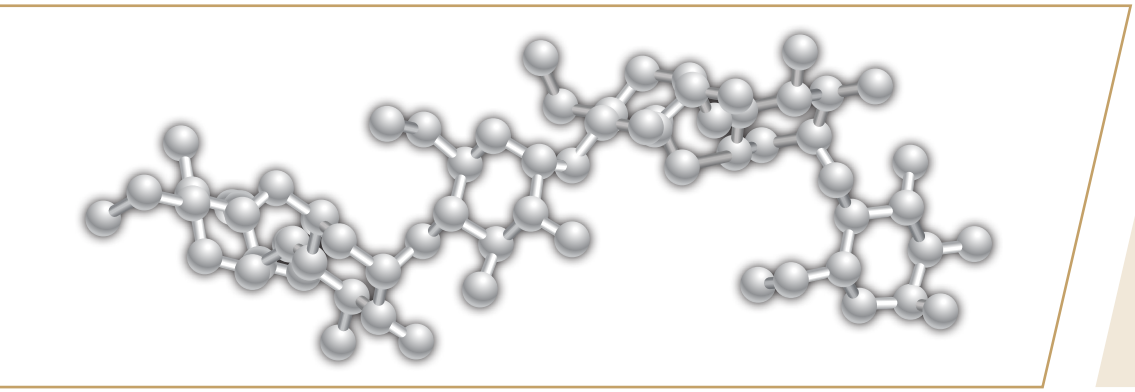
WHISTLER CENTER
for Carbohydrate Research

2022
ANNUAL REPORT

PURDUE UNIVERSITY

Food Science



3-D view of starch structure.

Industrial Members

(Members of 2022 Industrial Advisory Board)

Archer Daniels Midland

Cargill

General Mills

Grain Processing Corporation

Hayashibara

Mars Wrigley

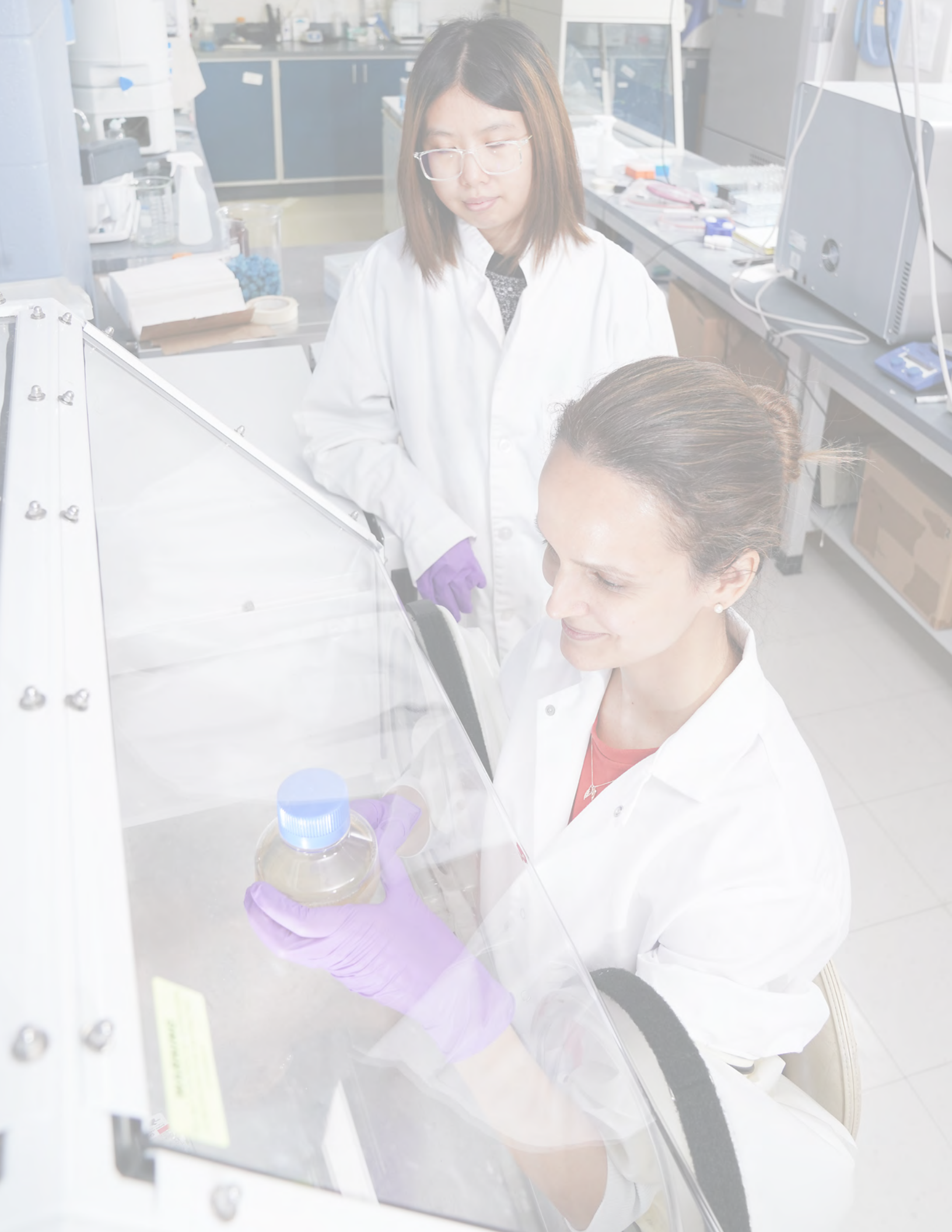
Mondelēz International

Nestlé

Novozymes

PepsiCo

Tate & Lyle



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Director's Statement

Welcome to the 2022 annual report of the Whistler Center for Carbohydrate Research. As director, it's a time for me to reflect on our accomplishments of the past year and also to note what's happening in the world of food and industrial-use carbohydrates.

It appears that there is increased interest in carbohydrates from the diet perspective, both in industry and among consumers. The nuances in carbohydrate qualities related to health and wellness are becoming ever clearer. This is true of both available carbohydrates, with regard to improving quality as well as reducing sugar, and dietary fibers that feed the gut microbiota. The Whistler Center is at the forefront of these research areas, as well as other areas of continuing importance, i.e., texturizing carbohydrates, interaction of carbohydrates in complex systems, clean label replacements, and other novel functions.

We are one of the few go-to carbohydrate centers of excellence for short- and long-term research, continuing education, brainstorming of ideas and analytical services. The Center has 15 faculty members (12 Purdue and 3 external) spanning most areas of food- and non-food-focused carbohydrate research and application. Our industrial partner research is designed to be interactive and iterative to solve carbohydrate-related problems, fitting well in the open innovation environment that exists today.

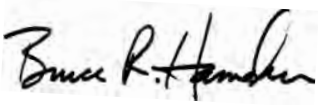
As you will see as you peruse this report, we had a highly productive 2022. Our faculty published 96 peer-reviewed scientific journal papers, gave 74 presentations, and brought in numerous new federal, industry, state and foundation grants. In research, the Center funded three faculty-industry team projects on topics related to company needs, in addition to a multiyear Center-supported project on sugar reduction/replacement that was completed in 2022. The latter systematically showed how a large range of simple sugars and oligosaccharides compare with sucrose in their functioning.

Continuing education is an important service we provide to our members. In 2022 we were back to our in-person, three-day October Short Course. (To check out what was taught, see Page 69.) We continued to offer our popular six-per-year webinar series on timely topics in carbohydrate research and to give our viewpoint regarding opportunities and what's on the horizon. We have an Education Package, for those interested only in this aspect of the Center, that combines both the short course and webinar series.

Our Purdue and external faculty are among the best in their fields and are recognized as such. At Purdue, Lavanya Reddivari was promoted to Associate Professor, Steve Lindemann was awarded both University Faculty Scholar and the Philip E. Nelson Endowed Chair of Food Science, Yuan Yao the Showalter Faculty Scholar, Senay Simsek the Distinguished Women Scholar, and I received the Morrill Award, the highest honor that Purdue confers onto a faculty member. Angie Gutterman, our super Whistler Center Coordinator, was promoted to Lead Administrative Assistant. At Arkansas Medical Center, Mario Ferruzzi was awarded the Inaugural Arkansas Children's Endowed Chair in Digestive Disease and Nutrition Research.

Please, take some time and read through our 2022 Whistler Center Annual Report to know who we are, what we do, and the many achievements we've had. Feel free to reach out to Angie or me with any questions.

Sincerely,



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

Summary of Major Research Accomplishments

Starches, Non-starch Polysaccharides and Cereals (Non-health)

J. BeMiller published with his former student, Kurt Villwock, a two-part series of articles in *Starch-Stärke* on "The architecture, nature, and mystery of starch granules," covering early to current investigations (303 references) and a comprehensive review (259 references) on the details of this starch granule structure.

B. Hamaker's group concentrates mostly on carbohydrates for health, though in this year published, with **O. Campanella**, papers in the non-health area on the desirable material properties of soluble corn bran arabinoxylan for high incorporation in cereal extrudates (*Food Hydrocolloids*), the effect of Hofmeister anions on the properties of a starch-protein-lipid nanoparticle (*International Journal of Biological Macromolecules*), and a novel extruded millet couscous process for West Africa (*International Journal of Food Science and Technology*).

M. Martinez's group focuses on translational polymer science, approaching the structure and function of food biopolymers (Projects 29, 31), their binding potential to plant secondary metabolites (Projects 28, 31), the elucidation of their complex structural biochemistry (Projects 30, 31), and their food structuring behavior (Projects 29, 30). During the last years his team has also worked on the fundamental aspects related to the structuring technologies of semi-solid plant-based foods (Project 29), as well as the establishment of green chemistry routes to transform polysaccharides into high-performing biomaterials (Project 30).

L. Mauer's group takes a materials science approach to manipulate and investigate food ingredient structures and functions, water-solid interactions, and amorphization and crystallization tendencies. Ongoing studies include investigations of the roles of sugars and oligosaccharides on the functional properties of starch, including how oligosaccharides may be useful for sugar reduction strategies (Project 32).

G. Narsimhan's group is conducting studies on the effect of xanthan on swelling of starch granules as a function of temperature and starch content. A mathematical model has also been developed which accounts for the effect of depletion forces on starch swelling by employing a mean field theory of non-adsorbing macromolecules (Project 33).

S. Simsek's group has developed a research program focused on the integration of cereal and crop quality with the structure-function relationships of carbohydrates. S. Simsek's group has also completed investigations related to processing and carbohydrate functionality in oat milk production (Project 39). This study identified how certain production methods affect carbohydrates in oat beverage bases. The extraction method impacted molecular weight of soluble carbohydrates in the oat milk bases that could affect the viscosity and mouthfeel of oat beverages. Amylase treatment ensured that there is enough available starch for enzymatic processing, as well as sufficient soluble solids content to closely emulate dairy milk and other benchmark plant-based beverages.

S. Simsek's group collaborated with **S. Lindemann** on a project studying *in vitro* fecal fermentation of sourdough bread (Project 41). Flour samples were used to make sourdough bread using two different sourdough starters: rye and wheat. Mill settings, flour particle size, and starter culture played a significant role in determining the nutritional attributes such as dietary fiber content, protein, starch digestibility, and antioxidant activity of sourdough bread samples. The differences in the sourdoughs with the rye and wheat starter revealed the biodiversity of microflora in starters. Finally, S. Simsek's group has begun investigation of extraction of cellulose from industrial hemp stalk for production of biodegradable superabsorbent material and cellulose gums, such as carboxymethyl cellulose for use in food products (Project 42). In collaboration with M. Bolt and R. Turco from the Agronomy Department, different varieties of industrial hemp are being investigated for use in creation of functional biodegradable materials for food packaging and food ingredients.

Y. Yao's group continued work on the modification and selection of carbohydrate-based (and other biopolymers) ingredients for food and pharmaceutical use. Ongoing studies include the characterization of biopolymers using a molecular rotor (MR) approach (Project 43), which is to determine the physicochemical changes in biopolymer-containing systems. Sponsored by an USDA grant, his group has started the work on plant-based emulsifiers and (micro)encapsulation wall materials (Project 44). In addition, his group has made progress in plant-based meat alternatives (Project 46).

Carbohydrates, Nutrition and Health

O. Campanella's group began a project on using an encapsulated iron-glycated soy phospholipid complex in extrusion to increase iron bioavailability in plant-based protein meat analogues (Project 4). They also conducted research on development of an extruded corn snack with high arabinoxylan and including resistant starch to increase gut fermentation and gut-brain axis activation (Project 5).

B. Hamaker's group works in the carbohydrates for health area, focused both on digestible/absorbable carbohydrates in the upper gastrointestinal tract (GI) and dietary fiber and the gut microbiome. Their overall goal is to understand how to use carbohydrates for physiological and metabolic endpoints related to nutrition and health. In fibers and the microbiome, they have worked for some years on understanding how to better match fibers to support specific beneficial gut bacteria or groups of bacteria and, in this year, report initial data showing the matching of a fiber to *Faecalibacterium prausnitzii* through a protocol they developed (Project 7) and a designed fiber mixture to support complementary groups of bacteria (Project 9). In other ongoing work in this area, studies were conducted on the effect of viscosity on growth of a gut bacteria and toward a possible hierarchical scheme of fibers based on specificity to bacteria (Project 8), and the potential for fiber mixtures to suppress *Clostridium difficile* bloom in the presence of an antibiotic (Project 9). In research on carbohydrates in the upper GI tract, they published *in vivo* studies (mouse and human) on triggering of the gut-brain axis and ileal break and began a study to understand gut-brain axis triggering from both direct ileal and gut fiber fermentation perspectives (Project 10). In Project 11, they reported on studies showing that slowly digestible starch improved metabolic flexibility, cellular ability to switch between oxidation of carbohydrate and fat (Project 11).

S. Lindemann's research program continues to identify important physical and chemical fiber structural elements that modulate the composition and metabolic function of gut microbial communities. To this end, the lab focused this year on brans and bran-derived fibers, as consumption of brans from grains, including arabinoxylans, contributes a significant amount of the dietary flux of polysaccharides to the gut. This year, his lab demonstrated that enzymatic debranching of sorghum arabinoxylans alters the microbiota that are most successful in fermenting them (Project 22). Further, they discovered that mixtures of branched and debranched polysaccharides resulted in microbial community structural responses that were governed by their ratio, but nonlinear metabolic responses in fermentations. Similar responses were observed in fermentation of fibers derived from distinct wheat genotypes. In Project 23, initial studies demonstrated effects of wheat bran particle size produced by distinct milling methods on metabolic outputs and community structures during fermentation. Recent findings demonstrated that the availability and metabolism of bran phenolics was particle size- and milling method-dependent. Work continues to identify the phenolics liberated, the molecular transformations being performed, and the species involved. Further, the lab continued Project 24, linking resistant glucan structures to the microbiota that are most efficient in fermenting them, both *in vivo* and *in vitro*. Project 25 has discovered links between inulin chain length and branching to fermenting microbial communities in a way that supports predictive modeling. Finally, the laboratory began a new project to identify how microbes divide their labor in degrading polysaccharides (Project 27). In addition, they measured digestion of oligosaccharide-starch interactions that influence physicochemical properties of starch to examine influences on fermentation by microbiota (Project 26).

E. Oh's group investigates the fermentation of non-conventional carbon sources by metabolically engineered yeast strains. This approach aims to generate value-added chemicals (Project 34) and to alleviate symptoms associated with functional bowel disorders (Project 35). In the area of sustainable bioprocesses, cost-effective feedstocks for bioconversion are critical for industrial fermentation strategies. Since widely used cell factories such as *S. cerevisiae* cannot ferment carbon sources in these agricultural residues, research efforts focused on developing engineered yeast strains capable of co-utilizing carbon sources in the hydrolysates of biomass. The group has developed a genetically engineered yeast platform capable of simultaneously utilizing non-glucose sugars derived from lignocellulosic and pectin biomass. Heterologous metabolic pathways were integrated into the genome of the engineered yeast strain using the CRISPR/Cas9 system. Additionally, they are working on a new class

of engineered yeast strains designed for the targeted elimination of undesirable carbohydrates during the dough fermentation process. The development of these designer microorganisms has the potential to alleviate irritable bowel syndrome (IBS) symptoms and enhance gut health for those affected.

L. Reddivari's group focuses on harnessing the bioactive compounds in foods to improve gut barrier function and prevent chronic inflammation, which is the underlying cause of many chronic colonic diseases. They are currently working on understanding the role of gut bacteria in the anti-colitic and anti-inflammatory properties of plant flavonoids (Project 36), dietary fiber (Project 37) and bacterial dysbiosis in the onset and severity of colitis (Project 38). The focus is on understanding the interaction between polysaccharides, flavonoids and gut bacteria plays a role in gut health and how the physicochemical properties influence the physiological effects.

S. Simsek's group has continued investigation of dietary fiber from dry beans. A study on the immunomodulatory activity of soluble dietary fiber was conducted (Project 40). The study showed that SDF-rich fractions extracted from dry beans promoted the secretion of pro-inflammatory molecules NO, TNF-α, IL-6, and IL-1β by RAW 264.7 murine macrophages. The results show the possibility of considering SDF-rich fractions extracted from dry beans as immunostimulators to aid in the prevention and fight of infections.

Chemical Structure and Function of Polysaccharides

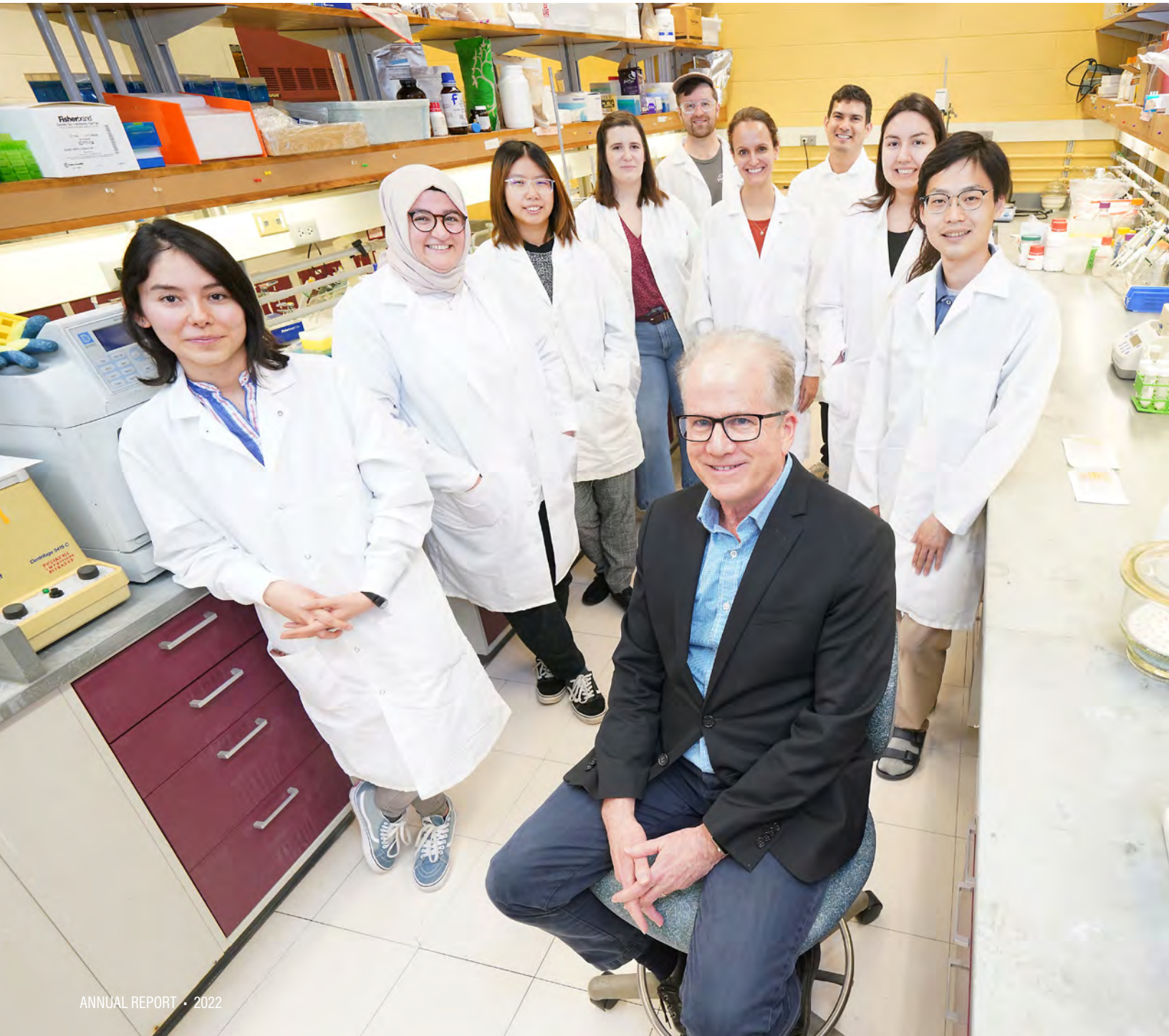
B. Reuhs and A. Terekhov run the analytical core facility at the Whistler Center dedicated to complex carbohydrate structural analysis. With other Whistler Center faculty, the group provides expertise and studies on non-starch polysaccharide structures related to physicochemical and rheology functionality, and gut microbiota fermentation properties. They also do service work for member companies (at a reduced rate) and outside laboratories.

Emerging Food Processes

O. Campanella's group investigates how the efficiency of processing techniques is influenced by food material composition of protein and polysaccharide-containing foods, and on byproduct and waste material processing. In the past year, they finished projects on use of whey protein as a gluten replacer (Project 1) and on plant-based protein meat analogue nutritional quality (Project 2). The application of twin-screw extrusion for the conversion of brewer's spent grains from waste to food was studied (Project 3). A study was initiated using reactive extrusion for byproduct manufacturing (Project 6).

O. Jones' research identifies structuring in colloids comprised of biopolymers, including proteins and polysaccharides, that contributes to useful functions in foods, beverages, or packaging materials. A collaborative project with Drs. **Campanella, Simsek, and Martinez** determined the effects of hydrolytic enzymes and high moisture extrusion on the rheological properties and composition of a pinto bean flour (Project 13). In the past year, two enzyme preparations were selected as most effective in changing the viscosity of bean flour during heat and shear. Ongoing high-moisture extrusion operations will demonstrate the capacity of reactive extrusion to increase efficiency for such hydrolytic actions in a suspension with complex flours. In another project, interactions between whey protein and a large and highly charged gum polysaccharide, gellan gum, were investigated in dilute solution and after heat-treatments (Project 14). This work leverages past research on whey protein interactions with other major polysaccharides, such as pectin and carrageenan. Results indicate strong interactivity at relatively high pH values but lesser degree of interactivity when compared to other polysaccharides, translating to different aggregation behaviors. Factors influencing these behaviors and the ultimate foaming capabilities are being assessed in the coming year.

J. Kokini's group continues research to identify important input parameters and analytical approaches for achieving desirable textures and stability of food products. They developed bioinformatic models to provide molecular insights on pea protein functionality (Project 15) and through machine learning to develop novel plant-based protein edible coatings for baked goods (Project 21). In pea protein research, they applied rheological models of creep ringing phenomena on pea protein emulsions (Project 16) and found new fat memetic functionality at sub-zero denaturation temperatures (Project 17). They researched the nonlinear rheological behavior of different food products (Project 18) and in thermoset protein gels, with emphasis on plant-based proteins (Project 19). On pulse flours, they are working to develop a fundamental understanding of the interaction between vital wheat gluten and pulse flours (Project 20).



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Faculty

James N. BeMiller

General Research Areas

- Starch
- Carbohydrate chemistry

Specific Research Areas

- Starch granule structure, reactivity, and behavior
- Chemical and biological modifications of starch
- Structure-functional property relationships of polysaccharides

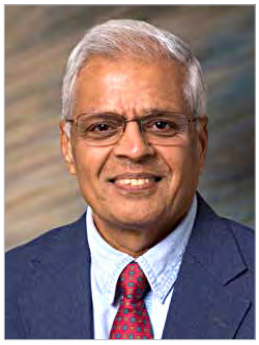
Osvaldo H. Campanella

General Research Areas

- Process modeling
- Rheology
- Material structure and texture
- Extrusion

Specific Research Areas

- Application of rheology to food science and food engineering
- Mathematical modeling of food process operations
- Online rheological techniques
- Rheology of biomaterials, dough, dairy products
- Characterization of material structure and texture; relationship to rheological properties
- Effect of glass transition on product texture
- Bioplastics: Uses of food processing wastes
- Reactive extrusion in the production of foods and bioplastics
- Production of plant-base meat analogs by extrusion technology



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

Mario G. Ferruzzi

General Research Areas

- Development of analytical approaches for assessment of micronutrients, phytochemicals and their metabolites in complex food and biological matrices
- Characterization of matrix factors that optimize stability and bioavailability of micronutrients and phytochemicals from foods
- Exploration of plant genetic and ingestive factors that impact bioavailability and metabolism of micronutrients and phytochemicals from plant foods using preclinical and clinical models

Bruce R. Hamaker

General Research Areas

- Carbohydrates and health
- Starch, chemistry and function
- Dietary fiber, chemistry and function

Specific Research Areas

- Glycemic carbohydrate digestion for slow digestion/low glycemic response, physiological and cellular response
- Dietary fiber, modifications in functionality and gut fermentability, gut microbiota and metabolites
- *In vitro, in vivo,* cell culture studies
- Cereal carbohydrate and protein functionality
- Textural properties influenced by carbohydrates
- Interactions between carbohydrates and other food components
- Processing and nutrition in developing countries

Owen G. Jones

General Research Areas

- Energy and stoichiometry of polysaccharide interactions with other materials
- Determination of size, morphology, and stability of colloidal suspensions
- Atomic force techniques to determine morphology and elasticity of sub-millimeter material

Specific Research Areas

- Role of chemical and physical structures in defining protein-polysaccharide interactions
- Controlled assembly of fibrous or particulate colloids from polysaccharides or proteins
- Emulsifying properties of colloidal materials
- Contributions of colloidal polysaccharide/protein assemblies to films, gels, or pastes

Jozef Kokini

General Research Areas

- Food materials science
- Linear and non-linear rheology
- Computational fluid dynamics
- Food nanotechnology and fabrication of nano-biosensors
- Phase behavior and compatibility of ingredients in food mixtures
- Food structure and texture during extrusion, mixing processes and computational fluid dynamics

Stephen Lindemann

General Research Areas

- Dietary fiber impacts on gut microbiome diversity, structure, and function
- Species-resolved metagenomics and metabolism
- Genomic mechanisms of polysaccharide fermentation
- Carbon, nitrogen and energy cycling by gut microbiota
- Microbiome-mediated impacts on host physiology
- Microbial systems ecology

Specific Research Areas

- Particle size and processing method impacts on microbial metabolism of wheat bran
- Arabinoxylan structure influences on gut microbiome structure and function
- Predictive ecology of gut carbohydrate metabolism
- Fiber targeting to gut microbes
- Microbial division of labor in polysaccharide degradation

Mario Martinez

General Research Areas

- Structure-function of biopolymers and biopolymeric systems
- Food structuring
- Binding interactions and digestion models

Specific Research Areas

- Structural elucidation of polysaccharides using MS- and NMR-based approaches
- Binding between small metabolites and food macromolecules
- Food and agricultural waste valorization through technology development
- Structuring of plant-based foods
- Organocatalytic (or catalyst-free) derivatization of macromolecules

Lisa J. Mauer

General Research Areas

- Food chemistry
- Water-solid interactions
- Food materials science

Specific Research Areas

- Structure-function relationships of food ingredients
- Small molecule effects on starch functional traits
- Solid state characterization
- Glass transitions
- Moisture sorption
- Deliquescence
- Crystallization and amorphization

Ganesan Narsimhan

General Research Areas

- Emulsions and foams
- Biopolymer interactions

Specific Research Areas

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

Eun Joong Oh

General Research Areas

- Fermentation science
- Metabolic engineering
- Synthetic biology

Specific Research Areas

- Biotechnological production of food ingredients and value-added chemicals using engineered microorganisms
- Multiplex CRISPR/Cas9-based genome engineering
- Microbial cell factories for industrial bioprocesses
- Regulatory networks in yeast
- Engineering probiotic strains for human health applications

Lavanya Reddivari

General Research Areas

- Plant bioactive compounds and health
- Flavonoids and carotenoids
- Gut microbial metabolism

Specific Research Areas

- Anti-inflammatory plant bioactives for improved gut health
- Reciprocal interaction of gut microbiome and plant bioactives in health and disease
- Interactions between plant bioactives and fiber/starch in the modulation of gut bacteria

Bradley L. Reuhs

General Research Areas

- Polysaccharide analysis
- Bacterial and plant cell wall compositions, structures and functions
- Sugars and polysaccharides in nutrition and food systems

Specific Research Areas

- Extractions and purification of acidic polysaccharides from cell walls of plants (including food products) and bacteria
- Pectin, hemicellulose, capsule, gum and lipopolysaccharides analysis
- Application of HPLC, MS, GC, GC-MS, FT-IR and NMR to structural studies of carbohydrates, including polysaccharides

Senay Simsek

General Research Areas

- Structure-function relationships of carbohydrates
- Industrial hemp utilization
- Grain and legume quality & utilization
- Carbohydrates in the baking industry

Specific Research Areas

- Carbohydrates and bioactives from grains for human health
- New carbohydrate functional ingredients
- Characterization and utilization of industrial hemp grain and byproducts
- Innovative uses for processing byproducts and waste materials
- Biodegradable packaging films
- Variation and functionality of sorghum carbohydrates and bioactive compounds

Yuan Yao

General Research Areas

- Novel biomaterials for food and health
- Chemistry and genetics of carbohydrate polymers
- Plant-based proteins and meat alternatives
- Biofilms and food safety
- Nanotechnology for foods and drugs

Specific Research Areas

- Structure, function, and applications of phytoglycogen and its derivatives
- Natural emulsifiers and encapsulation wall materials
- New ingredients and formulations for meat alternatives
- Machine learning in food science and technology
- Stabilization, solubilization, and delivery of active ingredients
- Genetic, enzymatic, and chemical modifications of carbohydrate polymers
- Evaluation and removal of pathogen biofilms
- Clean label of foods

Adjunct Faculty

Yonas Gizaw, PhD, is R&D director-principal scientist at Procter and Gamble Co. Currently, he is technical leader for chemistry transformative platform technologies in corporate R&D. Dr. Gizaw is a 20-year veteran of P&G with broad experience in biopolymers, nanotechnology, polymers physical chemistry, surfactants and colloids. He spent about eight years in Snack and Beverages, where he supported technology development for beverages (Sunny D) and Snacks (Pringles), then moved to the Fabric Care Strategic and Innovation division, where he was responsible for development of strategic technologies for cleaning and fabric feel (Downy & Tide), etc. The last several years Dr. Gizaw has focused his research on physical chemistry of wetting phenomena to develop disruptive technologies in superhydrophobic and superomniphobic surfaces. Prior to joining P&G, Dr. Gizaw received his doctoral degree from Purdue University in synthetic carbohydrate chemistry.

Bernhard Van Lengerich, PhD, is a former chief science officer and VP of strategic technology development at General Mills and former acting CTO at Beyond Meat. After apprenticeships as artisan baker and pastry chef, he studied food/biotechnology at Technical University of Berlin, Germany, and completed his PhD thesis in the field of extrusion with summa cum laude. He joined Werner and Pfleiderer (Coperion) in New Jersey as senior process engineer for extrusion, then joined RJR Nabisco, New Jersey, as director of extrusion research. He subsequently assumed the position of vice president of global R&D food at the Buehler Group in Switzerland. In 1994, Bernhard joined General Mills, Inc. in Minneapolis, where he led all GMI extrusion initiatives and GMI's Game-Changer Innovation Program, and created a novel GMI technology venturing initiative, enabling faster and higher impact innovations. As chief science officer and VP of technology strategy, he was responsible for science and technology development across the company. Bernhard retired from General Mills in 2015. He is the inventor or co-inventor of more than 150 patents and patent applications, holds an honorarium professorship at Technical University of Berlin, Germany, teaching extrusion science and technology, and he is a fellow of the Institute of Food Technologists in Chicago. Bernhard has been an invited participant in discussions at the White House Office for Science and Technology Policy on global protein security under the Obama administration. In 2016, he joined Beyond Meat in an advisory role as acting CTO and head of R&D, leading the development and launch of the first Beyond Burger in 2016. He served as board member of Beyond Meat until 2021. Bernhard is the founder of Seeding the Future Foundation, a 501(c) (3) organization focusing on seeding and supporting impactful innovations that help improve our food system. He also initiated the annual Global Food System Challenge, which is funded by the Seeding The Future Foundation. In addition, Bernhard serves as board member of the German Institute of Food Technology (DIL), Bountifield International, and he is an advisory board member of S2G Ventures, Brightseed Bio, PetriBio, UKKO, and several organizations in the U.S. and Europe.

Visiting Professors

Lin Chen completed his BS and MS degrees from China West Normal University in 2006 and 2010, respectively. He obtained his PhD degree from Sichuan Agriculture University in 2013. He joined Dr. Reddivari's group as a visiting professor in December 2021. His research focus was on the effect of anthocyanins on colorimetric indicator film properties. At the end of 2022, he returned to Chengdu University as an associate professor. There, his research focuses on plant bioactive components and its function on the meat.

Visiting Scientists

Mirian de Campos Costa received her BSc and MSc in Nutrition Science from Universidade Federal de Vicosa (Brazil), with a collaborative period at Southern Illinois University, Carbondale, and currently is a PhD student at the same university. In 2021, she joined Dr. Hamaker's group as a visiting scholar as part of a sandwich-PhD program supported by the government of Brazil. Her research is mainly focused on investigating the effects of bioactive compounds and fibers on the gut microbiota.

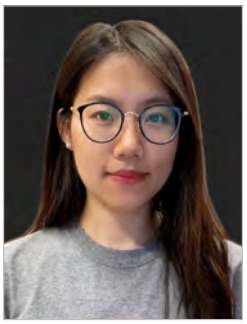
Fatma Yaren Garipkus is an undergraduate student in Erciyes University, Turkey, in the Agricultural Biotechnology Department. She came to Dr. Lindemann's lab for a summer internship in 2022. She worked on arabinoxylan (a common dietary fiber) extraction from wheat and sorghum brans, determining their chemical structure in terms of sugar compositions and metabolomic data.

Tingting Hong received her BS in Food Science and Engineering from Jiangxi Agricultural University in China. She completed her MS degree in Food Engineering from Jiangnan University, in China, where she is currently working on her PhD. Tingting received funding from the China Scholarship Council to study at Purdue University in the laboratory of Dr. Simsek for one year in November 2022. Her research focused on the use of polysaccharides to improve the quality of wheat flour products and explored the mechanism of interaction of polysaccharides with proteins and starches in wheat flour.

Seher Serin Karayiyen received her MS (2013) degree and PhD (2019) from the Department of Food Engineering at the University of Mersin in Turkey. Her research focused on determination of the effects of the *in vitro* digestion and *in vitro* fermentation properties of different types of resistant starches as related to human health. In December 2021, she joined Dr. Hamaker's group as a visiting scholar for a year. Her research focused on the effect of different types of resistant starches on the delay of fermentation in the large intestine and effect on the gut microbiota.

Noriaki Kitagawa received his MS degree in Science from Kyoto University, Japan in 2015. After that, he joined Hayashibara Co., Ltd. and has worked in the R&D division for eight years. He was engaged in the acquisition of novel carbohydrate-metabolizing enzymes and establishing efficient production methods for useful carbohydrate-related materials. In 2022, he joined Drs. Hamaker and Mauer's laboratories as a visiting scholar for three years. His current research is about the effects of small compounds with unique structures on starch from the aspect of physicochemical properties.

Veda Krishnan was a visiting scientist from Indian Council of Agricultural Research (ICAR), India. She joined Drs. Hamaker and Reddivari's laboratories in April 2021 for 12 months as a Fulbright Scholar. Her research focused on the role of natural food-derived flavonoids in activating the gut-brain axis through sweet-bitter signaling.



Meihui Yu graduated with her BS from the School of Food Science and Bioengineering, Qiqihar University (China). She received her master's degree from the School of Forestry, Northeast Forestry University (China). She is currently a PhD student studying at the School of Food Science and Engineering, Jiangnan University (China). In 2022, she joined Dr. Hamaker's lab as a visiting scholar for one year of training. Her field of interest was developing new starch-based food materials as prebiotic fibers.

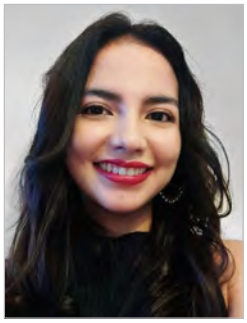
Graduate Students

Adriana Maribell Aguilar Torres is a PhD fellow in the Martinez lab at the Department of Food Science, AU FOOD (2021-, Aarhus University). Her research focuses on interactions between polysaccharides and polyphenols (secondary metabolites of plants) and the design of multifunctional materials. She holds a master's degree in Molecular Nutrition and Food Technology (2020, Aarhus University, Denmark) and a bachelor's degree in Food Science (2012, Universidad Autónoma de Nuevo León, México). Her research topics include interactions between primary (polysaccharides) and secondary metabolites of plants (polyphenols), interactions between secondary metabolites of plants (anthocyanins and phenolic acids), and microencapsulation of fish oil. Besides her academic career, she worked in the food industry for 2.5 years (Mondelez International and Bachoco México).

Miguel Alvarez Gonzales is a PhD student in the Lindemann lab. Miguel obtained his BS in Food Science and Technology from Zamorano University, Honduras, trained for a year in molecular biology techniques and bioinformatics, and completed his MS degree in Food Science with an emphasis in carbohydrate chemistry. In the Lindemann lab, he uses the structure and function of carbohydrates, chromatographic techniques, and bioinformatics to characterize wheat bran interactions with the gut microbiome.

Wenqiang Bai is a PhD student in the Martinez lab at the Department of Food Science, Aarhus University. He received his BS (2016) from Qingdao Agricultural University in China and his MS (2019) from Chinese Academy of Agricultural Sciences, both in Food Science. Since 2020, he has been a PhD fellow in the Department of Food Science at Aarhus University. His PhD research mainly focuses on understanding the structure-compatibilization relationships of pectic polysaccharides for food packaging applications.

Nuseybe Bulut is a PhD student in the Hamaker lab. She completed her BS degree in July 2014 at the Food Engineering Department, Istanbul Technical University (ITU), Turkey. She joined Dr. Hamaker's lab group in January 2017. Her MS research focused on fabrication of plant cell wall-like materials and their impact on the human gut microbiota, and she graduated in fall 2019. She continues her studies with Dr. Hamaker in the area of dietary fiber and the gut microbiome.



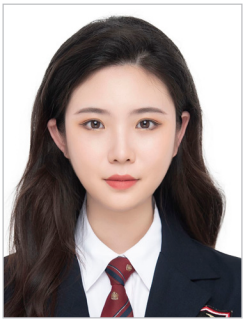
Laura Castellanos Suarez is a PhD student in the Campanella lab. Laura earned a BS and MS in Chemical Engineering from Universidad Industrial de Santander in Colombia, with a focus on food science and bioprocess. Currently, she is developing and evaluating an enriched ingredient for food and feed industries. The ingredient is derived from fermenting acid whey and poultry waste using an optimized eREX approach.

Zhuoran Chen is a MS student in the Yao lab. She received her BS in Food Science from Purdue University in 2020. She joined Dr. Yao's lab as an intern in 2020 before starting her MS program in 2021. Her research topics include novel plant-based functional food ingredients and innovative food manufacturing with a focus on plant-based proteins.

Jayani Maddakandage Dona Kulathunga was a PhD student in the Simsek lab. She received her BS in Food Science and Nutrition in 2017 from Wayamba University of Sri Lanka. She worked on ancient wheat species under the guidance of Dr. Simsek and earned her MS from North Dakota State University in 2020. In the summer of 2020, she started her PhD with research focused on dietary fiber and the gut microbiome. She graduated with her doctoral degree in 2022. After graduation, she accepted a faculty position in her home country, and now she is working as a senior lecturer at a government university in Sri Lanka.

Dila Donmez is a PhD student in the Campanella lab. She graduated with a BS in Chemical Engineering from Middle East Technical University in Turkey. She pursued her MS degree in the same department, with a research focus on the production of Pickering emulsions in a stirred tank. In 2020, she started her PhD studies. Her research currently centers around the encapsulation of fish oil with glycated phospholipid, utilizing both batch processing and reactive-extrusion methods.

Vidarshani Ellepola is a student in the Campanella lab. She obtained her BS from Uva Wellassa University of Sri Lanka in the field of Tea Technology and Value Addition, followed by an MS in food science and technology from Post Graduate Institute of Agriculture, University of Peradeniya Sri Lanka. Upon completing the degrees, she worked as a lecturer in the Department of Export Agriculture of Uva Wellassa University. In 2022, she received the Fulbright master's scholarship to study the prevention of vitamin oxidation through encapsulation techniques.



Fang Fang is a PhD student in the Martinez lab. She received her BS (2019) and MS degrees (2022) from Nanchang University (China), both in Food Science and Technology. During her master's period, she worked on the effect of different thermal processing on the *in vitro* digestion and fermentation characteristic of different whole grains. She is now a PhD student at Aarhus University in Denmark. Her PhD mainly focuses on the non-covalent (de-)binding between flavonoids and plant cell walls and their role on the promotion of beneficial colonic bacteria and derived catabolites.

Monique Felix is a PhD student in the Lindemann lab. She completed her BS in Biochemistry at Claflin University in May 2018. Her BS thesis was aimed at making beta-glucosidase more thermostable, which would make biofuel more cost effective by deleting the costly cooling system used to prevent enzyme degradation. Monique completed her MS in Agricultural Regulation at University of Arkansas at Pine Bluff. There, her research characterized the role of the IncFIB plasmid in *Salmonella* pathogenicity. She joined Dr. Lindemann's lab in January 2021. Her PhD research focuses on determining the traits that influences competitiveness for carbohydrates in the gut microbiome.

Wanxiang Guo is a PhD student in the Martinez lab. She received her BS in Food Science and Engineering from South China Agricultural University in 2018, and her MS in Food Science and Technology from South China University of Technology under the supervision of Professor Weizheng Sun in 2021. Her MS research determined the effect of processing on the stability of anti-nutritional factors in soymilk. She is now a student at Aarhus University and is investigating the effect of processing on the molecular structure of the main biopolymers present in cereal grains and their potential to become biodegradable polymers for packaging applications.

Jose Haro is a PhD student in the Reddivari lab. He completed his BS in Animal Science and his MS in Animal Production at Universidad Nacional Agraria La Molina (Peru). He worked there and at the IICA as an associate researcher and technical coordinator of several agriculture projects involving research in nutritional ecology, impact of livestock in climate change, and transformation of native food resources. He joined Dr. Reddivari's lab as a Fulbright Fellow in 2022 to determine the impact of bacterial dysbiosis associated with IBD on the anti-colitic effects of dietary 3-deoxy and 3-hydroxy flavonoids.

Harrison Helmick is a PhD student in the Kokini lab. His research focuses on using bioinformatics to develop structure-function relationships of plant-based protein to understand emulsification, gelling, and texturization in extrusion below 0°C. Prior to Purdue University, Harrison studied at Kansas State University and obtained a degree in Bakery Science. This turned into a career at Bimbo Bakeries, where he worked in production and process improvement. After graduation, he hopes to work with an innovative company that incorporates data in its decision-making process to drive the business forward.

Veeramani Karuppuchamy is a PhD student in the Campanella lab. He completed his BS in agricultural engineering at Tamil Nadu Agricultural University, India in 2007, an MS degree in Agricultural Engineering at South Dakota State University in 2011, and another MS in Food Science and Technology from Ohio State University in 2021. He worked in the food industry as a lab supervisor and quality assurance supervisor from December 2011 to July 2019. His PhD research focuses on value addition of food industry byproducts using twin screw extrusion for nutrition enhancement and application of rheology in expanded snack applications.

Anael Kimble is a MS student in the Jones lab. She graduated from McGill University in 2017 with a BS in Food Science and specialization in Food Chemistry. She spent four years working in the food industry in quality and food safety before joining Dr. Jones' lab in fall 2021. She is currently working on a Whistler Center-funded project on reactive extrusion of bean flour with the joint supervision of Dr. Campanella and Dr. Simsek.

Chih-Chun (Ariel) Kuo is a PhD student in the Campanella lab. She received her BS in Nutrition and Health Sciences from Taipei Medical University in Taipei, Taiwan, in 2018. She completed her MS in the Department of Food Science and Human Nutrition at Iowa State University in 2021. During her MS, she worked on developing biopolymer-based delivery systems using 3D printing technology for bioactive ingredients in food applications. Her current research focuses on the valorization of byproducts from the meat, fish, and dairy industries. Her work aims to develop sustainable and value-added products using integrated bioprocessing technologies.

Louie Le is a MS student in the Kokini lab. She completed her BS in Food Science at Purdue in 2021. She joined Dr. Kokini's lab in 2020 as an undergraduate research assistant, and she is currently pursuing her MS in the same lab. Her research focuses on nonlinear rheological properties of foods and plant-based proteins.

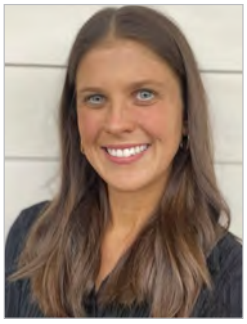
Dahye Lee is a PhD student in the Oh lab. She completed her BS and MS degrees in Food Engineering and Biotechnology at Dongguk University in South Korea. Her MS research identified the anti-biofilm effect of bacteriocins produced by lactic acid bacteria in fermented food. She then worked on a typhoid vaccine clinical trial as a research assistant at the International Vaccine Institute. She joined Dr. Oh's lab in 2021 to engineer *Saccharomyces cerevisiae* metabolic pathways and produce value-added chemicals from agricultural and forestry residues.

Ana Magallanes López was a PhD student in the Simsek lab. She completed her BS in Agroindustrial Engineering in fall 2015 at Chapingo Autonomous University in Mexico. Then she worked as a research assistant in the Wheat Quality and Chemistry Laboratory at the International Maize and Wheat Improvement Center (CIMMYT). She received her MS at North Dakota State University in 2018. She worked on the fate of deoxynivalenol during wheat wet-milling and characterization of the DON-free extracted starch and gluten. She performed her PhD at North Dakota State University on determining immune system reactions of soluble dietary fiber from dry beans during a chronic condition, such as obesity. She graduated in spring 2022. She is currently working as a research scientist with the Chemical Characterization team at Cargill, assessing the impact of postbiotics on animal and human health with metabolomic techniques.

Iván Misael López Rodulfo is a PhD student in the Martinez lab. He received his BS in Chemical Bacteriology and Parasitology from the Universidad Autónoma de Nuevo León (México) in 2019. He earned his MS in 2021 in Biomedical Physics and Engineering at Centro de Investigación y Estudios Avanzados (México). Following graduation, he continued working as a research assistant at the same institute, studying drug delivery systems. During the past year, he has been working on his PhD project at Aarhus University (Denmark), where he is studying non-covalent interactions between plant cell walls and compounds of interest, such as flavonoids.

Rosa Lopez is a PhD student in the Hamaker lab. She completed her BS in Biotechnology at Monterrey Institute of Technology and Higher Education in 2015. Later she obtained an MS from the Center for Research and Assistance in Technology and Design of the State of Jalisco, Mexico, identifying delivery capabilities of mucoadhesive polymeric films and emulsions. She joined Dr. Hamaker's lab in fall 2021. Her research focuses on the formation of starch-based complex materials and their evaluation to reach the small intestine and colon to activate physiological systems related to appetite, food intake, and weight management.

Cindy Mayorga is a PhD student in the Kokini lab. She completed her BS in Food Engineering at Universidad Tecnologica de Panama in 2016. In 2019, she received a Fulbright scholarship to join Dr. Kokini's lab to pursue her MS and work on the development of biosensors. Cindy graduated in 2022 and is now pursuing her PhD in the Department of Agricultural and Biological Engineering at Purdue University.



Jenna McClure is a PhD student in the Campanella lab. She received her BS in Exercise Science in 2013 and her MS in Food Science in 2021 from Ohio State University. Her MS project explored consumption of a novel soy pretzel and its effect on muscle recovery in athletes. Her current work focuses on extrusion of dietary fiber in snack foods and the impact this has on the gut microbiome and gut-brain axis.

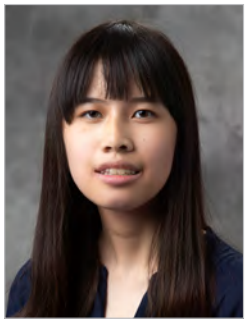
Edward Moncada is a PhD student in the Reddivari lab. He received his BS in Food Science and Technology from Zamorano University, Honduras. He was a visiting scholar at Purdue University in 2019, analyzing phytochemicals in organic onions. He returned to Dr. Reddivari's lab in 2021. His research, supported by a Whistler Center-funded project, assesses dietary fiber tolerance and the role gut bacterial dysbiosis plays in fiber assimilation in the gut.

Andres Munoz Salgado was a MS student in the Campanella lab. He completed his BS in Pharmaceutical Chemistry at la Universidad Nacional de Colombia in Bogota, Colombia. He was then a visiting scholar at the University of Akron, where he conducted research on controlled release drug delivery systems for breast implant applications. In 2022, he completed his MS degree in Food, Agriculture, and Biological Engineering at Ohio State University, where he conducted research on the applications of corn zein as a replacement for gluten and methylcellulose for plant-based analogues. Currently he is working for Archer Daniels Midland, where he is conducting research on alternative proteins for nutraceutical applications.

Kamrun Nahar is a MS student in the Yao lab. She graduated from National University of Singapore in 2015 with a BEng in Biomedical Engineering. She spent six years working in the food industry in plant-based food product development, quality, and functionality, especially in legumes. She joined Dr. Yao's lab as a graduate student in fall 2022. Kamrun's current research focuses on functional plant-based materials for emulsification and (micro) encapsulation.

Farzaneh Nasrollahzadeh is a PhD student in the Martinez lab. She completed her BS and MS in Food Science and Technology in 2013 and 2016, respectively, at Ferdowsi University of Mashhad. She started her PhD in Food Biophysics in 2019 at the University of Guelph, Canada. In her PhD project, her focus was on structuring plant-based foods with less refined plant proteins using high moisture extrusion and understanding involving mechanisms. She had also the chance to visit Aarhus University, Denmark, through the Mitacs Globalink Program in summer 2022, to work on sensory attributes of meat alternatives.

Vignesh Nathan is a PhD student in the Reddivari lab. He completed his BS in Health and Disease (Biology) from Purdue University in May 2021. His undergraduate research focused on using probiotic feed additives to improve swine nutrition and health. He worked as an intern at B2S Life Sciences, developing a COVID-19 antibody test. He joined Dr. Reddivari's lab in August 2021 to pursue a PhD in Food Science. His current research aims to understand the role various anthocyanins play in improving gut barrier integrity in piglets during early weaning stress.



Mai Nguyen is a MS student in the Lindemann lab. She received her BS in Microbiology and Food Safety at the University of Arizona in 2020. Her previous research experience was related to the prevalence of foodborne pathogens in water sources. Mai joined Dr. Lindemann's lab in fall 2020. Her research is focused on the effect of resistant dextrins on the diversity of the gut microbiota. Currently, she is a research associate I at Pivot Bio.

Adrianna Pilch was a MS student in the Mauer lab. She received dual BS degrees in Food Science & Human Nutrition and Chemistry at the University of Illinois at Urbana-Champaign in May 2020. She joined Dr. Lisa Mauer's lab in August 2020 to pursue her MS in Food Science; she determined the effects of different forms of vitamin C on wheat starch properties. She graduated in fall 2022 and is currently an associate food scientist at Newly Weds Foods.

Anurag Pujari is a PhD student in the Lindemann lab. He obtained his BS in Industrial Microbiology and his MS in Microbiology at the University of Pune, India. He joined the Diet-Microbiome Interactions Laboratory in spring 2021. His research focuses on the development of chemical probes that mimic certain characteristics of polysaccharides to study the microbial transport and hydrolysis traits as a response to consumption of these polysaccharides. Specifically, Anurag works on understanding the mechanism of hydrolysis of arabinoxylan from the GH43 family of enzymes.

Adam Quinn is a PhD student in the Lindemann lab. He completed his BS and MS in Food Science at Brigham Young University. He is currently investigating impacts of wheat genotypes on gut microbiota fermentation within the context of fiber and microbiome interactions.

Rajsri Raghunath is a PhD student in the Lindemann lab. She obtained her BS in Food Science at Michigan State University. Her undergraduate research was focused on characterizing the allergens in ancient wheat (specifically, Aegilops tauschii) and durum wheat. She also worked with mouse models on food allergy and immunology-focused research to understand how wheat allergy develops in transdermally sensitized BALB/cJ mice. She is currently investigating how cereal fibers originating from different cereal grains influence anaerobic fermentation by intestinal bacteria. She eventually hopes to use her graduate training to explore the human gut microbiome's relationship with a variety of factors, ex. dietary habits, gender, etc.

Monica Richmond is a MS student in the Hamaker lab. She graduated in 2019 from North Carolina State University, receiving two BS degrees in Food Science and Bioprocessing Science. Currently, Monica is determining the effects of viscosity on the gut microbiome regarding the utilization of dietary fibers. Her thesis focuses on the performance of *Bacteroides thetaiotaomicron* under various viscous conditions with the utilization of numerous sizes of substrates.

Kayla Roy is a PhD student in the Reddivari lab. She earned her BS in microbiology at the University of Maryland, College Park. After joining Dr. Reddivari's lab in 2021, her research goal is to determine the role of bacterial dysbiosis in IBD pathogenesis while studying the bioactive properties found in food used to treat the disease.

Shirley Clyde Rupert Brandão is a PhD student in the Campanella lab. She received her MS in Chemical and Biochemical Process Engineering at the Federal University of Pernambuco (UFPE), Brazil. Her MS thesis was about infrared drying and how ethanol pretreatment could increase the process efficiency, reducing the drying time, and if it could affect the quality parameter. In 2022, she joined Dr. Campanella's group. Her research focuses on applying computational fluid dynamics (CFD) to better understand the mass transfer and reaction when ozone gas is applied to prevent mycotoxin in grains.

Fransheska Semidey is a PhD student in the Oh lab. She received her BS in biomedical sciences at the University of Puerto Rico at Ponce and pursued a MS in Food Science and Technology at the University of Puerto Rico at Mayaguez. She is engaged in developing methods to minimize undesirable oligosaccharides by utilizing engineered baker's yeast. Her future research interests involve genetic engineering, focusing on future applications in emerging fields such as fermentation in space.

Shengyue Shan is a PhD student in the Campanella lab. She received her BEng in Food Science and Engineering in July 2017 at Sichuan University in China. She received her MS in Food Science and Technology at Ohio State University in 2019. She continued as a PhD student in the same department. Her research focuses on the characterization and simulation of the physical behaviors of protein-based food systems, including the heat transfer numerical analysis, the rheological properties of wheat dough and gluten-free dough, and fabrication of plant-based meat analog. She expects to graduate in spring 2023.

Lorena Silva Pinho is a PhD student in the Campanella lab. She has her MSc and PhD in Food Engineering with knowledge of food ingredient encapsulation using hydrocolloids and applications and experience in physical-chemical analysis, quality control, food consulting services, and innovation of food products. Her research centers on applying microparticles loaded with carotenoids in extruded products. In 2023, she will be part of the group as a postdoc, and her project will focus on developing meat analogs by enzymatic reaction extrusion.

Kasper Brandhøj Skov is a PhD student in the Martinez lab. He earned his MS in Chemistry and Biotechnology Engineering from Aarhus University in January 2022. His MS thesis explored the development of anisotropic structures using proteins, starch, and extrusion technology. His current focus is on utilizing chemo-mechanical methods to upcycle waste bread into high-performance biomaterials.

Paige Smith is a MS student in the Mauer lab. She completed her BS degree in Chemistry at Waynesburg University in May 2021. Paige's current research involves preconditioning different starches in oligosaccharides to modify the functionality of the starch by altering their physiochemical and thermal properties.

Emil Wedding Stentoft graduated with a BSc in Agrobiology, with a focus on food production, from Aarhus University, Denmark, in July 2021. He worked on increasing the protein content of extracts from *Ulva sp.* macroalgae. He started his MSc program in Molecular Nutrition and Food Technology at Aarhus University and is finalizing his MSc thesis in the Martinez group. His thesis work focuses on comparing static and semi-dynamic *in vitro* digestion models to test the bioavailability of polyphenols in the gastrointestinal tract.

Chong Teng is a PhD student in the Campanella lab. He received his BS in Food Science and Technology from Shanghai Jiao Tong University in 2015. Then he earned an engineer's degree from Ecole des Mines d'Albi-Carmaux in France and an MS degree from Shanghai Jiao Tong University, where he gained substantial experience as a production assistant and analytical chemist in food companies and research institutes. In 2019, he joined Dr. Campanella's lab, where he developed an animal fat tissue analog using plant-based materials. He is now focusing on the mineral binding capacity of plant proteins modified by enzymatic hydrolysis for improving the mineral bioavailability of plant proteins.

Jacob Thompson was a graduate student in the Lindemann lab. He earned his BS in Materials Science and Engineering at Michigan Technological University in May 2019. However, he soon discovered a passion for nutrition and decided to pursue it in the Interdepartmental Nutrition Program at Purdue. He joined the Lindemann lab in fall 2020 and focused on developing computational models to predict bacteria metabolism, with the goal of further understanding how genetics influence gut microbiome ecology.

Ankur Upadhyay is a MS student in the Campanella lab. He graduated from ICT, Mumbai, in 2022 with a BS in Food Engineering and Technology. He joined Dr. Campanella's lab in fall 2022. His research topic is on the metal-chelating ability of glycated soybean phospholipids and their application in extruded plant-based meats.

Ana M. Velásquez-Giraldo is a PhD student in the Campanella lab. She received her BS in Agro-industrial Engineering from Universidad Pontificia Bolivariana in Colombia. She earned her MS in Public Policy and Administration, with a concentration in Food Science Policy, at the University of Massachusetts, Amherst. She is currently studying Food, Agricultural and Biological Engineering at Ohio State University under the guidance of Drs. Campanella and Heldman. Her research focuses on the enhancement of flavor and texture of plant-based extruded meat analogues.

Travis Woodbury was a PhD student in the Mauer lab. He received a BS in Food Science from Brigham Young University-Idaho in 2018. He joined the lab as an MS student in 2018 and bypassed to the PhD program in 2019. Travis's research focused on developing strategies to replace sugar in starch containing food systems (primarily baked goods) by understanding the effects of non-digestible oligosaccharides and other zero added sugars on the thermal properties of starch and starch-related texture attributes in baked goods. Travis graduated in 2022 and is a research scientist at ADM.

Dan Zhang is a PhD student in the Campanella lab. She received her BS in 2017 from Nanjing Agriculture University and her MS in 2020 from Shanghai Jiao Tong University, both in Food Science and Technology. Her research focused on isolation and identification of antimicrobial compounds in galanga using HPLC and GC/MS. She joined Dr. Campanella's group at Ohio State University in 2021. Her current research focuses on the improvement of functionality of plant proteins by interacting with polysaccharides for production of gel-reinforced products and for potential food packaging applications.

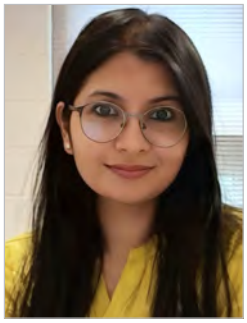
Xinruo "Tina" Zhao is a MS student in the Hamaker lab. She received her BS from the Department of Food Science at Purdue University in May 2021. She joined the lab to study about how fiber mixtures influence gut microbiome and *C. difficile* infection.

Rui Zhu is a MS student in the Jones lab. She completed her BS in Food Science and Engineering from Shanghai Institute of Technology in July 2019. After graduation, she worked in R&D in a confectionery company for two years in China, mainly focused on aerated milk candy products. She joined Dr. Jones' group in August 2021. Her current research determines how high acyl gellan gum and heat treatments impact the structural features and foam stabilizing properties of whey protein isolate solutions.

PhD Postdoctoral Research Associates

Rwivoo Baruah obtained his PhD from Indian Institute of Technology Guwahati, Assam, India. He worked as a research associate (CSIR) at the CSIR-Central Food Technological Research Institute (CFTRI) at Mysore, Karnataka, India for three years. He joined Dr. Lindemann's group as Fulbright visiting scholar for two years for his postdoctoral work in September 2022. His current research focuses on the consumption of exopolysaccharides (EPS) from cyanobacterial communities by gut microbiota, the enzymes involved, and their safety.

Julia Bechtner received her MS in Molecular Biotechnology in 2016 and her PhD in food microbiology in 2021, both from Technical University of Munich (Germany). She continued her research on exopolysaccharide-forming microorganisms at the University of Alberta (Canada) before joining Dr. Martinez´s group at Aarhus University (Denmark) in 2022, where she studies non-covalent interactions of polyphenols with plant polysaccharides and their influence on gut microorganisms. As a Novo Nordisk postdoctoral fellow, she is simultaneously working on the isolation of macromolecules from plant-processing byproducts using precision fermentation.



Kalpana Bhatt graduated with a PhD in Microbiology from Gurukula Kangri University, India, where she studied how plant-microbe interaction contributes to sustainability. Kalpana works in the lab of Dr. Simsek and is assisting ongoing research projects and working on the structure-function relationship of compounds in food systems, focusing on biological functionalities of bioactive compounds. Her personal interests vary from microbial food safety, environment microbiology, system biology and molecular docking, modeling, and simulation. Kalpana is enthusiastic about deciphering various traits of food science, contributing to a green, sustainable environment.

Thaisa Cantu Jungles received her BS in Nutrition from Pontificia Universidade Católica do Paraná (Brazil). She earned her MS and PhD in Biochemistry from Federal University of Paraná (Brazil). In 2015, she joined Dr. Hamaker's group as a visiting scholar for a year to conduct part of her PhD research. Her research was centered on the structural characterization of dietary fibers from fruits and their applications in the biological field. In 2018, she rejoined Dr. Hamaker's group as a postdoctoral researcher in the area of dietary fiber fermentation by the gut microbiota. Her current research focuses on the alignment of dietary fibers' chemical and physical structure to promote bacterial groups in the gut related to human health.

Álvaro Cruz Carrión, PhD, is a food and nutrition researcher, passionate about food biotechnology, nutrition and the agri-food sector. He is trained in laboratory techniques, designing and performing metabolomic studies with animal models related to bioavailability and metabolism of health promoting phytochemicals from foods. He joined the Arkansas Children's Nutrition Center as postdoctoral fellow in 2022, having previously served as a postdoctoral research scholar at North Carolina State University's Plants for Human Health Institute (2021-22) and as a Predoctoral Researcher at Rovira i Virgili University (2018-2021). He is involved in projects aimed at understanding the profile of micronutrients and bioactives in foods, their interactions in food systems and how these interactions serve to modify absorption and metabolism of these compounds by humans. He is particularly interested in strategies that can be harnessed to improve the nutritional and functional quality of food products for at-risk populations.

Chelsey Fiecke received her BS in Biology from the University of Northwestern-St. Paul (Minnesota). In 2021, she finished her PhD in Nutritional Biochemistry at the University of Minnesota, working on the effects of polyphenol-rich dietary components on oxidative stress, colon cancer, and gut microbiome composition. In 2021, she joined Dr. Ferruzzi's group as a postdoctoral fellow working on the application of ferulic acid-starch complexation to polyphenol-rich cereal grains and the influence of processing that fosters the formation of such complexes on starch digestibility and phenolic bioaccessibility. Her current research focuses on characterization of acylated and non-acylated anthocyanins in purple carrots for potential application as natural colorants in the beverage industry. Her research interests include the role of factors that influence polyphenol metabolism, such as gut microbiome composition, health status, dietary patterns, and food processing, in explaining inter-individual variability in health outcome responses to polyphenol-rich dietary components.

Marwa El Hindawy, from Cairo, Egypt, received her PhD from Purdue University in December 2018. She worked with Dr. Hamaker on slowly digestible carbohydrates and their role in activating the gut-brain axis to tackle obesity. During 2021, she worked on a clinical trial to validate the gut-brain axis activation in healthy humans using slowly digestible carbohydrates. In addition, a clinical trial was performed, investigating the attenuating effect of soluble dietary fiber consumption on postprandial blood glucose and insulin. Marwa left in spring 2022 and is now a research associate with the Singapore Institute of Food and Biotechnology Innovation (SIFBI).

Pablo Gallego-Lobillo obtained his PhD in Food Science and has focused on the characterization and development of novel bioactive compounds and the investigation of their effect on colonic microbiota. His main work is based on the biochemistry of dietary and prebiotic carbohydrates. Pablo has carried out *in vitro* and *in vivo* research related to carbohydrate digestion, modulation of the microbiota of prebiotics in pathologies, such as cancer, as well as the production of new carbohydrate derivatives, through various synthesis mechanisms. He will, in Mario Martinez' team, work on the investigation of polysaccharide-polyphenol interactions and their implications on cardiometabolic protection.

Laila Hossain joined Dr. Simsek's group as a postdoctoral research associate in September 2022. Previously, Laila was a postdoctoral fellow at the University of Adelaide, Australia, where she worked on the development of biodegradable active food packaging film. Laila completed her PhD at Monash University, Australia, in developing biodegradable, renewable nanocellulose superabsorbent for personal care products, food packaging and biomedical applications. Currently, Laila is working on extraction, functionalization, and surface modification of hemp fibers with the goal of quantifying structure-property relationships and producing new and innovative value-added products for the food industry. Laila is enthusiastic about developing new materials and modifying their structure to tune specific properties while maintaining environmental sustainability.

Deokyeol Jung completed two BS degrees in Food Science and Biotechnology and in Mathematics at Kyungpook National University in South Korea in 2015. He received his MS and PhD in Food Science and Biotechnology at the same university in 2018 and 2022, respectively.

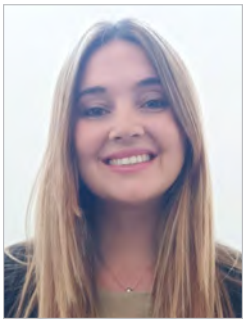
In September 2022, he joined Dr. Eun Joong Oh's group as a postdoctoral researcher. His current research focuses on 1) the production of value-added chemicals from pectin-rich biomass using engineered yeast and 2) the Cas9-based metabolic engineering of probiotic yeast to improve the gut bacteria.

Shiyu Li received her PhD in Preventive Veterinary Medicine from the Academy of Military Medical Sciences in China, and her MS and BS in Food Science. In 2017, she joined Dr. Reddivari's group as a visiting scholar for a year, then worked as a postdoctoral research associate in the same lab (2018-2022). Her research focused on the anti-inflammatory properties of food-based bioactive compounds and the role of gut bacteria.

Jongbin Lim received his PhD in Food Science from Purdue University in 2019. After graduation, he worked in Dr. Hamaker's group as a postdoctoral researcher for two years. In March 2022, he started his independent research career as a tenure-track assistant professor in the Department of Food Bioengineering at Jeju National University, South Korea. His group's research focus is to develop new biomaterials from food ingredients for improving physiological responses to obtain health benefits.

Oguz Kaan Ozturk completed his BSc (2011) and MSc (2014) degrees in Food Engineering at Middle East Technical University in Turkey. He also has an MBA (2013) degree from the same university. He received his PhD (2019) in the Food Science and Human Nutrition Department from the University of Illinois at Urbana-Champaign. His research focused on modeling water transport in food products during drying and sorption. He joined Dr. Hamaker's lab in April 2019 as a postdoctoral research associate and has worked on projects related to the structure and functionality of proteins and starches. His most recent work focuses on plant-based protein food analogues.

Guillermo Portillo obtained his BSc in Food and Chemical Engineering in 2006 at the University of Colima, Mexico, and his MSc in Environmental Sciences at the University of Applied Sciences in Cologne, Germany. He then spent five years as a project engineer in the chemical industry, leading optimization projects applying statistical modeling and process simulations. He obtained his PhD in Bioresources Engineering in 2021 from McGill University in Montreal, Canada. He joined Professor Mario Martinez's team in 2022 as a postdoctoral researcher at Aarhus University, working on sustainable chemical modifications of natural polymers for their use in packaging materials. His main research interests are focused on food waste valorization into valuable platform chemicals, green chemistry, development of novel materials, heterogeneous catalysis, and process simulation.

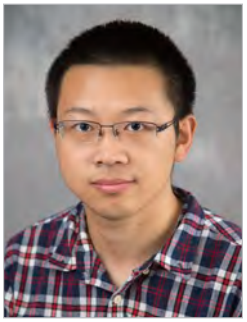


María Julia Spotti earned her BS degree in Biotechnology in 2008 and her PhD in Food Chemistry in 2013, both at the National University of Littoral in Argentina. In 2021, she joined Professor Martinez's group to conduct research focused on structure-function relationship in starch molecules. Before that, she was a postdoctoral research associate at Purdue University (2015-2016) and then associate researcher with the Scientific and Technical Research Council of Argentina (2016-2021). Her research interests focus on the physicochemical study of food colloids and their modifications through enzymatic, physical and chemical processes for improving their functional and nutritional properties, the extraction and characterization of biomolecules from food byproducts and the development of functional foods.

Clay Swackhamer joined the Department of Food Science at Purdue University as a postdoctoral research associate in August 2022 and is working with Dr. Hamaker. Clay completed his BS degree in Biological Engineering at Penn State University in 2015 and PhD in Biological Systems Engineering at University of California, Davis in 2022 under the supervision of Dr. Gail Bornhorst. His graduate work was investigating the mechanical breakdown of solid foods during *in vitro* gastric digestion with simulated peristalsis. Clay is a registered professional engineer (PE) in agricultural engineering. His current position, funded by a USDA-NIFA postdoctoral fellowship award, focuses on the effect of arabinoxylans with varying chemical and physical structures on the taxonomic composition of the colonic microbiome.

Pablo Torres-Aguilar is a postdoctoral researcher in Dr. Hamaker's group working on market-led strategies to improve micronutrient access in Niger, Senegal, and Kenya. He received his MS in Nutritional Sciences from the University of Illinois at Urbana-Champaign and PhD in Food Science from Purdue University. He completed his dietetic internship at Beaumont Health System in Royal Oak, Michigan, and holds credentials as a registered dietitian (RD) and certified nutrition support clinician (CSNC). Pablo serves as a commissioned officer in the US Army (reserve component) with the 256th Combat Support Hospital in Twinsburg, Ohio, as platoon leader. He will be joining the University of California, San Francisco as a Fogarty-NIH fellow under the mentorship of Dr. Craig Cohen, starting July 2023.

Natalia P. Vidal received her PhD in Food Quality and Safety from Basque Country University (Spain) in 2015. She worked as a postdoctoral fellow at Memorial University of Newfoundland (Canada), where she focused on the development of functional foods. In 2019, she joined Dr. Martinez's research group at Guelph University (Canada) and in 2021 moved to Aarhus University (Denmark), where she obtained an AIAS-Marie Skłodowska-Curie CoFund fellowship to develop foundational understanding about the effect of extrusion technology to improve the bioaccessibility and metabolic effects of brown macroalgae bioactive compounds in complex model systems resembling trendy foods.



Tianming Yao obtained his BS in Food Science and Technology from Shanghai Jiao Tong University, China. He joined Dr. Srinivas Janaswamy's group in August 2015 as a master's student, focusing on the interaction of polyphenols and starch networks. In 2017, Tianming continued as a PhD student with Drs. Lindemann and Hamaker with a focus on how complex structures of dietary fibers govern fecal microbial ecologies. He was trained with interdisciplinary knowledge on analytical skills (such as GC and HPLC), bioinformatics and next generation sequencing techniques. He completed his PhD in 2021, and now is a postdoctoral researcher in Dr. Lindemann's lab. He works on various projects, including microbial communities in the human gut and other environmental sites. He endeavors to establish a mechanistic understanding of how microbial division-of-labor on polysaccharide consumption modulates community assembly and succession with the ultimate goal of formulating a precise strategy to improve human gut health.

Merve Yildirim Erturk received her BS in Food Engineering from Middle East Technical University in Turkey. She completed her MS in the same department, focusing on production on low-fat products with double emulsions. She joined Dr. Jozef Kokini's laboratory for PhD studies in 2017 with a focus on the nonlinear rheological properties of proteins and biopolymers. She earned her PhD in 2022 and joined Dr. Yao's lab as a postdoctoral research associate, where she works on microencapsulation and stabilization of active food ingredients using novel, plant-based ingredients.

Whistler Center Staff

Dane Deemer is a hybrid wet- and dry-lab biologist focused on predicting microbial community interactions. As the project manager for Dr. Stephen Lindemann's lab, he helps undergraduate and graduate students with project organization, execution, and goal reaching, along with bioinformatics consulting. Dane provides services for industrial associates in areas such as bioinformatics, software development, and data analysis. He is a full-stack software developer with a passion for algorithm development, database integration, automation, and app development. Dane is considered a bridge between computer scientists and applied life scientists.

Angie Gutterman received her bachelor's degree in business administration from Butler University in 1985. She joined the Whistler Center as the center's coordinator in September 2019. Angie enjoys working with our industrial members, graduate students, and postdocs, and she is looking forward to planning in-person events with our members.

Bhavesh Patel received a BS degree in Dairy Technology from Gujarat Agricultural University, Anand, India, and an MS degree in Food Technology from Central Food Technological Research Institute (CFTRI), Mysore, India. His PhD in Food Science is from Pennsylvania State University, where his research involved study of starch and polysaccharide structures and the effect of processing conditions on thermal and physical properties. Bhavesh joined Drs. Campanella and Hamaker's groups in 2008 and has worked on the development of processes for isolation of corn fiber polysaccharides and enhancing their functional properties, as well as fiber rheology and fiber incorporation into processed foods and gel formation kinetics. He conducted a project related to enzymatic conversion of complex polysaccharides into useful industrial and food products. Currently, he does short-term research projects for the Whistler Center member companies.

Anton Terekhov is proficient in analytical chemistry, molecular biology techniques and analytical instruments such as NMR, GCMS, LCMS and FTIR. Anton has more than 15 years of experience in an interdisciplinary laboratory environment, including the fields of analytical chemistry, microbiology, genetics, geology and chemical and civil engineering. His main research area is carbohydrate analysis using above-mentioned analytical instruments. He is director of analytical services for the Whistler Center.

Kristin Whitney completed her BS in Food Science and MS in Cereal Science at North Dakota State University. She previously worked in the Department of Plant Sciences at NDSU as a research specialist in the Carbohydrate Chemistry and Wheat Quality group. In August 2021, Kristin joined the Department of Food Science at Purdue University as a senior research associate in Dr. Senay Simsek's group. Kristin assists with research projects related to structure-function relationships of carbohydrates and grain macromolecules. She is responsible for coordinating research projects and sample analyses related to crop utilization, carbohydrate functionality, and functional ingredients in baking.

Our People, Our Projects

Campanella

1. The Potential of Whey Protein Fibril to be Used as a Gluten Replacer in a Dough System
2. *In Vitro* Digestion Study of Meat Analogue Produced by High Moisture Extrusion
3. Valorization Of Brewers' Spent Grains (BSG) by Co-rotating Twin-screw Extrusion
4. Iron Fortification by Glycated Soybean Lecithin
5. Development of a Novel High-fiber Puff Snack to Modulate the Gut Microbiome and the Gut-brain Axis
6. Valorization of Byproducts from the Meat, Fish, and Dairy Industries with Novel Manufacturing Processes

Hamaker

7. Matching Prebiotic Fibers to Beneficial Gut Bacteria
8. *In Vitro* Gut Fermentation Studies on Dietary Fibers
9. Dietary Fiber Mixtures and Design for Effectiveness
10. Slowly Digestible and Resistant Carbohydrates and the Gut-brain Axis
11. Cellular and Physiological Response of Slowly Digestible Carbohydrates
12. Plant-based Proteins and Zein Viscoelasticity

Jones

13. Effect of Enzymatic Hydrolysis and Extrusion on Bean Flour Functionality
14. Associative Complexes of Dairy Proteins and Gellan Gum

Kokini

15. Applications of Structural Bioinformatics in Understanding Molecular Origins of Pea Protein Gelation and Emulsification
16. Exploration of Creep Ringing Phenomena in Cold Denatured Pea Protein Emulsions
17. Design of Cold Extrusion Processing and Structure-function Relationships for Pea Protein Functionalization
18. Development of the System of Physical Processes (SPP) Methodologies for the Study of Food Systems in the LAOS and MAOS Regions
19. Development of Relationships Between Protein Secondary Structure and Fundamental LAOS Parameters in Thermoset Protein Gels
20. Mechanistic Understanding of Protein-protein Interactions in Pulse Flour Bread Doughs
21. Application of Machine Learning Algorithms in Understanding the Development of Color and Gloss in Plant-based Protein Edible Coatings

Lindemann

22. Bran Arabinoxylan Chemical Structure Effects on Fermentation by Gut Microbiota
23. Genotype, Particle Size, and Processing Effects on Wheat Bran Fermentation by Gut Microbiota
24. Influence of Resistant Glucan Structure on Fermentation by Gut Microbiota
25. Structure Effects on Competition for Oligosaccharides by Gut Microbiota
26. Oligosaccharide-Starch Interactions Influence on Digestibility and Fermentation
27. Division of Labor in Polysaccharide Degradation

Martinez

28. Understanding the Nature and Implications of the Physical Binding Polyphenols and Dietary Polysaccharides
29. Scalable Mimicry of the Myofibrillar Hierarchy Using Plant Proteins
30. Establishment of Green Chemistry Routes to Enhance the Performance of Polysaccharides
31. Novel Biotechnological Route for the Exploitation of Soluble Fibers from Plant Processing Waste

Mauer

32. Effects of Small Molecules on Starch Functional Properties

Narsimhan

33. Effect of Polysaccharides on Starch Swelling

Oh

34. Development of Microbial Platforms Capable of Co-fermenting Non-conventional Substrates for Enhanced Production of Value-added Chemicals
35. Fermentation of Undesirable Oligosaccharides by Designer Baker's Yeast to Alleviate Functional Bowel Disorders

Reddivari

36. Anti-colitic Effects of Flavonoids and the Role of Gut Microbiota
37. Physicochemical Properties and Physiological Effects of Dietary Fiber
38. Role of IBD-associated Bacteria in Colitis Onset and Severity

Simsek

39. Evaluation of Production Methods and Groat Type with Effects on Quality Analysis of Oat Beverage
40. Structural and Functional Characteristics of Dietary Fiber from Raw and Cooked Dry Beans
41. Effect of Milling Parameters and Starter Cultures on Nutritional Attributes and *In Vitro* Fecal Fermentation of Sourdough Bread
42. Extraction of Cellulose from Industrial Hemp for Production of Food Packaging

Yao

43. Molecular Rotor-based Characterization of Biopolymers in Oil/Water Systems Including Emulsions
44. Preparation of Naturally Occurring, Plant-based Emulsifiers and (Micro) Encapsulation Cell Wall Materials
45. Impact of Thermal Processing on Emulsification Properties of Naturally Occurring, Plant-based Emulsifiers
46. Innovative Formulations of Plant-based Meat Alternatives

Project Summaries

1 The Potential of Whey Protein Fibril to be Used as a Gluten Replacer in a Dough System

P.I.: Osvaldo Campanella

Researchers: Shengyue Shan, PhD student (The Ohio State University); Da Chen (University of Idaho); Enrico Federici (Beyond Meat)

Collaborators: Owen Jones

Objectives: Evaluate the feasibility of using whey protein fibril as a gluten replacer to be used in bread dough systems with fundamental rheological methods. The connection between the protein microstructure and rheological properties was also explored.

Progress: The project was finished and published in *Frontiers in Nutrition*. The increasing awareness of celiac disease, an autoimmune disorder caused by the consumption of products containing gluten, has led to a growing interest in the development of gluten-free bakery products. Gluten-free bakery products often show compromised quality attributes in comparison to their gluten-containing counterparts. In this study, it was shown that the dough reinforced by whey protein fibril at pH 7 showed similar linear rheological properties and strain harden behavior in biaxial extension to gluten dough. The study provided a potential direction for the further improvement of gluten replacer improvement.

2 *In vitro* Digestion Study of Meat Analogue Produced by High Moisture Extrusion

P.I.: Osvaldo Campanella

Researchers: Da Chen (University of Idaho); Diana Rocha-Mendoza (The Ohio State University); Shengyue Shan, PhD student (The Ohio State University); Zachary Smith (The Ohio State University); Israel García-Cano (The Ohio State University)

Collaborators: Julie Prost (Clextral, Inc); Rafael Jimenez-Flores (The Ohio State University)

Objectives: The study aimed at evaluating whether a plant-based meat analog has the ability to provide equivalent nutrition as animal meat.

Progress: The project is finished and published in *Journal of Agricultural and Food Chemistry* as a supplementary cover. The meat analog was prepared by high moisture extrusion with soy and wheat proteins, and its physicochemical properties, *in vitro* digestion and cellular uptake of the released peptides were systematically compared with chicken breast. It was found that the soluble peptides in the meat analog showed higher molecular weight and higher hydrophobicity after *in vitro* digestion. Meat analog digests showed lower permeability of peptides across Caco-2 cells. Amino acid composition analysis showed that there were fewer essential and non-essential amino acids in the meat analog permeates. As an emerging food with high sustainability potential and low heat concerns, meat analogs can mimic the hardness, chewiness and cohesiveness of animal meat, but more research needs to be done for improvement of their nutritional value.

3 Valorization of Brewers' Spent Grains (BSG) by Co-rotating Twin-screw Extrusion

P.I.: Osvaldo Campanella

Researcher: Veeramani Karuppuchamy, PhD student

Objectives: This project evaluates the application of twin-screw extrusion for the conversion of brewers' spent grains (BSG) from waste to food. The optimum extrusion conditions for maximizing retention of quality attributes will be determined.

Progress: Brewers' spent grains (BSG) from three commercial suppliers across the US were purchased and proximate composition was performed. The analysis found that there was a small difference in dietary fiber content among the samples. We also investigated the application of vibrational spectroscopy for the prediction of chemical composition. We will improve the robustness of developed models by adding more BSG samples to the calibration. BSG samples from a local brewery were procured and chemically analyzed. The aim

was to find a supplier with a short lead time at a reasonable cost. We are also studying the moisture sorption properties at different relative humidities. Two posters will be presented at the 2023 IFT annual meeting. Our next step is to decide the particle size of BSG samples to be used in extruded snack applications.

4 Iron Fortification by Glycated Soybean Lecithin

P.I.: Osvaldo Campanella

Researcher: Ankur Upadhyay, MS student

Objective: The objective of this project is to incorporate an encapsulated iron-glycated soy phospholipid complex during extrusion processing for application in plant-based meat analogs, for the purposed to increase the iron bioavailability, prevent food quality deterioration reactions, and mask unpleasant metallic taste of the traditional fortification technique. For this, the iron-binding ability of glycated phospholipids synthesized by varying different product and process parameters will first be assessed, followed by pilot-scale extrusion trials.

Progress: Just begun.

5 Development of a Novel High-fiber Puff Snack to Modulate the Gut Microbiome and the Gut-brain Axis

P.I.s: Osvaldo Campanella, Yael Vodovotz (The Ohio State University)

Researcher: Jenna McClure, PhD student

Collaborator: Bruce Hamaker

Objective: The objectives of this project are to (1) develop a corn snack extruded with corn arabinoxylan fiber with optimal starch resistance and fermentable fibers to upregulate short chain fatty acids and beneficial bacterial production in the gut, (2) conduct physical and sensory testing on the control product versus products with 10, 15, and 25% fiber, and (3) characterize the microbiome by *in vitro* testing for the optimized snack.

Progress: Previous studies have shown that the highly branched structure of corn arabinoxylan resulted in slow fermentation rates in the gut, making it an ideal fiber for use in human studies. Additionally, slower fermentation rates have been linked to increased production of short chain fatty acids in the gut. During this year, four extruded corn-based snack puff products with varying levels of fiber up to 25% were produced at Ohio State. Physical testing including Instron texture analysis, differential scanning calorimetry, nutritional profiling, and scanning electron microscopy are currently being done. Future work will focus on coating and sensory acceptability testing, along with *in vitro* fermentation tests.

6 Valorization of Byproducts from the Meat, Fish, and Dairy Industries with Novel Manufacturing Processes

P.I.: Osvaldo Campanella

Researcher: Chih-Chun (Ariel) Kuo, PhD student

Collaborators: Rafael Jimenez-Flores (The Ohio State University); Macdonald Wick (The Ohio State University)

Objectives: To advance the utilization of waste and byproducts generated in agricultural and food systems. Objective 1 focuses on the fermentation process of products in the meat and dairy industries. Objective 2 will move on to the optimization of a reactive extrusion (eREX) approach with fish-byproducts to achieve functional ingredients with biopeptides suitable for fish feed development.

Progress: Work was initiated in August 2021 to investigate a fermentation process of meat byproducts from cattle blood with acid whey. This was based on previous studies of acid whey fermentation of fish waste. An optimized condition of waste-stream concentration, waste-stream ratio, and time and temperature for fermentation was established to control the degree of protein hydrolysis. A manuscript is currently being prepared. In addition, preliminary tests have been initiated on the efficacy of improved fermentation hydrolysis in an eREX process using fish byproducts.

7 Matching Prebiotic Fibers to Beneficial Gut Bacteria

P.I.: Bruce Hamaker

Researchers: Thaisa Cantu-Jungles, Postdoc; Nusebye Bulut, PhD student

Objective: High specificity of dietary fiber structures to gut bacteria has led to the idea that fibers can be matched to beneficial gut bacteria. Our interest here is in finding a protocol to identify matched fiber prebiotics that precisely support specific gut resident probiotic bacteria and could have predictable response in a population.

Progress: We have been interested for some time in the concept of how one could match dietary fiber structures to support specific beneficial bacteria in the gut. In our paper in *mBio* in 2021 (Cantu-Jungles et al., *Dietary fiber hierarchical specificity – the missing link for predictable and intense shifts in gut bacterial communities*), an insoluble beta-glucan with an unusual structure was shown to specifically promote an *Anaerostipes sp.*, a butyrate-producing bacteria. We then developed a procedure to match a fiber to a known gut resident probiotic bacteria and, in this year, ran initial tests using *in vitro* fecal fermentation to identify such a matched fiber to *Faecalibacterium prausnitzii*, a bacterium some groups are working on to make an oral probiotic. Using qPCR, a fiber structure was found that promoted *F. prausnitzii in vitro* in 10 different fecal donors. Matching of fibers to preferentially support gut resident probiotic bacteria, or existing and next-generation oral probiotics, holds the promise to bring precision and predictable response to prebiotic fibers which is lacking in current commercial prebiotics.

8 *In Vitro* Gut Fermentation Studies on Dietary Fibers

P.I.: Bruce Hamaker

Researchers: Thaisa Cantu-Jungles, Postdoc; Monica Richmond, MS student; Mirian de Campos Costa, Visiting Scholar

Collaborators: Osvaldo Campanella; Steve Lindemann; Ali Keshavarzian (Rush University Medical School, Chicago), Eric Martens (University of Michigan)

Objective: Fermentable dietary fibers have the potential to produce positive short chain fatty acid (acetate, propionate, butyrate) changes in the colon and microbiota composition by favoring certain bacteria or bacterial groups. Here, our interest is in understanding how various factors, such as viscosity, affects fiber fermentation and how fibers can be selected with more consistent response in a population.

Progress: M. Richmond finished her MS research on the effect of viscosity on the growth of *Bacteroides thetaiotaomicron*, in collaboration with E. Martens and O. Campanella, following the hypothesis that viscous fibers that are slow fermenting (e.g., xanthan gum) reduce gut bacterial growth more than fast fermenting ones. Further, she studied the effect of different sized substrates (gelatinized amylopectin, DE-1 maltodextrin, maltose, pullulan, polygalacturonic acid) in different xanthan viscosities on growth of *B. theta*. Bacterial access to fermentable substrates for growth depended on size, with the large amylopectin molecule providing slower growth in higher viscosity xanthan than the smaller glucans and showing differences between pullulan and polygalacturonic acid which represent linear and globular structures of approximately the same molecular size. Slowly fermentable viscous agents, such as xanthan, likely change substrate competition in the proximal region of the colon, but as they are degraded no longer have an effect on substrate utilization by the gut microbiota.

T. Cantu-Jungles and M. de Campos Costa began a project to better understand how dietary fibers could be classified based on our proposed hierarchical specificity scheme, whereby higher specificity fibers have more consistent response across a diverse human population (Cantu-Jungles and Hamaker, *A new view on dietary fiber selection for predictable shifts in the gut microbiota*, *mBio* 2020). A number of fibers were selected based on simple to complex chemical and physical structures to understand responses in different fecal donors. Results will be reported next year.

9 Dietary Fiber Mixtures and Design for Effectiveness

P.I.: Bruce Hamaker

Researchers: Thaisa Cantu-Jungles, Postdoc; Xinruo Zhao, MS student

Collaborators: Ali Keshavarzian (Rush University Medical School, Chicago); Sarkis Mazmanian, Reem Abdel-Haq (California Institute of Technology); Frank Schuren, Jan Willem van der Camp (TNO, The Netherlands)

Objective: To understand how dietary fiber mixtures can be put together in a mechanistic way to support a healthy gut bacterial community.

Progress: T. Cantu-Jungles has worked toward a mechanistic design of fiber mixtures to support different groups of gut bacteria, each containing recognized health-related bacteria, and with our collaborators at Rush Medical School in a clinical study has recently shown improvement in important biomarkers in Parkinson's disease patients. A four-component fiber mixture was shown *in vitro* to support different key core gut bacterial groups, and in the clinical study (10 days, 20 g fiber mixture per day) there was significant improvement in gut barrier function (monitored by serum zonulin) and reduced gut and brain-related inflammation biomarkers. The fiber mixture was tolerable as per a questionnaire given to the Parkinson's patients. In another collaborative study using a mouse model (α-synuclein overexpressing [ASO] mice) with Parkinson's disease-like symptoms developed at Caltech, a similar designed fiber mixture improved motor movement and reduced α-synuclein aggregation in the substantia nigra, which occurred in the control (non-prebiotic-fed) mice. Prebiotics, and particularly ones designed for effective support of gut beneficial bacteria, may have a role in such diseases. This study was published in *eLife* in November 2022 (Abdel-Haq et al., *A prebiotic diet modulates microglial states and motor deficits in α-synuclein overexpressing mice*).

X. Zhao is studying the effect of fiber mixtures on the growth of *Clostridium difficile* using an *in vitro* fecal fermentation experimental design. This is in collaboration with A. Keshavazian at Rush Medical School and has the hypothesis that designed fiber mixtures could be more suppressive of *C. difficile* growth in antibiotic-compromised microbiota than a single fiber. Fiber types were selected that showed no support for *C. diff.* in culture, and in initial experiments a few fibers were found to have suppressive effect on the bacterium.

10 Slowly Digestible and Resistant Carbohydrates and the Gut-brain Axis

P.I.: Bruce Hamaker

Researchers: Rosa Lopez, PhD student; Marwa El-Hindawy, Postdoc; Jongbin Lim, Postdoc

Objective: To understand how to design dietary carbohydrates to activate the gut-brain axis for appetite control, lower food intake, and weight management.

Progress: In last year's report, papers were cited from our group showing that ileal (distal small intestine)-digesting carbohydrates activated the gut-brain axis in mice as evidenced by elevated plasma glucagon-like peptide-1 (GLP-1), lower food intake, and lower weight gain (*Dietary starch is weight reducing when distally digested in the ileum*, *Carbohydrate Polymers*, 2021; Lim et al., *Structural requirements of flavonoids for selective inhibition of endo-type α-amylase versus exo-type α-glucosidase for inducing slow but complete starch digestion*, *Food Chemistry*, 2022) and triggering of the ileal brake in humans (Chegeni et al., *Activation of gastrointestinal ileal brake response with dietary slowly digestible carbohydrates, with no observed effect on subjective appetite, in an acute randomized, double-blind, crossover trial*, *European Journal of Nutrition*, 2022). In 2022, we completed a clinical study showing significant increase in plasma GLP-1 with two distally-digesting carbohydrate preparations and will be submitting this work for publication in 2023.

R. Lopez worked toward understanding the potential synergy of direct activation of the gut-brain axis, as measured by elevated plasma GLP-1 levels, by ileal-digesting carbohydrate and carbohydrate fermentable in the large intestine. She has been developing carbohydrate materials with varying susceptibility (i.e., rate) to digestion and is readying to do a mouse study to look at activation of the gut-brain axis separately and together in the ileum and cecum.

11 Cellular and Physiological Response of Slowly Digestible Carbohydrates

P.I.: Bruce Hamaker

Researchers: Anna M.R. Hayes, former PhD student; Clay Swackhamer, Postdoc; Pablo Torres Aguilar, Postdoc

Collaborators: Buford Nichols (Baylor College of Medicine, Houston); Amy Lin, (A-Star, Singapore); Roberto Quezada-Calvillo (Universidad Autónoma San Luis Potosí)

Objective: To understand the cellular and physiological responses to slowly digestible carbohydrates that might have value in the area of controlled glycemic response, satiety control and metabolic fuel utilization.

Progress: In last year's report, slowly digestible carbohydrates were reported in the PhD thesis of A. Hayes to promote in mice metabolic flexibility, the ability to efficiently switch between oxidation of carbohydrate and fat. Poor metabolic flexibility has been associated with obesity and type 2 diabetes. This interesting, and potentially important, dataset – based on a series of mouse studies using metabolic cages to obtain respiratory exchange ratios at Baylor College of Medicine where carbohydrate digestion rate was changed using various techniques – was further analyzed. A "metabolic flexibility factor" (MFF) was devised to quantitate metabolic flexibility, and overall higher MFF was found in diets high in slowly digestible starch than in resistant starch, sucrose, or high fat. The study can be found online as *Moderating carbohydrate digestion rate promotes metabolic flexibility in mice* (*BioRxiv*, January 08, 2023). P. Torres Aguilar showed effect of diet on metabolic flexibility in a comparison study between subjects in the US (West Lafayette) and Kenya, and this will be reported next year.

12 Plant-based Proteins and Zein Viscoelasticity

P.I.s: Bruce Hamaker and Osvaldo Campanella

Researchers: Oguz Ozturk, Postdoc; Andres Munoz Salgado, MS student (The Ohio State University)

Objective: To understand whether viscoelastic corn zein networks can be incorporated into commodity plant-based proteins for improvement of texture of meat and cheese analogues.

Progress: We reported last year that corn zein can be effectively dispersed inside of a soy or pea-based protein mixture to provide viscoelasticity. O. Ozturk and A. Munoz Salgado successfully developed formulations with zein and alkaline agents (i.e., ingredients with a set of conditions) that mimic the textural profiles of a range of plant-based protein meat and cheese analogues. This work was published online in 2022 in *Food Hydrocolloids* in two papers – Ozturk et al., *Dispersion of zein into pea protein with alkaline agents imparts cohesive and viscoelastic properties for plant-based food analogues*, and Salgado et al., *Matching textural properties of commercial meat and cheese products using zein as the viscoelastic agent and calcium hydroxide as the textural modifier in plant-based formulations*. Further work was begun using the extruder with a cold-forming die in Dr. Campanella's lab and will be reported next year.

13 Effect of Enzymatic Hydrolysis and Extrusion on Bean Flour Functionality

P.I.: Owen Jones

Researcher: Anael Kimble, MS student

Collaborators: Osvaldo Campanella; Senay Simsek; Mario Martínez

Objective: Determine the effects of extrusion treatments and enzyme-assisted fiber hydrolysis on the rheological and nutritive properties of bean flours.

Progress: Viscosity of pinto bean flour was evaluated during heat and shear with or without hydrolases active against non-starch polysaccharides. Certain enzyme preparations were more successful at significantly changing the viscosity of bean flour suspensions at temperatures between 50 and 80 degrees Celsius. High-moisture extrusion trials were performed on the pinto bean flours with enzyme

preparations to assess the relative activity of enzymes during intense treatment within the extruder barrel. These experiments are part of ongoing studies of a Whistler Center faculty-industry team project, to be completed in 2023, that evaluate the effectiveness of enzyme-assisted reactive extrusion in increasing soluble dietary fiber content and improving rheological behaviors of the bean flours.

14 Associative Complexes of Dairy Proteins and Gellan Gum

P.I.: O. Jones

Researcher: Rui Zhu, MS student

Objective: Determine the conditions favoring association and colloidal structure development for dairy proteins and gellan gum.

Progress: Gellan gum and non-denatured whey proteins were isolated from commercial samples. Interactions between these components were evaluated in dilute aqueous solutions as a function of pH and protein-to-polysaccharide ratio. Heat-induced aggregation of protein was assessed in relation to the degree of interaction with gellan gum using light scattering and imaging. Ongoing tests are determining the efficacy of the interactions and aggregation processes on foaming capabilities.

15 Applications of Structural Bioinformatics in Understanding Molecular Origins of Pea Protein Gelation and Emulsification

P.I.: Jozef Kokini

Researchers: Natalia Rodriguez, undergraduate student; Harrison Helmick, PhD student

Objective: This research aims to develop relationships between bioinformatic models of pea protein and give molecular insight on how pea protein forms gels and emulsions.

Progress: This work is part of a USDA grant that aims to develop structure-function relationships of pea protein and understand how structure can be modified in order to achieve targeted end uses. In this work, a series of homology models have been generated for pea protein, as well as other pulses, from global sources in order to compare the amino acid similarity and differences based on cultivar and growing region. These models are analyzed for a number of bioinformatic features that are thought to correlate with experimental properties. It has been found that the surface properties of the protein three-dimensional structure correlates well with experimental values like surface hydrophobicity and zeta potential. These models were also used to estimate the hydrogen bonding contribution to thermoset gels made with pea protein using a combination of multiple linear regression and secondary structure data. This has shown the potential of bioinformatics to predict end-use properties of proteins based on models generated from the amino acid sequence of the protein.

16 Exploration of Creep Ringing Phenomena in Cold Denatured Pea Protein Emulsions

P.I.: Jozef Kokini

Researcher: Natalia Rodriguez, undergraduate student; Harrison Helmick, PhD student

Objective: This project aims to apply rheological models to creep data generated on pea protein emulsions, with a particular focus on the oscillatory region that occurs in the first few seconds of the measurement known as creep ringing.

Progress: Creep ringing is a phenomenon that occurs in the first few seconds of a creep experiment due to the inertia of the equipment, as well as the particle network of the material on the rheometer. While this is typically seen as experimental noise, recent work has shown that by including instrument inertial terms into the three-parameter Jeffreys model, it is possible to obtain information on the particle network before flow and as it yields. This project used different cold denaturation pre-treatments of pea protein to study how cold denaturation impacts emulsions stabilized with the protein and xanthan gum. It was found that a combination of ethanol and low temperature led to significantly improved emulsion stability, and that the creep ringing data could provide greater insight into the particle network than traditional creep models, such as the Burger Model. Stability was induced by an increase in protein hydrophobicity, which was bioinformatically estimated and experimentally measured. These two values also showed a high level of correlation in a 6-protein dataset that was used to standardize surface hydrophobicity measurements.

17 Design of Cold Extrusion Processing and Structure-function Relationships for Pea Protein Functionalization

P.I.: Jozef Kokini

Researcher: Harrison Helmick, PhD student

Objective: This research develops a process for low temperature functionalization of pea protein involving sub-zero temperatures and shear forces in extrusion and the physicochemical characterization of that extrudate.

Progress: It is well known that proteins denature as the result of heat and other processing techniques, but proteins also denature at low temperatures. This phenomenon is driven by decreasing hydrophobic interactions at lowering temperatures. In this work, we have subjected pea protein to cold temperatures, changes in tempering water pH, and shear forces through extrusion using twin and single screw extruders. Extrudates were characterized by measuring changes in secondary structure, zeta potential, surface hydrophobicity, and SDS-PAGE. We have shown that cold denaturation occurs during extrusion, and that it leads to hydrophobic amino acid exposure in pea protein with no changes in disulfide bonding. To leverage the changes in hydrophobicity, oil was added to the pea protein before extrusion, and it was found that significantly more oil could be conjugated to proteins at low temperatures as compared to high temperatures. This may help in the production of fat memetics in different food products.

18 Development of the System of Physical Processes (SPP) Methodologies for the Study of Food Systems in the LAOS and MAOS Regions

P.I.: Jozef Kokini

Researcher: Anh Minh Le, MS student

Objective: This research aims to study the nonlinear rheological behavior of different food products, with a particular emphasis on advancing usage of the SPP methodologies.

Progress: This work studies and compares the nonlinear rheological behavior of three different classes of foods using the Sequence of Physical Processes method of Rogers et. al., and Fourier Transform coupled with Chebyshev Decomposition by Ewoldt and McKinley. The evolution of deltoid size with increasing strain allowed for the determination of a critical strain before the irreversible network breakdown occurred. The time component from SPP allowed for more accurate capture of the linear viscoelastic region and crossover points by the 3D amplitude sweep. Deltoid and trefoil profiles provided a detailed and distinctive intracycle behavior of each class of the food. Under increasing amplitude, predominantly elastic networks showed gradual structural rearrangement while the changes were more erratic and abrupt in suspensions and emulsions. Under increasing frequency, elastic responses overtake viscous responses in all samples due to shorter relaxation times.

19 Development of Relationships Between Protein Secondary Structure and Fundamental LAOS Parameters in Thermoset Protein Gels

P.I.: Jozef Kokini

Researchers: Linh Nghiêm, undergraduate student; Anh Minh Le, MS student

Objective: This research aims to study the nonlinear rheological behavior of thermoset protein gels, with an emphasis on plant-based proteins.

Progress: Gelation is an important process in the creation of new food products aimed at replacing meat and dairy products. It is known that a variety of plant-based proteins form gels when a sufficient concentration of protein is suspended in water and heated above the protein's temperature of denaturation before cooling. In this project, it is hypothesized that the energy contained within those gels can be quantified through physicochemical analysis including secondary structure measurements, zeta potential, surface hydrophobicity, and SDS-PAGE. Furthermore, it is expected that the chemical energy will show a proportionality to the rheological responses of the material. These physicochemical measurements are currently being compared with non-linear rheological parameters derived from the SPP methodology to gain a molecular understanding of these rheological phenomenon and how they might change throughout the heating and cooling process.

20 Mechanistic Understanding of Protein-protein Interactions in Pulse Flour Bread Doughs

P.I.: Jozef Kokini

Researchers: Yukina Murata, undergraduate student; Anh Minh Le, MS student

Objective: This research aims to produce model bread products using a combination of vital wheat gluten and pulse flours from different sources. The dough is tested to understand how the rheology of these products change during mixing and fermentation, as well as textural properties of the final products.

Progress: Pulse flour is gaining traction in the food market as an alternative to wheat flour in a variety of baked goods due to its high protein content. Therefore, research on the characteristic of pulse-substituted bread doughs has been extensively conducted. Despite the improvement in nutritional values, many studies show that the low content of gluten protein in pulse flour substituted dough has significantly reduced the dough's extensibility, the final loaf volume upon baking, and the overall textural qualities upon consumption. This project aims to evaluate pulse flour dough systems with different gluten concentrations by monitoring the changes in the rheological properties as well as chemical properties such as starch crystallinity and protein secondary structure during fermentation. The baking performance will also be examined to access the final sensorial property of the product.

21 Application of Machine Learning Algorithms in Understanding the Development of Color and Gloss in Plant-based Protein Edible Coatings

P.I.: Jozef Kokini

Researchers: Kara Benbow, undergraduate student; Harrison Helmick, PhD student

Objective: This work is aimed at replacing egg washes with plant-based protein edible coatings in model baked goods and model color through machine learning.

Progress: Many baked goods are brushed with eggs and egg whites in order to create a golden brown and glossy surface that consumers have come to expect. In this work, pea protein-glycerol solutions are being tested for their suitability in replacing traditional egg washes. Coatings with variable pH, protein concentration, and glycerol concertation are applied to pie crusts and baked for differing amounts of time. These products are then evaluated for their glossiness, color, height, and texture. Furthermore, images are taken of the pie crust and the color is estimated using a machine learning model, trained on >1200 images of different colors of paper. Model results show that it is possible to accurately estimate color, and current developments are working toward maintaining these results under variable lighting conditions, as would be present inside a bread oven, or if images are taken outdoors. Together, this project aims to identify suitable plant-based replacements for egg washes, and provide models that could be used as part of computer vision systems in bakeries.

22 Bran Arabinoxylan Chemical Structure Effects on Fermentation by Gut Microbiota

P.I.: Steve Lindemann

Researchers: Tianming Yao, PhD student; Anurag Pujari, PhD student

Collaborator: Senay Simsek

Objectives: 1) To identify interrelationships between fine fiber structures of dietary fibers and the microbial consortia that most efficiently degrade them, 2) Determine the influence of structural modification of arabinoxylan structure on microbiome responses.

Progress: T. Yao continued his experiments using structural variants of sorghum arabinoxylan (SAX), either using enzymatically debranched SAX, where he had previously determined that enzymatic processing of SAX with arabinofuranosidases *in vitro* changed the targeting of these molecules to microbiota (with respect to their ability to grow in consortia), both with respect to fermenting microbiome composition and metabolic outputs. Specifically, enzymatic pre-processing with *B. ovatus* arabinofuranosidases greatly improved the competitiveness of diverse members of genus Bacteroides, including *B. ovatus*, and changed the utilization pattern of different linkages. This year, assisted by A. Pujari, T. Yao extended this study by performing sequential batch cultivation of mixtures of native (NSAX) and debranched (DBSAX) SAX, finding that the

abundances of fermenting microbiota linearly responded to the mixture of the polysaccharides, but that some aspects of fermentation (short-chain fatty and organic acid production) were emergent. Further, he performed a cross-over experiment, finding that communities cultivated on either native or debranched SAX rapidly adjusted to the opposite substrate, both compositionally and metabolically. A. Pujari also began development of a recombinant enzyme production system to identify the functions of distinct arabinofuranosidases that were previously discovered in metagenome-assembled genomes.

23 Genotype, Particle Size, and Processing Effects on Wheat Bran Fermentation by Gut Microbiota

P.I.: Steve Lindemann

Researchers: Miguel Alvarez Gonzales, PhD student; Adam Quinn, PhD student

Collaborators: Bruce Hamaker, Senay Simsek

Objectives: 1) Determine the degree to which the fermentation of a bran particle depends upon its size, 2) identify mechanisms by which particle size might influence the structure and function of gut microbiota, 3) determine how different mechanisms of mechanical processing might influence microbiota responses to bran particles, and 4) determine the impact of wheat genotypes on microbiome responses.

Progress: M. Alvarez performed experiments to determine to what extent the chemical composition and microbial fermentation of variously sized bran particles was influenced by the processing method (roller mill, hammer mill, disc mill, cyclone mill, or stone mill) used to reduce the size of those particles. He determined that the arabinoxylan structures isolated from differently sized particles depended upon the milling method used to generate them, especially with respect to degree to which backbone regions were substituted. These chemical composition differences translated into differences in microbial responses – identical fecal microbiota converted particles (even those of the same size) to different metabolic outcomes with respect to short-chain fatty acid (SCFA) production. Miguel identified microbial species associated with particles varying in size and milling method. Further, he performed a preliminary cross-over experiment in which he inoculated communities adapted to each particle size (coarse or fine) on the opposite particle type, finding that SCFA production and community structure rapidly adapted. These data strongly suggest that it is the particle's various niches that support distinct microbiota, rather than stochastic assembly on particles, that drives how wheat bran-fermenting communities form. Further, Miguel identified that milling methods differentially liberate bran polyphenols, and that metabolism of those polyphenols is differential across particle sizes of brans as well. This will be the subject of a new project beginning in 2024.

Recently, A. Quinn began a project to identify the extent to which bran structural features of relevance to the microbiome have been altered by selection of production wheat lines over time. To accomplish this, he has performed trial comparison of some ancient and modern wheat lines, revealing differences in arabinoxylan structure and bran fermentation profiles. These encouraging data suggested a larger trial, so, in collaboration with S. Simsek's group at NDSU, multiple field replicates of modern and ancient lines were grown in randomized blocks under the same field conditions. Fermentation of flours from these different lines, digested *in vitro* to mimic passage through the upper gastrointestinal tract, revealed that distinct genotypes performed differently in fermentations metabolically, and there were genotype-specific species associations, suggesting that some wheat genotypes offer distinct niches for organisms. These data further suggest that seed planting decisions may be influential on health via the microbiome, which has not been rigorously examined.

24 Influence of Resistant Glucan Structure on Fermentation by Gut Microbiota

P.I.: Steve Lindemann

Researchers: Mai Nguyen, MS student; Dane Deemer, staff scientist

Collaborators: Bruce Hamaker; Brad Reuhs

Objectives: 1) To determine whether different glucans select for different microbial composition and diversity and result in different metabolic outcomes *in vitro*, and 2) determine whether these effects also occur *in vivo*.

Progress: Picking up on previous experiments performed by A. Romero, which illustrated resistant glucan-specific interactions with gut microbiota across donors, M. Nguyen continued this work using

a sequential batch cultivation approach, which revealed that different glucan structures ferment to different metabolic outcomes, even given an identical inoculum. Experiments with each of three donor's fecal microbiota revealed that microbial diversity sustained by each of these carbohydrates relates strongly to structural complexity, and each carbohydrate selected for different microbial populations. These data strongly suggest that increased carbohydrate complexity results in multiplication of niches, and therefore sustainable diversity. Further, she found that communities rapidly adapt their rates of fermentation to the substrates provided. M. Nguyen went on to perform a feeding trial with C57BL/6 mice receiving six distinct resistant glucans, revealing differences in gut microbiome membership and community structure after four weeks of feeding. Work is ongoing to characterize the physiological impacts of these microbiome shifts in mice.

25 Structure Effects on Competition for Oligosaccharides by Gut Microbiota

P.I.: Steve Lindemann

Researchers: Jacob Thompson, PhD student; Anurag Pujari, PhD student; Monique Felix, PhD student

Objectives: 1) To determine the mechanisms by which structural properties of oligosaccharides influence microbial competition for these carbohydrates, 2) to predictively model competition for oligosaccharides given known consumption properties of microbes, 3) to identify signatures of competition for oligosaccharides in complex microbiomes, and 4) to identify oligosaccharide structure-microbiome competition influences on host physiology at high throughput.

Progress: This is a program to understand competition for oligosaccharide substrates among microbiota at a predictive level, using a strong focus of carbohydrate chemistry, microbial ecology, computational predictive modeling, and host physiology. We begin this investigation looking at competition along a single structural parameter (chain length) using chicory inulins as model oligosaccharides that vary only in this dimension, as well as branching (agave inulin). This year, we refined a draft kinetic model that describes degradation of inulins varying in DP according to assumed species parameters. M. Felix continued to identify growth properties of inulin-consuming microbes that lend to modeling, continued to evolve strains able to consume larger inulins and screen populations of genome-sequenced enterobacteria to determine what genes are important to increased size ranges of inulin consumption. J. Thompson identified eight clades of *Faecalibacterium prausnitzii,* identified their genomic differences that might contribute to differences in interactions with human cells, and generate genome-scale flux-balance models to predict metabolite formation. A. Pujari continues to isolate inulin oligomers of defined DP by size exclusion chromatography, and collaboration with Dr. Aaron Wright at Baylor University is underway to convert these into probes for chemical biology analyses.

26 Oligosaccharide-Starch Interactions Influence on Digestibility and Fermentation

P.I.: Steve Lindemann

Researchers: Paige Smith, MS student; Tianming Yao, Postdoctoral fellow

Collaborators: Lisa Mauer, Bruce Hamaker

Objectives: 1) To identify oligosaccharide-starch interactions that alter the functional properties of starches, 2) to determine the outcomes of these OS-starch interactions on enteroendocrine L-cells, and 3) to determine the outcomes of OS-starch interactions on fermentation by gut microbiota.

Progress: In 2022, we investigated a wide swath of industrially relevant oligosaccharides for their influence on wheat starch structure and properties and high concentration (~2 M). Post-screening, we identified a suite of oligosaccharides that displayed altered starch gelatinization and pasting profiles and determined that these structural influences were durable post-exposure to removal of oligosaccharides (i.e., in water). Oligosaccharide incubation conditions were then optimized. These oligosaccharide-starch complexes are now being tested for their digestibility in in vitro digestion, and subsequently tested for the interactions with L-cells and microbiota.

27 Division of Labor in Polysaccharide Degradation

P.I.: Steve Lindemann

Researchers: Tianming Yao, Postdoctoral fellow; Sajal Bhattarai, PhD student

Objectives: 1) Determine how microbiota differentially regulate their polysaccharide degradation genes as a function of their neighbors, both in aerobic and anaerobic communities, 2) Identify how community membership relates to community productivity, 3) Quantify how microbial degeneracy – and diversity – relates to functional stability.

Progress: This year, we began an NSF-funded project investigating the fundamental principles that govern how microbial communities ferment polysaccharides across community types. To this end, we are using two substrates – white sorghum arabinoxylan (WSAX) and exopolysaccharide (EPS) extracted from cyanobacterial biofilms – as model substrates, and investigating anaerobic and aerobic degradation of these polymers, respectively. We have isolated and modified WSAX and also have extracted EPS from a variety of biofilms. Concurrently, we have isolated 23 members from SAX-degrading communities to generate combinatorial synthetic communities to investigate rate and extent of polymer degradation.

28 Understanding the Nature and Implications of the Physical Binding Polyphenols and Dietary Polysaccharides

P.I.: M. Martinez

Researchers: Julia Bechtner, Postdoc; Pablo Gallego-Lobillo, Postdoc; Ivan Lopez, PhD student; Fang Fang, PhD student; Adriana Maribel Aguilar-Torres, PhD student; Emil Stentoft, MSc student

Collaborators: Clarissa Schwab (Aarhus University); Martin Krøyer Rasmussen (Aarhus University); Bruce Hamaker

Objectives: To understand the nature and nutritional implications of the physical binding polyphenols and dietary polysaccharides.

Progress: The nature of binding has been revealed using a broad set of techniques, including homonuclear and heteronuclear multidimensional NMR, ITC and multidimensional ESI-MS-QTOF with ion mobility. Furthermore, the most advanced semi-dynamic *in vitro* digestion procedures have been optimized, revealing important pathways of polyphenols during digestion. Colonic fermentation studies are schedules for spring 2023 and all results will be published in 2023. This is just the beginning of this work and this project will continue for three more years.

29 Scalable Mimicry of the Myofibrillar Hierarchy Using Plant Proteins

P.I.: M. Martinez

Researchers: Julia Spotti, Postdoc; Farzaneh Nasrollahzadeh, PhD student; Kasper Skov, PhD student

Objectives: The purpose of this research project is to advance plant-based meat product and/or technology development in simultaneous protein sourcing/characterization, formulation and processing.

Progress: In our first study, we evaluated the potential of commercial dry- and wet-fractionated hemp protein concentrates to develop highly fibrous meat analogues through high moisture extrusion cooking (Nasrollahzadeh, et al. 2022). Macronutrient composition, mineral profile, phenolic fractions, and protein molecular properties were investigated to elucidate the underlying mechanisms for the functionality and structuring behavior of hemp protein concentrates obtained through common dry and wet extraction routes. Taken together, results showed that the structure and, hence, functionality of hemp protein concentrates is critically affected during Alkaline Extraction-Isoelectric precipitation (AE-IP), and that dry-extracted hemp protein concentrates might represent a better source of structuring building blocks despite their lower protein content. Hemp protein concentrates resulted in High Moisture Meat Analogues (HMMAs) with an outstanding level of anisotropy and fibrous-like mesoscale structures, in which S–S bonds were presumed to have an important role. Despite their lower protein content, dry-fractionated hemp HMMAs were still highly fibrous and without the detrimental hardness, dark color, and excessive proportion of bound water that the wet-fractionated

hemp HMMAs presented. Nevertheless, dry-fractionated hemp HMMAs contained almost three times higher phytic acid than pea and wet-fractionated hemp HMMAs, with the potential to increase the daily intake of phytic acid for a vegetarian person living in the European Union, but not for consumers living in developing countries. Based on these findings and the premise that plant protein fractions are complex systems that could represent a versatile platform of building blocks for novel foods, we further investigated the potential common principles leading to anisotropy formation by comparing different protein concentrates/isolates (Nasrollahzadeh, et al. 2023). This work showed that the structuring potential of plant protein fractions during thermomechanical processing should be explained by both molecular and colloidal mechanisms acting in concert and involving proteins, polysaccharides, and polyvalent ions. We will now conduct further work on combining novel approaches to remove the textural shortcomings of plant-based foods thanks to the Novo Nordisk Foundation.

30 Establishment of Green Chemistry Routes to Enhance the Performance of Polysaccharides

P.I.: M. Martinez

Researchers: Natalia Prieto, Postdoc; Guillermo Portillo-Perez, Postdoc; Wenqiang Bai, PhD student; Wanxiang Guo, PhD student; Kasper Skov, PhD student

Objectives: This project aims to establish scalable, catalyst-free, derivatization reactions of polysaccharides to unlock their capacity to fabricate sustainable biomaterials

Progress: Hydroxyl groups of polysaccharides offer a chemical platform for esterification and etherification reactions, which are driven by metal-based or alkaline catalysts. Our project works with the idea that catalysts are not needed provided the correct green chemistry routes are established. For example, in our first work published (Vidal et al. 2022), we investigated the organocatalytic acetylation using tartaric acid. The effect of the degree of substitution with alkanoyl (DSacyl) and tartaryl groups (DStar) on thermal and moisture resistivity, and film-forming properties was investigated. Pea starch with DSacyl from 0.03 to 2.8 was successfully developed at more efficient reaction rates than acetylated maize starch. Nevertheless, longer reaction time resulted in granule surface roughness, loss of birefringence, hydrolytic degradation, and a DStar up to 0.5. Solid-state 13C NMR and SEC-MALS-RI suggested that tartaryl groups formed crosslinked di-starch tartrate. Acetylation increased the hydrophobicity, degradation temperature (by ~17 %), and glass transition temperature (by up to ~38 %) of pea starch. This complementary mode of catalysis has enormous potential for savings in cost, time, and energy, resemble an easier experimental procedure, and reduce chemical waste.

31 Novel Biotechnological Route for the Exploitation of Soluble Fibers from Plant Processing Waste

P.I.: Mario Martinez

Researcher: Julia Bechtner, Postdoc

Objectives: This project aims to explore a novel biotechnological route for the selective isolation of intact soluble fibers by using microorganisms that have been genetically modified to secrete a set of enzymes degrading other plant cell wall polysaccharides. Furthermore, this project also aims to provide the much-needed structure-function relationships of specific soluble fibers and unlock their use as hydrocolloid, binding platform, and prebiotic.

Progress: The project has started recently and no published data is yet available. The cross-disciplinary team of this project, involving biotechnology, glycomics and physico-chemistry tools, expects to harness precision fermentation (cell factories) to position specific soluble fibers as one of the most promising hydrocolloids and prebiotics in the food sector.

32 Effects of Small Molecules on Starch Functional Properties

P.I.: Lisa Mauer

Researchers: Travis Woodbury, PhD student; Adrianna Pilch, MS student; Paige Smith, MS student; numerous undergraduate students

Collaborators: Steve Lindemann. Bruce Hamaker, Ganesh Narsimhan, Yuan Yao

Objective: To investigate starch properties, including gelatinization and retrogradation, in the presence of a variety of sweeteners, oligosaccharides, and other small molecules, and in environments containing different amounts of water.

Progress: We are investigating the thermal and physicochemical properties of starch in different environments and in the presence of a wide variety of sweeteners, oligosaccharides, and other small molecules to establish relationships between small molecule type and structure, water activity, molecular weight, glass transition temperature, and intermolecular interactions with starch gelatinization, pasting, swelling, and retrogradation traits.

33 Effect of Polysaccharides on Starch Swelling

P.I.: Ganesh Narsimhan

Researchers: Gio Thuy Nguyen, undergraduate student; Yuncheng Wang, undergraduate student

Collaborator: Owen Jones

Objective: To characterize the effect of xanthan gum on swelling behavior of starch suspensions.

Progress: Starches are incorporated in food products for a variety of reasons, such as stabilizing, thickening, binding and gelling. Starch occurs as discrete granules. Upon exposure to water, starch granules swell when heated. This results in thickening of starch suspension (known as pasting) due to an increase in volume fraction of swollen granules. Starch pasting results in an increase in its viscosity. Therefore, the texture of a variety of food products, such as sauces, puddings, soups, batter mixes, etc. are influenced by pasting. The rheology and texture of starch paste obtained by cooking of starch granules are governed by its swelling. It is, therefore, necessary to quantify swelling in order to predict the rheology of starch paste as well as to develop new food formulations. Equilibrium swelling of normal maize starch (NMS) when heated to different temperatures (75, 80, and 85°C) at different xanthan concentration (0 to 5 wt %) was characterized. Addition of xanthan resulted in a decrease in equilibrium starch swelling, though this decrease was less pronounced at higher wt % NMS suspensions. Interestingly, equilibrium swelling decreased with an increase in wt % of NMS even in the absence of xanthan possibly due to steric interparticle interactions. Equilibrium swelling was predicted using a model that imposes the equality of chemical potential of water inside and outside the granule with the assumption that xanthan does not penetrate into the granule. Flory Huggins lattice model and mean field theory of non-adsorbing macromolecules were employed to evaluate solvation of starch molecules and segment density distribution of xanthan between granules to predict the depletion forces between the granules. We are currently investigating the effect of xanthan on the kinetics of swelling of starch granules.

34 Development of Microbial Platforms Capable of Co-fermenting Non-conventional Substrates for Enhanced Production of Value-added Chemicals

P.I.: Eun Joong Oh

Researchers: Dahye Lee, PhD student; Deokyeol Jung, Postdoc

Objectives: 1) Develop a stress-tolerant yeast platform for the simultaneous co-utilization of non-glucose carbon sources, and 2) Validate the effect of multiplex metabolic pathways on bioproducts in an engineered yeast platform

Progress: Plant biomass hydrolysates contain various carbon sources, including hexoses and pentoses. Noting that simultaneous co-fermentation of mixed sugars plays an essential role in implementing economic conversion processes producing biofuels, our working hypothesis is that simultaneous co-fermentation of diverse carbon sources by engineered strains will offer enhanced substrate utilization and product formation. To investigate this hypothesis, we developed a genetically modified yeast platform capable of concurrently

utilizing non-glucose sugars from lignocellulosic and pectin biomass. We engineered the yeast by introducing a cellobiose transporter (cdt-1) and a β-glucosidase (gh1-1) for the cellobiose pathway, as well as three heterologous genes, D-galacturonic acid reductase (gaaA), 2-keto-3-deoxy-L-galaconate aldolase (gaaC), and L-galactonate dehydratase (lgd1) for the galacturonic acid pathway. Due to the conflicting optimal pH levels for the cellobiose (pH 5) and galacturonic acid (pH 3.5) pathways, adaptive laboratory evolution was conducted in YP medium containing both galacturonic acid and cellobiose. As a result, the evolved strain exhibited significantly enhanced consumption rates for both galacturonic acid and cellobiose. Following the isolation of evolved strains, causal mutations responsible for the desired phenotypes were identified through sequencing.

35 Fermentation of Undesirable Oligosaccharides by Designer Baker's Yeast to Alleviate Functional Bowel Disorders

P.I.: Eun Joong Oh

Researchers: Fransheska Semidey, PhD student; Deokyeol Jung, Postdoc

Collaborator: Senay Simsek

Objectives: 1) Engineer enzyme secretion pathways in baker's yeast, 2) Engineer Saccharomyces cerevisiae invertase activity and specificity toward fructans, and 3) Develop a baker's yeast platform for expressing recombinant fructanase.

Progress: Our proposed work involves the expression of recombinant fructanase in baker's yeast to reduce fructans for FODMAP-sensitive individuals. To introduce a fermentation capability for fructans in *S. cerevisiae*, the expression system of the heterologous enzyme has to be optimized. In previous studies, naturally inulin-utilizing *Kluyveromyces species* converted inulin into ethanol efficiently. Therefore, one of the fructanases, inulinase, was selected as a target heterologous enzyme. The inulinase gene from *K. marxianus* (Km) was introduced into the genome of S. *cerevisiae*. The Km inulinase signal peptide and inulinase gene were isolated from the chromosomal DNA of Km by the polymerase chain reaction (PCR). The expression cassette for the Km inulinase gene, including the strong CCW12 promoter, the CYC1 terminator, and the Km inulinase signal peptide, was integrated into the baker's yeast genome using the CRISPR/Cas9 system. The recombinant strain exhibited a significant inulin consumption rate compared to the control strain. These results strongly endorse the feasibility of creating a dual enzyme expression system, including *S. cerevisiae* invertase and Km inulinase, to test our hypothesis.

36 Anti-colitic Effects of Flavonoids and the Role of Gut Microbiota

P.I.: Lavanya Reddivari

Researchers: Shiyu Li, Postdoc; Jose Haro, PhD student; Vignesh Nathan, PhD student

Objectives: 1) Assess the effect of the human UC-associated microbiota on the anti-colitic properties of phlobaphenes (PHLO) and anthocyanins (ANTH) in a whole food matrix. 2) Evaluate the capability of blueberry phenolic extracts to mitigate gut barrier disruption using porcine intestinal epithelial cells (IPEC-J2).

Progress: Six-week-old germ-free IL-10 -/- mice [C57BL/6] were colonized with human fecal microbiota from Ulcerative Colitis (UC) patients. They were assigned to four dietary treatments and a purified control diet (Control). The diets were substituted with 25% maize near-isogenic lines (NILs), developed to express PHLO and/or ANTH (Diet A: no flavonoids; B: PHLO, C: ANTH, D: both). After seven weeks the mice were exposed to 1.5% DSS in the drinking water for six days to induce colitis before sacrifice. Body weight loss was observed after DSS application. Higher liver weights (12%) and lower cecum weights (14-28%) were observed in mice given the maize diets in comparison to the control diet. A and B diets aggravated the DSS-induced increase in gut permeability (2 and 7-fold) but the D diet decreased the permeability (2-fold) compared to a control diet. IL-6 expression was higher in the diets containing flavonoids. The expression of Muc2, a gene related to mucin production in the gut membrane, was higher in treatment D followed by C and B. A synergistic anti-colitic activity of phlobaphenes and anthocyanins is suggested, implying underlying mechanisms of interaction.

Porcine intestinal (IPEC-J2) cells were pretreated with 1 or 2.5 ug/ml blueberry phenolic compounds (BPE) for 24 h and challenged with 10 ug/ml lipopolysaccharide for 6 h. Pretreatment with 1 ug/ml BPE preserved CAT activity. Reduced paracellular permeability of FITC-dextran was observed in a dose-dependent manner. 1 ug/ml BPE

increased the relative abundance of occludin and reduced IL-8 expression following LPS challenge. LPS reduced gene expression of occludin, but pretreatment was able to preserve the protein levels. Preliminary results indicate that the addition of blueberry phenolic compounds can be an effective management plan for post-weaning diarrhea through the conservation of antioxidant status, reduction of intestinal permeability and inflammation, and preservation of tight junction proteins.

37 Physicochemical Properties and Physiological Effects of Dietary Fiber

P.I.: Lavanya Reddivari

Collaborators: Bruce Hamaker, Brad Reuhs

Researchers: Edward Moncada, MS student; Shiyu Li, Postdoc

Objective: Assess the effect of fiber physicochemical properties such as rate of fermentability, solubility and structure complexity on fiber fermentation in the presence of healthy and colitis-associated bacteria.

Progress: Fiber fermentation with healthy human fecal sample showed that the fermentation rate was high for fibers such as oat bran and potato starch despite their low solubility. However, psyllium husk with a higher solubility showed a lower fermentation rate. Pectin (HMP) and Inulin (ChIn) resulted in a higher amount of SCFAs and gas production (GP), whereas wheat bran (WB) had lower levels of SCFAs and GP. In contrast, when using the UC fecal sample as inoculum, HMP, and ChIn showed lower levels of SCFAs and GP, suggesting that the colitis-associated bacteria were not capable of fermenting the fibers or that fiber fermentation was delayed due to the low bacterial diversity. α-and β-Diversity were significantly different between the UC and healthy donors. We suggest that the diversity dissimilarity between donors generated significant differences in SCFAs and GP levels when comparing them within each fiber.

38 Role of IBD-associated Bacteria in Colitis Onset and Severity

P.I.: Lavanya Reddivari

Researcher: Kayla Roy, PhD student

Objective: Investigate whether the onset and severity of ulcerative colitis in IL-10 -/- mice is dependent on fecal microbiota transplantation from ulcerative colitis patients.

Progress: Inflammatory bowel disease (IBD) is a chronic inflammatory condition that affects around 1% of the U.S. population. IBD is comprised of Chron's Disease and Ulcerative Colitis (UC), with UC having a higher incidence rate. Specifically in UC, bacterial dysbiosis is positively correlated with colitis severity and incidence. Germ-free IL-10-/- mice, genetically susceptible to colitis and of an average age of 20 weeks, were gavaged orally with fecal samples taken from healthy individuals or a severe colitis patient with a fecal calprotectin level of 1947 ug/mg. The Disease Activity Index (DAI) was calculated based on occult blood, weight loss, stool consistency, and grimace. DAI was used to assess colitis severity weekly in transplanted mice for eight weeks. There was a significant difference in alpha (Shannon Index) and beta diversity (unweighted UniFrac) between the colitis patient and healthy donors indicating dysbiosis (p=.0001; p=.001). The colitis donor had a reduction in species richness. Furthermore, there was a distinct and separate clustering of bacteria between the mice recipients of the two treatments, which clustered with the donors. Compared to mice with healthy individual-associated bacteria, colitic-associated bacteria did not significantly increase the colitis incidence or severity in IL-10 -/- mice. Furthermore, there were no significant differences in DAI scores, organ weights, and gut permeability between the treatments. Thus, this study demonstrates that bacterial dysbiosis alone is not sufficient to induce colitis in genetically predisposed mice.

39 Evaluation of Production Methods and Groat Type with Effects on Quality Analysis of Oat Beverage

P.I.: Senay Simsek

Researchers: Brandon Olson, MS student (North Dakota State University); Kristin Whitney, Staff

Collaborator: Teresa Bergholz (Michigan State University)

Objective: The ability to efficiently produce high-quality plant-based beverages is key for advancing the plant-based food and beverage industry. This study investigates how certain production methods affect the quality of oat beverages.

Progress: B. Olson (NDSU) completed his MS thesis research on the topic of the impact of processing on quality and carbohydrate function in oat milk base. The recent uptick in consumption of plant-based beverages has forced companies to modify production methods to further optimize the process. The objective of this study was to evaluate how groat type, water to grain ratio, and extraction method affect the quality and composition of oat beverage. The oat milk extractions were done with a (1:4) or (1:6) ratio of grain to water. Extraction was done by dry milling, wet milling, or dry milling with α-amylase treatment. The samples were blended with water and then centrifuged. The oat milk base was homogenized before analysis. Carbohydrate content and characterization was completed to assess impacts of processing on carbohydrate quality and functionality.

Wet milling and the use of an amylase treatment produced significantly ($p<0.05$) higher values of soluble solids, total solids, and total starch within the beverage base. Stabilized groats produced the highest value of total starch of 62.0%. When assessing the groat type, it was shown that stabilized groats would be a better option than both non-stabilized and rolled groats. This is because the heat-treated groats have more available starch for the enzymatic process, as well as inactivating natural enzymes like lipase. The water to grain ratio did not have a major effect on the samples, beside for the percent solids and yield. This was due to the simple fact that the 1:4 ratio had 50 g of groat flour, while the 1:6 ratio only had 33 g. The extraction methods explored included dry milling, wet milling, and amylase treatment. The amylase-treated samples tended to be higher in free glucose and total starch, as well has producing the samples with the highest ($p<0.05$) degree Brix. While oat type and water ratio did not impact the molecular weight of soluble carbohydrates, amylase treatment significantly ($p<0.05$) increased molecular weight of soluble carbohydrates. To ensure a quality oat beverage, it is recommended that stabilized groats, 1:4 water to grain ratio, and amylase treatment is utilized.

40 Structural and Functional Characteristics of Dietary Fiber from Raw and Cooked Dry Beans

P.I.: Senay Simsek

Researcher: Ana Magallanes Lopez, PhD student (North Dakota State University)

Collaborators: Osvaldo Campanella, The Ohio State University; Estelle Leclerc (North Dakota State University)

Objectives: To characterize the composition and rheological properties of dry beans' (pinto and black) soluble dietary fiber extracted from raw and cooked samples.

Progress: A. Magallanes Lopez (NDSU) continued her work with soluble dietary fiber (SDF) from dry beans with study of the immunomodulatory properties in collaboration with E. Leclerc (NDSU). After conducting physicochemical analysis of soluble dietary fiber rich fraction extracted from dry beans, additional work was done to evaluate dry bean soluble dietary fiber as inflammatory immunomodulatory compounds. Immunomodulatory polysaccharides are compounds able to modulate the immune system by activating specific mechanisms of the host response. In macrophages, which are cells of the innate immune system, the toll-like receptors (TLR) are involved in the detection of pathogens and subsequent production of inflammatory mediators. TLR-4 has been identified as the receptor with affinity for polysaccharides extracted from various sources. Therefore, the present study investigated the immunomodulating properties of SDF rich fractions extracted from dry beans on the RAW 264.7 murine macrophage cell line. When the macrophages were cultured with SDF-rich fractions, the secretion of pro-inflammatory molecules, such as NO, TNF-α, IL-6, and IL-1β, was detected. In addition, enhanced transcript levels of TNF-α, IL-6, and IL-1β were observed. Furthermore, by using the TLR-4 antagonist TAK-242, TLR-4 was identified as one receptor-activated in macrophages upon SDF-rich fraction modulation. The SDF-rich fractions' monosaccharide composition revealed that glucose, arabinose, xylose, mannose and galacturonic acid were significantly ($p < 0.05$) correlated to the immune response. The results suggest the potential of SDF-rich fractions as immunomodulators.

The study also showed that SDF-rich fractions extracted from dry beans promoted the secretion of pro-inflammatory molecules NO, TNF-α, IL-6, and IL-1β by RAW 264.7 murine macrophages. The results suggest that the SDF-rich fraction elicited the pro-inflammatory response of macrophages through TLR-4 mediated activation. In addition, SDF-rich fractions promoted TLR-4 mRNA expression, suggesting the enhancement of the macrophages' immune response. The obtained results show the possibility of considering SDF-rich fractions extracted from dry beans as immunostimulators to aid in the prevention and fight of infections.

41 Effect of Milling Parameters and Starter Cultures on Nutritional Attributes and *In Vitro* Fecal Fermentation of Sourdough Bread

P.I.: Senay Simsek

Researcher: Jayani Maddakandage, PhD Student (North Dakota State University)

Collaborator: Steve Lindemann

Objectives: Objectives of this study were 1) to evaluate the nutritional quality of sourdough bread made with stone milled hard red spring wheat flour, 2) characterize arabinoxylans extracted from stone-milled whole wheat flour and sourdough bread, and 3) evaluate whether in vitro fecal fermentation of sourdough bread is affected by mill settings and starters.

Progress: J. Maddakandage (NDSU) completed her PhD dissertation on sourdough bread prepared from stone milled wheat flour and studied the *in vitro* fecal fermentation in collaboration with S. Lindemann. Hard red spring wheat was ground into whole grain flour using a stone mill. Three different gap settings and two different rotation speed values were used to produce flour samples with six different treatments, and those flour samples were used to make sourdough bread with two different starter cultures. Significant ($p < 0.05$) differences were observed in moisture, protein, dietary fiber content, arabinoxylan content, total starch content, starch digestibility and protein digestibility between sourdough bread samples with rye and wheat starter cultures. Higher protein digestibility values were observed for the majority of sourdough samples with the rye starter culture compared to the sourdough with the wheat starter culture. The antioxidant capacity of polyphenols extracted from bread samples was negatively correlated with the coarse particle size fraction, while it is positively correlated with the fine particle size fraction. Processing whole grain flour into sourdough bread significantly ($p < 0.05$) reduced the phytic acid content and fructan content and improved the antioxidant activity. The results of the in vitro fecal fermentation experiments revealed that starter culture significantly ($p < 0.05$) affected alpha diversity and donor had a substantial effect on the community structure. The starter culture significantly affected the community evenness and richness, resulting in greater alpha diversity indices (Shannon even, inverse Simpson) for sourdough bread samples with rye starter culture. Beta diversity results revealed that donors had a substantial effect on the community structure as shown by the clusters. The results of SCFA production revealed that the acetate and propionate production was positively correlated with the coarse particle size fraction and positively correlated with the fine particle size fraction at 6 hours and at 48 hours confirming that particle size plays an important role in microbial metabolite production. These results demonstrated that selected starter cultures and the raw material with the desired particle size can be used to improve the nutritional attributes of sourdough bread and the potential application in the baking industry. Any future studies should be conducted to evaluate the interactions between different methods of whole-grain processing (sourdough, straight dough and sponge dough bread making) and gut bacteria.

42 Extraction of Cellulose from Industrial Hemp for Production of Food Packaging

P.I.: Senay Simsek

Researcher: Laila Hossain, Postdoc

Collaborators: Marguerite Bolt, and Ron Turco (Purdue University, Agronomy Department)

Objective: To explore added value uses to industrial hemp grown in Indiana

Progress: This project is in its initial phase and several varieties of industrial hemp have been grown from which the stalk material has been collected. Thus far, the stalk material has been processed for extraction of cellulosic material. Preliminary work has been done to characterize the yield and structure of cellulose and hemicellulose from the industrial hemp stalks. Laila has also begun working on modification of the cellulose and development of biodegradable superabsorbent material. The preliminary super absorbent generated from hemp

cellulose was found to absorb 140 grams of water per gram of super absorbent material. This is a promising start to this study in which we hope to create a biodegradable superabsorbent material that can be customized for various applications in food packaging materials.

43 Molecular Rotor-based Characterization of Biopolymers in Oil/Water Systems Including Emulsions

P.I.: Yuan Yao

Researcher: Jingfan Chen, PhD. (Graduated, working on two manuscripts related to molecular rotor)

Objective: To advance the molecular rotor-based methodology as a new method to characterize biopolymers.

Progress: When biopolymers are incorporated in the oil/water systems, such as an oil/water two-layer system or an emulsion, the distribution of biopolymer molecules in the oil and aqueous phases and at the oil-water interface affects the properties and performance of the system, such as the stability of emulsions. Since the signals of fluorescence emission of CCVJ, a hydrophilic molecular rotor, are related to the structural characteristics of biopolymers and the polarity of solvent (e.g., oil or water), CCVJ was used to study the oil/water two-layer systems and emulsions. In this project, the biopolymers used were starch octenylsuccinate, phytoglycogen octenylsuccinate, acacia gum, and sodium caseinate.

44 Preparation of Naturally Occurring, Plant-based Emulsifiers and (Micro) Encapsulation Cell Wall Materials

P.I.: Yuan Yao

Researcher: Merve Yildirim Erturk, Postdoc

Objective: To explore novel encapsulation materials from plant sources.

Progress: This project is sponsored by USDA grant titled *Novel, Plant-Based Wall Materials for Spray-Dry Microencapsulation: Manufacturing, Characterization, and Performance Evaluation*. Progress being made on the extraction process. The goal is to characterize and maximize both the quality and quantity of materials that govern the emulsification and encapsulation properties, respectively.

45 Impact of Thermal Processing on Emulsification Properties of Naturally Occurring, Plant-based Emulsifiers

P.I.: Yuan Yao

Researcher: Kamrun Nahar, MS student

Objective: To explore novel emulsifiers from plant sources.

Progress: This project is sponsored by USDA grant titled *Novel, Plant-Based Wall Materials for Spray-Dry Microencapsulation: Manufacturing, Characterization, and Performance Evaluation*. Progress is being made on the characterization of thermal processing. The goal is to study, at fundamental level, how the thermal processing conditions can affect the hydrophobic and interfacial properties of naturally occurring emulsifiers.

46 Innovative Formulations of Plant-based Meat Alternatives

P.I.: Yuan Yao

Researcher: Zhuoran Chen, MS student

Objective: To improve the texture of meat alternatives while maintaining nutrition benefits.

Progress: For plant-based meat alternatives, disadvantages in texture, flavor, and protein quality are several of the challenges the industry and research community need to address. In this project, we focus on improving the texture of plant-based meat alternatives without compromising the nutrition value of products, particularly for alternatives to ground beef patties. Progress has been made at a formulation level, whereas more work remains to be done to gain in-depth understanding of food component interactions in the ground beef patty-alternative system.

Publications and Other Scholarly Activities

A. Papers, Books, Book Chapters, and Patents Published

BeMiller, J.N.

1. **Villwock, K.** & **BeMiller, J.N.** (2022). The architecture, nature, and mystery of starch granules. Part 1: A concise history of early investigations and certain granule parts. *Starch-Stärke, 2022,* 2100183.

2. **Villwock, K.** & **BeMiller, J.N.** (2022). The architecture, nature, and mystery of starch granules. Part 2. *Starch-Stärke, 2022,* 2100184.

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3. Brito-Oliveira, T.C., Moraes, I.C., Pinho, S.C., & **Campanella, O.H.** (2022). Modeling creep/recovery behavior of cold-set gels using different approaches. *Food Hydrocolloids, 123,* 107183.

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13. McCaw, J.C.S., Fleck, T.J., **Tejada-Ortigoza, V.** ,Patel, B., Son, S.F., & Gunduz, I.E., **Campanella, O.H.**, & Rhoads, J.F. (2022). Vibration-assisted printing of highly viscous food. *Additive Manufacturing, 56,* 102851.

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Ferruzzi, M.G.

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See paper in Campanella (Tejada-Ortigoza et al.)

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See paper in Campanella (Chen et al., Shan et al.)

Kokini, J.L.

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Reddivari, L.

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Simsek, S.

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See paper in Martinez (Vidal et al.)

Yao, Y.

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

January

Hamaker, B.R. Food as Medicine, how new food carbohydrates could have equitable access from the perspective of a food scientist. Purdue Health Equity Forum, Purdue University. West Lafayette, IN.

Lindemann, S.R. Polysaccharide structure and niche structure: how fine structure mediates selection and maintenance of diversity among gut microbial communities. Department of Genetics, Evolution, and Environment, University College London. London, United Kingdom.

Oh, E.J. Sustainable and safe production of food ingredients and value-added products through metabolic engineering. Chung-Ang University. Seoul, South Korea.

February

Hamaker, B.R. Gut microbiome composition in relation to structure function of dietary fibres. Healthgrains, International Life Science Institute (ILSI) Europe, virtual talk.

Lindemann, S.R. Fine cereal fiber structure influences on gut microbiome responses: the effects of genotype and processing. Centro de Desarrollo de Productos Bóticos, Instituto Politécnico Nacional. Mexico City, Mexico.

Reddivari, L. Near-isogenic lines as a tool to understand the plant food-gut bacteria-health complexity. Department of Horticultural Sciences, Texas A&M University, College Station, TX.

March

Helmick, H., Kokini, J.L. Optimization of a single screw extruder for low temperature applications. Graduate Industrial Research Symposium. Purdue University. West Lafayette, IN.

Martinez, M.M. Good carbs, bad carbs: gaps and opportunities for edible plant cells. Transcolab Summit. Braganca, Portugal.

Oh, E.J. Engineering yeast strains for producing food ingredients and value-added chemicals. Department of Biochemistry, Purdue University. West Lafayette, IN.

Reddivari, L., Nutrient bioavailability – phytonutrient and beyond, Anti-colitic effects of bioactive compounds: Role of gut bacteria. W4002 Multi State Meeting, virtual talk.

Vidal, N.P., Roman, L., Swaraj, S., Ragavan, V., **Simsek, S., Martinez, M.M.** Improving the nutritional value of cold-pressed oilseed cakes through extrusion cooking. Transcolab Summit. Braganca, Portugal.

April

Ettestad, S., **Helmick, H., Kokini, J.L.** Understanding how protein structure impacts its function and effect of cold denaturation on protein gelation. Purdue Undergraduate Research Symposium. Purdue University. West Lafayette, IN.

Ferruzzi, M.G. Where are we and what's missing in dietary guidance for tea? 6th International Symposium on Tea and Human Health, virtual talk.

Hamaker, B.R. Potential of dietary carbohydrates in weight reduction. Federal University of Vicosa. Vicosa, Brazil.

Hartanto, C., **Helmick, H., Kokini, J.L.** Understanding how protein structure impacts its function and effect of cold denaturation on protein gelation. Purdue Undergraduate Research Symposium. Purdue University. West Lafayette, IN.

Helmick, H., Kokini, J.L., Optimization of a single screw extruder for low temperature applications. Institute of Food Technologist, Indiana Division Meeting. Purdue University, West Lafayette, IN.

Lindemann, S.R. The devil is in the details: how dietary fiber fine structures divergently interact with gut microbiota. Department of Integrative Physiology, University of Colorado. Boulder, CO.

May

Campanella, O.H. New horizons for extrusion technology in agriculture and applications. European Centre for Biotechnology and Bioeconomy (CEBB). Pomacle/Bazancourt, France.

Ferruzzi, M.G. Food factors that modify absorption, metabolism and potential bioactivity of phenolics. Instituto Politécnico Nacional - Centro de Desarrollo de Productos Bióticos. Mexico, virtual talk.

Ferruzzi, M.G. Review of food factors that modify absorption, metabolism and potential bioactivity of phenolics. University of California, Davis, Nuts and Berries Conference. Davis, CA.

Hamaker, B.R. Overview of Purdue University work – cacao processing and by-production utilization, Workshop. USAID-sponsored PERU-Hub project. National Agrarian University La Molina. Tarapoto, Peru.

Helmick, H., Kokini, J.L. Quantitative structure property relationships of cold denatured pea protein during gelation. OIGP 2022 Spring Reception. Purdue University. West Lafayette, IN.

Reddivari, L. Chemical considerations of aseptic processing. 39th Annual Aseptic Processing and Packaging Workshop Focus on the Present - Planning for the Future. Purdue University. West Lafayette, IN.

Hamaker, B.R. Designing foods that activate satiety response. Whistler Center for Carbohydrate Research Technical Conference. Purdue University. West Lafayette, IN.

Reddivari, L. Selection of dietary fibers for gut health based on physicochemical properties. Whistler Center for Carbohydrate Research Technical Conference. Purdue University. West Lafayette, IN.

Lindemann, S.R., Yeruva, L. Microbes and milk sugars: benefits to immune system. Whistler Center for Carbohydrate Research Technical Conference. Purdue University. West Lafayette, IN.

Ozturk, O. Imparting new textural properties into plant-based protein products. Whistler Center for Carbohydrate Research Technical Conference. Purdue University. West Lafayette, IN.

June

Campanella, O.H. Food material science research and processing. University of Paris-Saclay. Paris, France.

Campanella, O.H. Food extrusion program at The Ohio State University. Improve. Amiens, France https://www.improve-innov.com/en/

Eckrote, S.L., **Nathan, V., Reddivari, L.** Anti-pathogenic activity of blueberry phenolic compounds on *Salmonella Enterica Serovar Typhimurium* (ST) and enterotoxigenic *E. Coli* (ETEC) in IPEC-J2 cells. Undergrad Research Symposium. Purdue University. West Lafayette, IN.

Hamaker, B.R., Cantu-Jungles, T. Precision nutrition for population benefit: a prebiotic fiber blend example. IAFNS Annual Meeting & Science Symposium. National Press Club, Washington, D.C.

Hamaker, B.R., Cantu-Jungles, T. Path towards predictable microbiota outcomes for fibre prebiotics. Food Innovation Asia Conference. Bangkok International Trade & Exhibition Centre (BITEC). Bangkok, Thailand, virtual talk.

Leonard, L.M., Li, S.S., **Reddivari, L.,** Cross, T.-W.L. Development of a gnotobiotic mouse model with distinct bacterial equol producing capabilities. Indiana Branch American Society of Microbiology, ASM. Purdue University. West Lafayette, IN.

July

Hamaker, B.R. Dietary fibers and their use as prebiotics. University of Valladolid, Valladolid, Spain.

Leonard, L.M., Li, S.S., **Reddivari, L.,** Cross, T.-W.L. Establishment of a gnotobiotic mouse model for determining the health benefits of microbial metabolite equol. Beneficial Microbes Conference, Wisconsin Union. Madison, WI.

Lindemann, S.R. Synbiotic delivery of human microbiota and paired fiber improves post-antibiotic resilience in mice in sex-dependent ways. Anaerobe Society of the Americas, Anaerobe 2022. Seattle, WA.

Moncada, E., Reddivari, L. Selection dietary fibers for gut health based on their physicochemical properties. Institute of Food Technologist Annual Meeting. Chicago, IL.

Oh, E. J. Engineering yeast strains for producing food ingredients and value-added chemicals. The 2022 UST Global Mentoring Conference. Korea Research Institute of Bioscience and Biotechnology (KRIBB). Daejeon, South Korea.

August

Ferruzzi, M.G., House, J., Amegatcher, I., Liceaga, A. National Academy of Science Engineering and Medicine Food Forum Roundtable: The role of processing in creating healthy and sustainable alternative protein products. Virtual talk.

Hamaker, B.R. Slow digestion of sorghum foods and potential health benefits. IGP Institute Monthly Meeting, Kansas State University, virtual talk.

Lin, Y., **Simsek, S.,** Bergholz, T. Impact of chlorinated water on pathogen inactivation during wheat tempering and resulting flour quality. International Association for Food Protection annual meeting. Pittsburgh, PA.

Lin, Y., Dolan, K., **Simsek, S.,** Bergholz, T. Inactivation of *Salmonella* and shiga-toxin producing *Escherichia coli* on soft wheat kernels using vacuum steam pasteurization. International Association for Food Protection Annual Meeting. Pittsburgh, PA.

September

Bai, W., Prieto, N., Martinez, M.M. Structure-function relationships of pectin in pea starch composite films. 5th International EPNOE Junior Scientist Meeting 2022. Aveiro, Portugal.

Campanella, O.H. Fabrication, characterization, and potential food applications of texturization of foods. Society of Food Engineering (SoFE). 15th Conference of Food Engineering. Raleigh, North Carolina.

Guo, W., Spotti, J., Martinez, M.M. Structural integrity of the main biopolymers present in stale white bread. 5th International EPNOE Junior Scientist Meeting 2022. Aveiro, Portugal.

Lindemann, S.R. Using polysaccharides to modulate gut microbiomes for improved health. Symposium. Purdue Institute for Immunology, Inflammation, and Infectious Disease (PI4D). West Lafayette, IN.

Mauer, L.J. Understanding how sweetener solutions influence starch gelatinization. Conference on Food Engineering. Society of Food Engineers. Raleigh, NC.

Mauer, L.J. Women and leadership in food engineering: representation, experience, and success. Conference on Food Engineering. Society of Food Engineers. Raleigh, NC.

Nasrollahzadeh, F., Skov, K., Chen, M., Mekonnen, T., Dutcher, J., **Martinez, M.M.** Exogenous addition of a nano-scale dimension dramatically enhances the tensile properties and juicy mouthfeel of plant-based whole cut meat analogues. 5th Food Structure and Functionality Symposium. Cork, Ireland.

Skov, K., Suwal, S., Corredig, M., **Martinez, M.M.** Structuring and phase behavior of milk protein concentrate and pea starch during high moisture extrusion processing. 5th Food Structure and Functionality Symposium. Cork, Ireland.

Yao, Y. Structures, functions, & applications of phytoglycogen, a plant-based dendrimer-like biopolymer, and its derivatives. University of Illinois Urbana-Champaign. Champaign, IL.

October

Campanella, O.H. New horizons in extrusion technology and its applications in the food industry. Plenary session of the VIII Congreso Internacional de Ciencia y Tecnología de los Alimentos (CICyTAC). Cordoba, Argentina.

Ferruzzi, M.G., Manaker, L.M. Bioactives: impacts on health and how to communicate with consumers. Academy of Nutrition and Dietetics Food and Nutrition Conference and Expo Foundation Breakfast. Orlando, FL.

Hamaker, B.R. Dietary fibre: State of the field, challenges and opportunities (keynote talk). International Association for Cereal Science and Technology, 8th International Conference on Dietary Fibre 2022. Leuven, Belgium.

Helmick, H., Kokini, J.L. Determining protein stability using random forest regression with applications in cold extrusion. Elmore Family School of Electrical and Computer Engineering. Purdue University. West Lafayette, IN.

Le, A.M., Kokini, J.L. Effect of fat on non-linear rheological behavior of processed cheese spreads using coupled amplitude-frequency sweeps, Fourier Transform-Chebyshev polynomials method, sequence of physical processes, and quantitative network analysis. Society of Rheology. Chicago, IL.

Lindemann, S.R. Subtle differences in fine bran hemicellulose structures govern succession and metabolism of gut microbiota. International Association for Cereal Science and Technology, 8th International Conference on Dietary Fibre 2022. Leuven, Belgium.

Lindemann, S.R. Manipulating fiber polysaccharide structure to alter targeting to gut microbiota. 9th World Congress on Targeting Microbiota, International Society of Microbiota. Paris, France.

Martinez, M.M. "Good" and "bad" carbohydrates, the importance of the interactions between the molecules of the plant cell. VIII International Congress of Food Science and Technology. Cordoba, Argentina.

Ozturk, O., Salgado, A., **Campanella, O.H., Hamaker, B.R.** Using zein as a cohesive and viscoelastic agent in plant-based food analogues. 16th International Hydrocolloids Conference. Guelph, Canada, virtual talk.

Simpson, A., Leonard, L.M., Maher, G., Choi, M.S., **Reddivari, L.,** Cross, T.-W.L. Identification of human gut microbiomes capable of producing equol through colonization of germ-free mice. Purdue Women's Global Health Institute (WGHI) Conference and the Purdue Health and Human Sciences (HHS) Research Day. Purdue University. West Lafayette, IN.

Spotti, J., Giannini-Kurina, F., Román, L., Henriksson, T., Moldin, A., **Martinez, M.M.** Understanding starch fine molecular structure and its influence in the retrogradation behavior of different wheat varieties. VIII International Congress of Food Science and Technology. Córdoba, Argentina.

November

Campanella, O.H. Food material science and applications on plant proteins processing. Cereal & Grains 22. Bloomington, MN.

Hamaker, B.R. Evidence that whole grain fibers support important butyrogenic gut bacteria. Cereals & Grains 22. Bloomington, MN.

Hamaker, B.R. Where mechanistic understanding of carbohydrate function meets personalized nutrition. Cereals & Grains 22. Bloomington, MN.

Høgsgaard, K., Vidal, N.P., Marietou, A., Fiehn Gam, O., Li, Q., Catalano, J., **Martinez, M.M.,** Schwab, C. Fucose but not fucoidan enhances propionate formation of intestinal microbiota through microbial cross-feeding. Danish Microbiological Society Conference. Copenhagen, Denmark.

Martinez, M.M. Molecular and colloidal principles determining anisotropic food structuring from seed protein fractions. Cereals & Grains 22. Minneapolis, MN.

Martinez, M.M. Food structure and multicomponent interactions determine carbohydrate nutritional quality. Cereals & Grains 22. Minneapolis, MN.

Martinez, M.M. Exploitation of biopolymers from food crops within planetary boundaries. Food Analytics Conference 2022. Copenhagen, Denmark.

Martinez, M.M. Food structure and multicomponent interactions determine carbohydrate nutritional quality. Department of Food Science, University of Barcelona. Barcelona, Spain.

Whitney, K., Vaca, J., Bolt, M., Turco, R., **Simsek, S.** Industrial hemp grain – development of cultivar quality assessment. Cereals & Grains 22. Bloomington, MN.

Whitney, K., Alava-Vargas, M., **Simsek, S.** Craft milling and the local foods movement: quality of stone milled flour. Cereals and Grains 22. Bloomington, MN.

December

Lindemann, S.R. Microbial composition analysis using mothur. Food Engineering Department, Necmettin Erbakan University. Konya, Turkey.

Lindemann, S.R. Manipulating the microbiome for improved brain function via the gut-brain axis. Faculty of Medicine, Necmettin Erbakan University. Konya, Turkey.

C. Graduate Degrees Awarded

Spring 2022

1. Jayani Maddakandage Dona Kulathunga, PhD, *Effect of milling parameters and starter cultures on nutritional attributes and in vitro fecal fermentation of whole wheat bread.*
2. Ana Magallanes-López, PhD, *Ingredients extracted from dry beans: Chemical, structural and functional characterization.*
3. Cindy Mayorga, MS, *Feasibility of soy protein isolate electrospun nanofibers decorated with metal noble nanoparticles as a possible biodegradable SERS platform*
4. Kasper Brandhøj Skov, MS, *Twin-screw extrusion of milk protein concentrate with pea starch to create a fibrous structure for low fat meat analogues*
5. Pablo Torres-Aguilar, PhD, *Experimental and clinical investigations of slowly digestible carbohydrates for improved physiological outcomes and metabolic health*

Summer 2022

6. Merve Yildirim, PhD, *Nonlinear rheology of food materials.*

Fall 2022

7. Adrianna Pilch, MS, *Effects of different forms of vitamin C on wheat starch properties.*
8. Travest Woodbury, PhD, *Sugar reduction in baked goods systems.*

D. Recognitions, Awards, and Honors

Julia Bechtner
Novo Nordisk Postdoctoral Fellow

Nuseybe Bulut
Kirleis Graduate Student Award

Osvaldo Campanella
2022-2023 CFAES Distinguished International Research and Engagement Award

Thaisa Cantu-Jungles
2022 Young Researcher Fundamental and Applied Research Grant Recipient, Global Prebiotic Association

Mario Ferruzzi
Inaugural Arkansas Children's Endowed Chair in Digestive Disease and Nutrition Research

Yonas Gizaw (Adjunct Professor)
Promoted to R&D Director-Principal Scientist, Procter and Gamble Co.

Bruce Hamaker
Morrill Award
Purdue University

Harrison Helmick
Bilsland Dissertation Fellowship

Institute of Food Technologists Annual Meeting - Education and Outreach Division, second place

Office of Interdisciplinary Graduate Programming, Spring Showcase, Certificate of Excellence

Graduate industrial Research Symposium hosted by Agricultural and Biological Engineering, first place

American Society of Baking; Board of Directors Member at Large

Steve Lindemann
23 PAIR Fellow, Biocrossroads

Cereal and Grains Association; Young Scientist Research Award

Showalter Faculty Scholarship

University Faculty Scholar, Purdue University

Philip E. Nelson Endowed Chair of Food Science, Purdue University

Outstanding Graduate Educator Award, Department of Food Science, Purdue University

Lisa Mauer
Selected to be on the planning committees and serve as a liaison for the Big Ten Academic Alliance DEO and DLP programs

Vignesh Bose Nathan
BJ Liska Outstanding Teaching Assistant Award, Department of Food Science, Purdue University

Fransheska Semidey
ARGE Graduate Diversity Research Assistantship

Shengyue Shan
Institute of Food Technologists Student Oral Competition - Product Development Division, second place

Senay Simsek
Distinguished Women Scholar, the Purdue University Office of the Provost and the Susan Bulkeley Butler Center for Leadership Excellence

Clay Swackhamer
USDA-NIFA postdoctoral fellowship

Yuan Yao
Showalter Faculty Scholar, Purdue University

Merve Yildirim
Bilsland Dissertation Fellowship

Phi Tau Sigma, Hoosier Chapter President

Phi Tau Sigma, Student Relations Representative

E. Special Events

Whistler Center Short Course, October 4-6, 2022

As is our tradition, the course is designed to provide one day on carbohydrate fundamentals followed by two days of advanced special topic sessions. After holding the course online for two years, we were able to have it in person in 2022. All sessions were recorded so that our members could visit our website to view the recordings. This provides our members an opportunity to attend all offerings. For individuals subscribing to our Educational Package, the Short Course recordings were available for one month.

October 4, 2022

- Introduction to carbohydrates: Basic concepts – monosaccharides, oligosaccharides, and polysaccharides, Y. Yao
- Basic principles of Rheology and viscoelasticity and applications in the world of cereal products, J. Kokini
- Modifications of starch and other polysaccharides, Y. Yao
- Starch granule structure and properties, S. Simsek
- Polyols and high-intensity sweeteners, Y. Yao
- Carbohydrate nutrition and labeling, B. Hamaker

October 5, 2022

- Hydrocolloids and functionality (Parts I & II), J. Keller
- Formulating plant-based semisolid foods, M. Martinez
- Complex carbohydrate structure analysis (non-starch), B. Reuhs
- Starch material properties, L. Mauer
- Metabolism of fibers in the gut microbiome, S. Lindemann
- Dietary polysaccharide and phenolic interactions in gut health, L. Reddivari
- Texturization of plant proteins using different techniques, O. Campanella & O. Ozturk

October 6, 2022

- When polysaccharides and proteins interact and stop behaving as simple solutions, O. Jones
- Polysaccharide architecture and functionality, S. Janaswamy
- Modification of starch for enhancement of functional and nutritional properties, S. Simsek & Y. Yao
- Precision nutrition concept and dietary carbohydrates, B. Hamaker

F. Webinar Series

The Whistler Center webinar series is given six times a year to member companies and others who have purchased our Education Package.

Ganesan Narsimhan
Professor of Food Science, Department of Food Science, Purdue University
Role of macromolecules in emulsion stabilization
January 27, 2022

Jozef Kokini
Professor and Scholle Endowed Chair in Food Processing,
Department of Food Science, Purdue University
Explaining what surface enhanced Raman spectroscopy is and how to use it in Food Science to learn more about foods
March 31, 2022

Osvaldo Campanella
Professor and Carl E. Haas Endowed Chair in Food Industries,
Department of Food Science and Technology, The Ohio State University
New horizons in extrusion technology and applications
June 9, 2022

Eun Joong Oh
Assistant Professor, Department of Food Science, Purdue University
Gut fermentation of dietary carbohydrates
July 13, 2022

Senay Simsek
Department Head and Dean's Chair in Food Science, Purdue University
Nutritional and technological functions of ancient grains
September 14, 2022

Owen Jones
Associate Professor, Department of Food Science, Purdue University
Atomic force microscopy techniques to characterize colloidal and material properties
November 10, 2022

2022 Belfort Lecture

2022 Belfort Lecturer

Les Copeland

Sydney Institute of Agriculture
School of Life and Environmental Sciences
University of Sydney

The Belfort Lectures were established and endowed by Dr. Anne D. Belfort in memory of her late husband, Dr. Alan M. Belfort, who was awarded a PhD from Purdue University in carbohydrate chemistry in 1960. Support for the Belfort Lectures was generously continued by their daughter Anne E. Belfort. Persons honored by being chosen to give a Belfort Lecture are scientists who have made outstanding contributions to glycoscience.

Our 2022 Belfort Lecturer, Dr. Les Copeland, is Emeritus Professor of Agriculture in the University of Sydney. His academic interests are in the areas of agricultural, grain and food science, with special emphasis on the structure-function relationship of food starches. He has published more than 180 research papers and book chapters and has been the primary mentor of 34 PhD students. Dr. Copeland is editor-in-chief of the journals Cereal Chemistry (Wiley) and Agriculture (MDPI), and a director of the Australian Government Cotton Research and Development Corporation. He is a former dean of agriculture. Dr. Copeland has BSc (Hons) and PhD degrees from the University of Sydney and he has held research positions at Yale University, the University of Buffalo, the University of California, Davis, and at the Australian National University. He is a Fulbright Alumnus, the recipient of an Excellence in Teaching Award from the American Association of Cereal Chemists-International (now Cereals & Grains Association) and the FB Guthrie Science Medal of the Australasian Grain Science Association for outstanding scientific achievement and contribution to knowledge in the field of grain science. Dr. Copeland was awarded a Membership of the Order of Australia (AM) in 2019 for significant service to agricultural science as an academic and researcher.

Dr. Copeland is interested in the chemistry and biochemistry of foods and food plants. The main themes of his research are the structure, function and nutritional properties of food starches; the chemistry of food grains; and the effects of growing conditions on grain quality.

WHISTLER CENTER
for Carbohydrate Research

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Food Science