like Hasek.** Chronic distal digesting of starch reduces subsequent starch digestion through a post-translational mechanism which reduces mucosal disaccharidase activities. Experimental Biology annual meeting, Boston, MA.

7. **Lisa Mauer**. Fundamentals and consequences of water-solid interactions. Decagon Devices Webinar, Pullman, WA.

8. **Lisa Mauer**. Fundamentals and consequences of water-solid interactions: What is deliquescence and why does it matter? Washington State University, Pullman, WA.

9. **L. Zhou**, **Xi Wu**, **Xiaoyu Wu**, **Ganesan Narsimhan**. Pore formation in dmpc bilayers by antimicrobial peptide melittin: mathematical model and comparison with experiments. American Chemical Society National Meeting, New Orleans, LA.

10. **Amy Hui-Mei Lin**, M. Diaz-Sotomayor, R. Quezada-Calvillo, S. E. Avery, S. K. C. Chacko, Like Yan, **Z. Ao**, **Bruce Hamaker**, B. Nichols. Reduced glycemic response to starch feeding of Mgam null mice is buffered by increased endogenous gluconeogenesis. Experimental Biology, Boston, MA.

11. **Osvaldo Campanella**. Application of nanotechnology in the beverage industry. "Alimenta tu Ingenio" School of Biotecnology and Foods. Tecnologico de Monterrey. Monterrey, Mexico.

May

12. **Amy Hui-Mei Lin**. A new view of starch digestion: starch sources influence glucose generation at mucosal α-glucosidase level. The 10th International Conference on Food Science and Technology, Jiangnan University, Wuxi, China.

13. **Amy Hui-Mei Lin**. Structure of slowly digestible dextrin. Whistler Center for Carbohydrate Research Technical Conference, Purdue University, W. Lafayette, IN.

July

14. **Lisa Mauer**. "Food processing and packaging" at pre-meeting short course. Institute of Food Technologists annual meeting, Chicago, IL.

15. **Osvaldo Campanella**. "Structure/function relationship of rheological behavior of carbohydrate texturants" at pre-meeting short course. Institute of Food Technologists annual meeting, Chicago, IL.

16. **Bruce Hamaker**. In-vitro techniques for dietary carbohydrate digestion and fermentation. Institute of Food Technologists annual meeting, Chicago, IL.

17. **Bruce Hamaker**. Potential of functionalizing non-wheat cereal proteins for gluten-free products. Institute of Food Technologists annual meeting, Chicago, IL.

18. **Preetam Sarkar**, **Yuan Yao**. Starch octenyl succinate stabilized emulsion for the protection of nisin activity in a cantaloupe juice food model. Institute of Food Technologists annual meeting, Chicago, IL.

19. **Janaswamy Srinivas**. Organized polysaccharide matrices as stable delivery vehicles. Institute of Food Technologists annual meeting, Chicago, IL.

20. **Lohit Myneedu**, **Janaswamy Srinivas**. Structure-function relationship of Kappa-carrageenan: Effect of KCl, KBr, and KI. Institute of Food Technologists annual meeting, Chicago, IL.

21. **Belinda Christina**, L.S. Taylor, **Lisa Mauer**. Crystallization inhibitor properties and effects of selected polymers in the chemical and physical stability of vitamin C. Institute of Food Technologists annual meeting, Chicago, IL.

22. **Mathew Allen**, L. S. Taylor, **Lisa Mauer**. A comparison of analytical techniques used to determine the deliquescence points of crystalline ingredients. Institute of Food Technologists annual meeting, Chicago, IL.

23. **Na Li**, L.S. Taylor, **Lisa Mauer**. Moisture-dependent crystallization of amorphous (-)-epogallocatechin gallate. Institute of Food Technologists annual meeting, Chicago, IL.

24. **Na Li**, L.S. Taylor, **Lisa Mauer**. Kinetics of deliquescence of organic and inorganic food ingredients. Institute of Food Technologists annual meeting, Chicago, IL.

25. **Krystin Marrs**, **Mohamed Ghorab**, L.S. Taylor, **Lisa Mauer**. Effects of co-formulation on the water-solid interactions and behaviors of crystalline and amorphous solids. Institute of Food Technologists annual meeting, Chicago, IL.

26. **Amanda Deering**, D. Jack, **Lisa Mauer**, R. Pruitt. Examination of the movement and persistence of Salmonella s.v. Typhimurium and E. Coli O157:H7 to ripe tomato fruit following various routes of contamination. Institute of Food Technologists annual meeting, Chicago, IL.

27. **Lisa Mauer**. Triple-bag hermetic storage for cowpea in West and Central Africa. Part of the "Reduce, Reuse, Recycle: A Sustainable Packaging Approach" session. Institute of Food Technologists annual meeting, Chicago, IL.

28. **Mohammad Chegeni**, **Bruce Hamaker**. Influence of different malto-oligosaccharides on the sucrose-isomaltase expression of Caco-2 cells. Institute of Food Technologists annual meeting, Chicago, IL.

29. **Daniel Erickson**, **Osvaldo Campanella**, **Bruce Hamaker**. Understanding the aggregative behavior of maize zein as it pertains to the development of viscoelastic properties in a gluten-free dough system. Institute of Food Technologists annual meeting, Chicago, IL.

30. **Meric Simsek**, **Bruce Hamaker**, B.L. Nichols, R. Quezada-Calvillo. Differential effects of polyphenols on the expression of interstinal maltase-glucoamylase. Institute of Food Technologists annual meeting, Chicago, IL.

31. **Tao Feng**, **Bruce Hamaker**, **Haining Zhuang**. Study of amylose salvation and amylose-linoleic acid inclusion behavior in water by molecular dynamic simulation. Institute of Food Technologists annual meeting, Chicago, IL.

32. **Tao Feng**, H. Zhuang, **Osvaldo Campanella**, **Bruce Hamaker**, **Deepak Bhopatkar**, M. Carignano, Sung Hyun Park. Polysaccharide Conformation and its Effect on Solution Rheology and Texture. Institute of Food Technologists annual meeting, Chicago, IL.

33. **Amy Hui-Mei Lin**. Starch digestion and small intestinal mucosal α-glucosidase. Institute of Food Technologists annual meeting, Chicago, IL.

34. **Osvaldo Campanella**. Development of models and methods to study processing of foods. Universidad Técnica Federico Santa María, Viña del Mar, Chile.

August

35. **Osvaldo Campanella.** Mathematical models: A useful tool for food processing studies. Universidad Técnica Federico Santa María, Viña del Mar, Chile.

September

36. **Bruce Hamaker**. Alsberg French Schoch Award recipient presentation - The intricacies of starch digestion and a view towards quality and health benefit. Start Round Table, Albuquerque, NM.

37. **Amy Hui-Mei Lin**. Beyond α-amylase hydrolysis: up-to-date overview of starch digestion. Starch Round Table, Albuquerque, NM.

38. **Amy Hui-Mei Lin**. Branch amount and pattern of starch internal structure influences the glucogenesis by Nt-maltase glucoamylase. American Association of Cereal Chemists International Annual Meeting, Albuquerque, NM.

39. **Byung-Hoo Lee**. Enzymatic synthesis of 2-deoxy-glucose-containing maltooligosaccharides to test the location of starch digestion in the small intestine. Start Round Table, Albuquerque, NM.

40. **Bruce Hamaker**. Alsberg French Schoch Award recipient presentation - The intricacies of starch digestion and a view towards quality and health benefit. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

41. **Daniel Erickson**, S. Renzetti, A. Jurgens, **Osvaldo Campanella**, **Bruce Hamaker**. Modulating state transition and mechanical properties of viscoelastic resins from maize zein through interactions with

plasticizers and co-proteins. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

42. De La Peña, **Bhavesh Patel**, **Osvaldo Campanella**, F.A. Manthey. Improving the nutritional quality of pasta: Rheological studies on pasta dough with nontraditional ingredients. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

43. **Methap Fevzioglu**, **Osvaldo Campanella**, **Bruce Hamaker**. On the viscoelastic mechanisms in cereal proteins: How can we use structural models on gluten viscoelasticity to functionalize non-gluten proteins? American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

44. **Stacey Hirt**, **Owen Jones**. Specific salt effects on the formation and thermal transitions of electrostatic complexes among β-Lactoglobulin and pectin. American Chemical Society 246th National Meeting, Indianapolis, IN.

October

45. **Bruce Hamaker**. Polysaccharide digestion and fermentation. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

46. **Bruce Hamaker**. Conflict of Interest - Myth or Reality: Academic Perspective. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

47. **Amy Hui-Mei Lin**. Branch abundance and pattern of starch internal structure affect glucogenesis by mucosal Nt-maltase-glucoamylase. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

48. **Daniel Erickson**, **Mehtap Fevzioglu**. On the viscoelastic mechanisms in cereal proteins; how can we use structural models on gluten viscoelasticity to functionalize non-gluten protein? American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

49. **Byung-Hoo Lee**, D.W. Ko, Sang Hoo Yoo, **Bruce Hamaker**. Enzymatic synthesis of 2-deoxy-glucose-containing maltooligosaccharides to test the location of starch digestion in the small intestine. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

50. **Lisa Lamothe**, Sathaporn Srichuwong, **Bruce Hamaker**. Hydrothermal and enzymatic solubilization of insoluble dietary fiber from cereal and pseudocereal sources. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

51. **Yunus Tuncil**, **Mehtap Fevzioglu**, **Osvaldo Campanella**, **Bruce Hamaker**. Accessible protein body-free sorghum kafirin shows better functionality than kafirin in normal sorghum. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

52. **Meric Simsek**, R. Quezada-Calvillo, B. L. Nichols, **Bruce Hamaker**. Different polyphenols have different affinities for maltase of total human intestinal homogenate, inhibiting glucose release. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

53. E. De La Pena, **B.K. Patel**, **Osvaldo Campanella**, F.A. Manthey. Improving the nutritional quality of pasta: Rheological studies on pasta dough with nontraditional ingredients. American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.

54. **Amy Hui-Mei Lin**. Starch and starch digestion in humans. DSM Nutritional Products, North America Starch Digestibility Roundtable II. Madison, WS.

55. **L. Zhou**, **Xi Wu**, **Xiaoyu Wu**, A. Singh, A. Bhunia, **Ganesan Narsimhan**. Pore Formation in 1,2-Dimyristoyl-Sn-Glycero-3-Phosphocholine Bilayers and Listeria Monocytogenes by Low Concentrations of Antimicrobial Peptide Melittin. American Institute of Chemical Engineers 2013 Annual Meeting, San Francisco, CA.

56. **Osvaldo Campanella.** Food Extrusion. Traditional and New Trends. Innova 2013, Montevideo, Uruguay.

57. **Osvaldo Campanella.** Seven hours Course on Extrusion. Innova 2013. El Laboratorio Tecnológico del Uruguay LATU, Montevideo, Uruguay.

58. **Osvaldo Campanella.** Methods to study foods and biomaterials and their role on processing. Cytal 2013 Conference. Rosario, Argentina.

December

59. **Lisa Mauer**. Center for Food Safety Engineering Pathogen Detection Technologies. 2013 Annual Meeting of the MOST-USDA Joint Research Center for Food Safety. Shanghai, China.

E. GRADUATE DEGREES AWARDED

1. **Madhuvanti S. Kale Ph.D.**, *Corn bran arabinoxylans: Structure-function relationships, gel formation and potential application of the gels as bioactive delivery matrice*, May.
2. **Na Li Ph.D.**, *Catechin stability in powder and solution systems*, May.
3. **Hua Chen, Ph.D.**, *Structure and functions of highly-branched alpha-D-glucans*, December.
4. **Stephany Tandazo,** *Rheological properties of gluten free dough systems*, December.
5. **Stacey Hirt, M.S.**, *Specific salt effects on the formation and thermal transitions among β-lactoglobulin and pectin electrostatic complexes*, December.
6. **Laura Zimmer, M.S.**, *Pickering stabilization of oil-water interfaces by heated β-lactoglobulin/pectin particles*, December.

F. RECOGNITIONS, AWARDS, AND HONORS

1. **Bruce Hamaker** was appointed Distinguished Professor of Food Science at Purdue University, December 2013.
2. **Bruce Hamaker** received the 2013 AACCI (American Association of Cereal Chemists International) Alsberg-French-Schoch Award. This award, given every 2-4 years at the annual AACCI meeting, honors "chemists who have made distinguished contributions to fundamental starch science."
3. **Bruce Hamaker** has been named an international scholar in Sejong University, Seoul, South Korea.
4. **Daniel Erickson** received the AACCI Best Student Research Award paper "Modulating state transition and mechanical properties of viscoelastic resins from maize zein through interactions with plasticizers and co-proteins". American Association Cereal Chemists International Annual Meeting, Albuquerque, NM.
5. **Belinda Christina (**M.S. Student) received the Purdue University Committee of the Education of Teaching Assistants (CETA) Teaching Award.
6. **Matt Allan** and **Laura Zimmerer** were members of the Purdue Food Science College Bowl Team that won the Midwest Regional Competition. Purdue's team participated in the national competition at the Institute of Food Technologists (IFT) Annual Meeting in Chicago.
7. **Luis Arturo Bello Pérez** was awarded by Elsevier the Scopus Mexico 2013 award. This award honors Mexican researchers affiliated with institutions whose academic career have had an excellent production recorded in the Scopus database, the most comprehensive database of references currently available. Dr. A. Bello-Perez is a professor at the Center for Development of Biotic Products of the National Polytechnique Institute-Mexico. His has been on sabbatical at the Whistler Center since 2012.
8. **Meric Simsek** received the Megazyme Award from the Carbohydrate Division of American Association of Cereal Chemists International.

9. **Na Li's** poster "Moisture-dependent crystallization of amorphous (-)-epogallocatechin gallate" placed first in the Food Chemistry Division at the IFT Annual Meeting.
10. **Preetam Sarkar's** poster "Starch octenyl succinate stabilized emulsion for the protection of nisin activity in a cantaloupe juice food model" placed third in the Carbohydrate Division at the IFT Annual Meeting.
11. **Yunus Emre Tuncil** was selected as a vice chair of AACCI student division.
12. **Daniel Erickson** won the Corn Refiner's Association (CRA) award for his poster at the annual American Cereal Chemist's meeting.
13. **Amy Hui-Mei Lin was** Chair of the Carbohydrate Division of IFT.
14. **Osvaldo Campanella** was appointed Adjunct Professor at the Institute Tecnologico of Monterrey.

Whistler Center Short Course, October 15-17, 2013

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

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

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

Dr. J McRorie, a pre-clinical and clinical scientist at Procter & Gamble Co., taught *"Gastrointestinal physiology and the physics of fiber in health and disease"*.

As is our tradition, the course was designed to provide one-day on carbohydrate fundamentals followed by two days advanced special topic sessions. Day I consisted of a general session. Advanced topical areas were presented on days 2 and 3, so that each participant could attend 4 advanced topic sessions of their choice.

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

Wednesday and Thursday Breakout Sessions

1A/1B - Advances in modifications of starch properties, J. BeMiller

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

3A/3B - Glycemic carbohydrates, B. Hamaker and A. Lin

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

5A/5B - Hydrocolloids and functionality, J. Keller

6A - Gastrointestinal Physiology and the Physics of Fiber in Health and Disease, John McRorie

7A - Dietary fiber/prebiotics and changing colon microbiota, B. Hamaker

8A - Complex carbohydrate structure analysis (non starch), B. Reuhs

9B - Water-solid interactions: crystalline and amorphous solids, L. Mauer

10B - Analysis starch structure, and genetic starch modifications, A. Lin and C. Weil

11B. - Dietary fiber and the microbiome, B. Hamaker

12B - Polysaccharide architecture and functionality including starch, R. Chandrasekaran and J. Srinivas

13B - Polysaccharide-protein interactions, O. Jones

Structure and digestibility of selected resistant starch

2013 Belfort Lecturer
Dr. Jay-Lin Jane
Charles F. Curtiss Distinguished Professor, Department of Food Science and Human Nutrition, Iowa State University

Dr. Jay-lin Jane is a Charles F. Curtiss Distinguished Professor in the Department of Food Science and Human Nutrition, Iowa State University. She received her Ph.D. degree with a focus in Carbohydrates from the Department of Biochemistry and Biophysics at Iowa State University. Dr. Jane's primary research interests are in starch structures, properties, and applications. She has also done research on biodegradable plastics using biopolymers, including starch and protein. Dr. Jane and her students conducted studies to understand the internal structures of starch granules using approaches, including cross-linking reactions between adjacent starch molecules to determine the relative locations of amylose and amylopectin in the granules and surface gelatinization methods to peel off layers of starch granules from the surface combining with confocal-laser light scattering microscopy to reveal the internal structures of the granules. They also unveiled structures of elongated starch-granules and resistant starch of high-amylose starch and the formation of these starches. She is currently working on the development and characterization of resistant starch to reduce the digestion rate of starch for prevention of diabetes and colon cancer. Dr. Jane has published 180 refereed papers, 10 patents, and delivered 200 invited/keynote/plenary lectures in more than 28 countries. Dr. Jane has received numerous awards including the Alsberg-French-Schoch Award from the AACC International and The Merit of Science Award from the Japanese Applied Glycoscience Association.