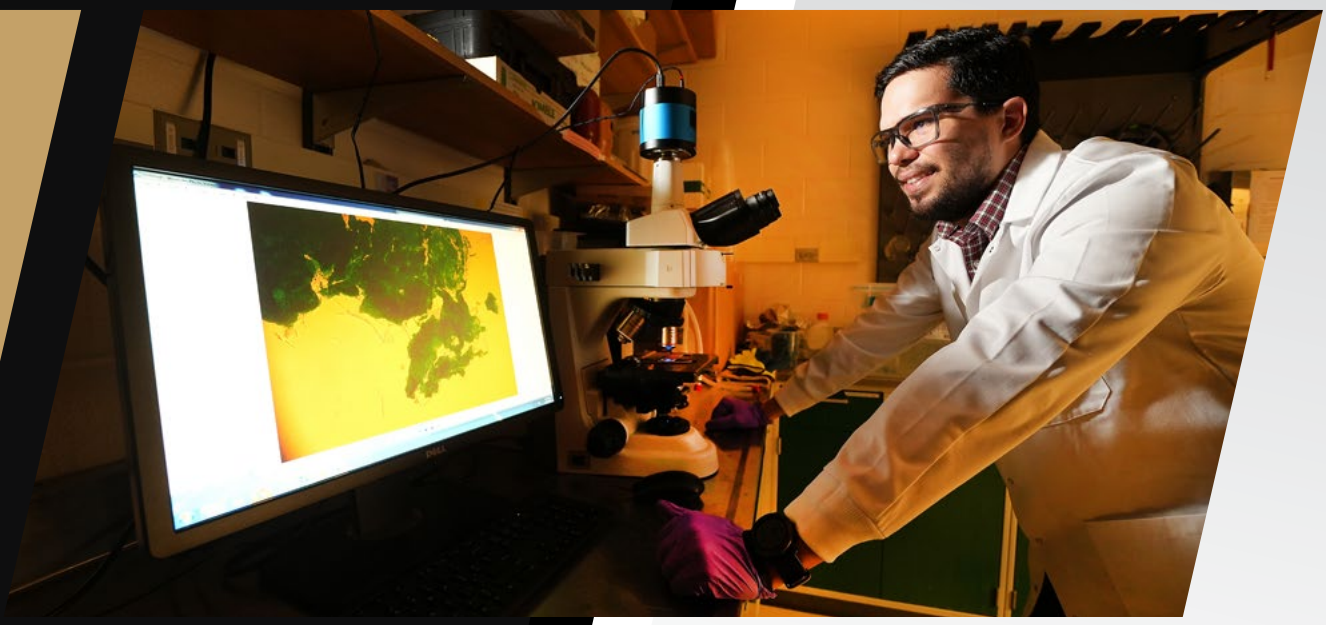
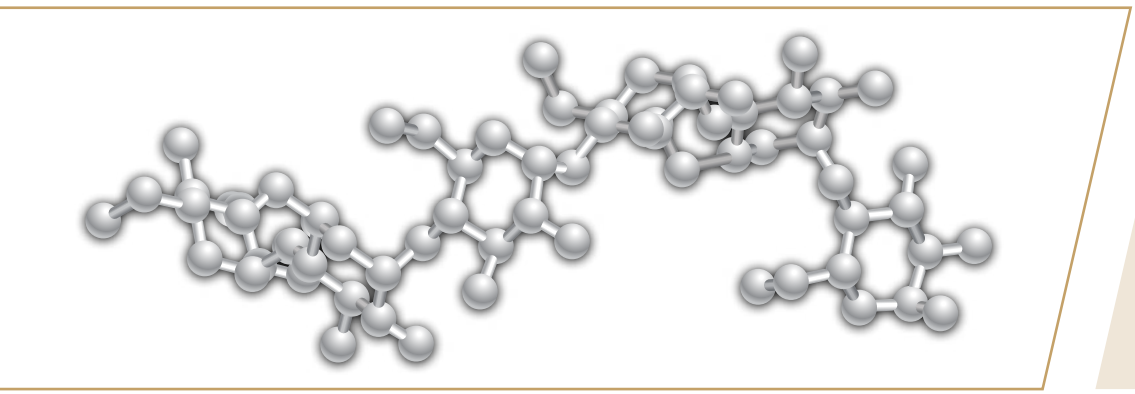
WHISTLER CENTER
for Carbohydrate Research



2023
ANNUAL REPORT

PURDUE UNIVERSITY

Food Science



3-D view of starch structure.

Industrial Members

(Members of 2023 Industrial Advisory Board)

Archer Daniels Midland

Cargill

General Mills

Hayashibara

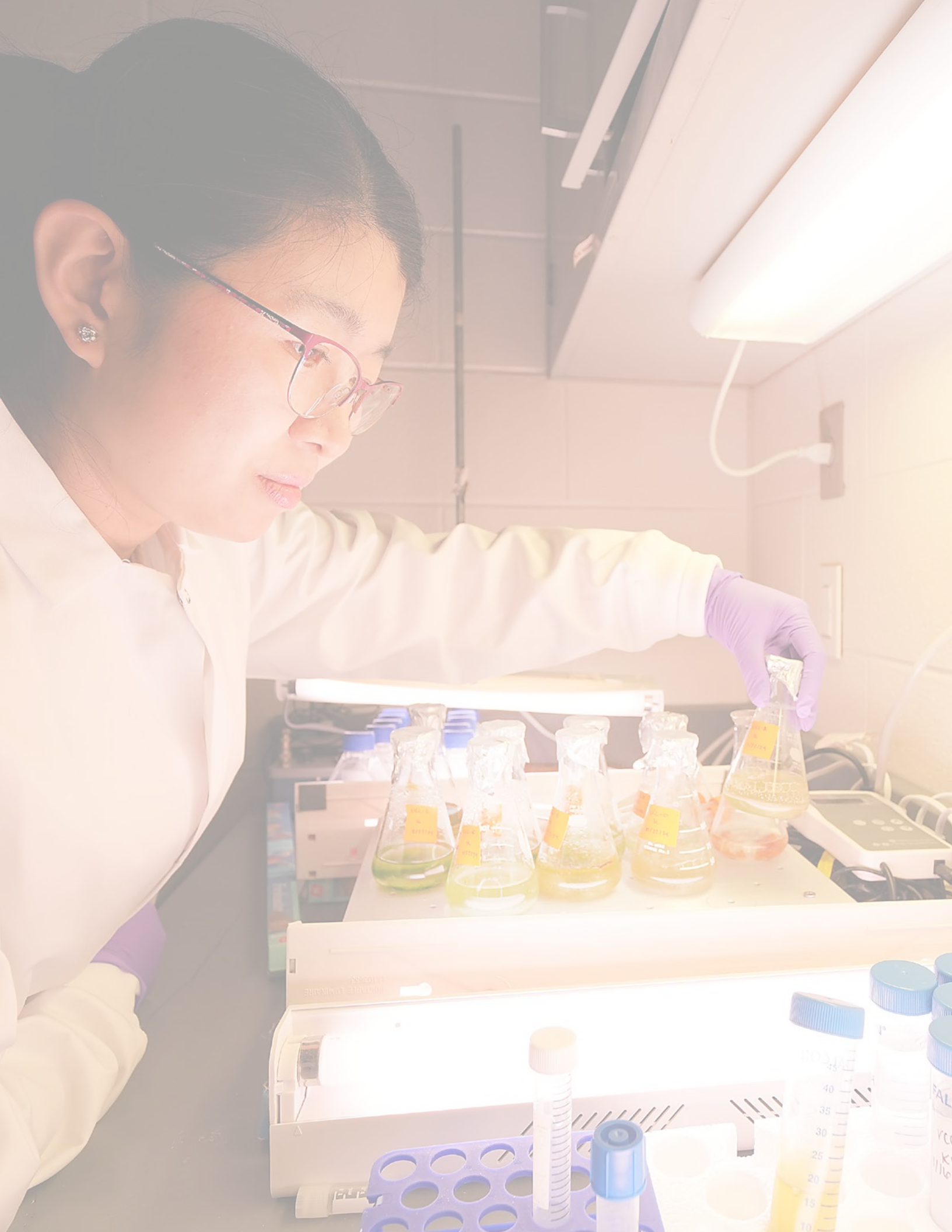
Mars Wrigley

Mondelēz International

Novozymes

PepsiCo

Tate & Lyle



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Director's Statement

Welcome to our 2023 Whistler Center for Carbohydrate Research annual report. As you might know, we are a leading university research center with industry members focused on carbohydrates in foods and for industrial uses. We are a go-to center for research and education that focuses on how polysaccharides, oligosaccharides and sugars behave in foods and the body. I invite you to take a look inside at what we do and have accomplished in the last year.

Science is moving fast, and it's also true in the area of carbohydrates. In this time of consumer concern about food and health and ultra-processed foods, we are at the forefront of understanding the basics of how to improve carbohydrates for health. We now have three laboratories working on prebiotics and have the know-how to select prebiotic fibers for gut and whole-body health. We're working toward optimizing carbohydrate systems for weight management (i.e., GLP-1 elevation) and glycemic control, and we have cutting-edge research happening in sugar reduction/replacement. We have the largest comprehensive carbohydrate-centric faculty to team up on getting the right texture, building molecular assemblies with new functions, and translating basic carbohydrate science to industry. While we've seen, in recent years, numerous changes in consumers' views on carbohydrates, fundamentally new opportunities are coming with the possibility to be translational all the way to consumers.

What do we offer to our industrial members? We provide an education series including a 2½-day carbohydrate short course with new topics introduced each year in the advanced sessions on days 2 and 3, and a webinar series six times per year, where we give not only the latest research findings but also our perspectives of what opportunities may be on the horizon for companies. We have internally funded research projects with member scientists' participation and conduct numerous research projects and analyses for our member companies. And, we're a phone call or web-meeting away for questions, brainstorming and problem-solving with our faculty.

At our May Technical Conference, which follows our annual meeting, we were honored to bring in Professor Christophe Courtin from KU Leuven, Belgium, as our 2023 Belfort Lecturer. In terms of metrics, our 17 faculty members had a terrific year with 102 refereed publications in mostly high-impact journals, 90 presentations at national and international meetings, and graduated 16 MS and PhD students. Our students, postdocs and faculty had numerous recognitions and honors.

I invite you to read through our 2023 Whistler Center annual report, which includes our personnel, starting on page 11, faculty research projects and summaries on page 37, followed by publications, presentations, graduations, awards and a synopsis of our short course and webinars. I also would like to take this opportunity to introduce our new coordinator, Melissa Jones, who joined the Whistler Center at the end of 2023, and announce a new position, Whistler Center Assistant Director, that has graciously been taken by faculty member Owen Jones. The three of us are here to answer any questions you might have.

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)

T. Carvajal's group is dedicated to the detailed examination and utilization of the physical and chemical determinants that govern particle interactions, with a specialized interest in the characterization of particle and powder properties of a diverse array of starch and plant-derived substances, including proteins, fibers, and lipidic compounds. Comprehensive surface characterization frameworks are utilized to acquire deep foundational knowledge on the behavioral patterns of a variety of unprocessed and pristine materials, as well as those that have undergone transformation through innovative processing technologies. The overall goal of the research is to determine the interplay between surface architecture and material functionality, as well as the pivotal connection between processing methods and end-product stability and performance. Recent work includes studies on the relation between surface structuring and powder performance (Project 13) and chemical kinetics models to identify activity of starch enzymes in relation to starch surface structure (Project 14).

M. Martinez's group focuses on translational polymer science, approaching the structure and function of food biopolymers (Projects 36, 38, 39), their binding potential to plant secondary metabolites (Projects 36, 39), the elucidation of their complex structural biochemistry (Projects 36,39), and the fundamental aspects related to the structuring technologies of semi-solid plant-based foods (Project 38). During the last years, his team has also work on the establishment of green chemistry routes to transform polysaccharides into high-performing biomaterials (Project 37), the compatibilization of polysaccharides into high performing bioplastics (Project 40), and the evaluation of the chemical safety of polysaccharide-based bioplastics as food contact packaging materials (Project 40).

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 41).

G. Narsimhan's group is conducting studies on the effect of xanthan on equilibrium swelling of different starches as a function of temperature and moisture 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 42).

Y. Yao's group continued work on the processing and selection of functional biopolymers, including carbohydrate polymers and plant-based proteins. Sponsored by an USDA grant, his group intensively works on plant-based emulsifiers and wall materials for (micro)encapsulation (Project 54, 55). In addition, his group has made exciting progress in plant-based meat alternatives, with a focus on developing natural binders to replace methylcellulose (Project 56). Currently, he is also taking an initiative in the area of circular agriculture, with a focus on connecting crop farming loops and animal farming loops.

Carbohydrates, Nutrition and Health

O. Campanella's group completed several studies related to the encapsulation of compounds prone to oxidation. Some studies were related to the encapsulation of polyunsaturated fatty acids (PUFA) in a matrix formed by crude de-oiled soy lecithin and dextrose conjugated by Maillard reaction with applications in food and feed products (Project 6). Such glycated soy phospholipid complexes are being investigated as a carrier for iron in extrusion processes to increase iron bioavailability in plant-based protein meat analogues (Projects 2B, 7). A similar approach is being used to protect polyunsaturated hemp oil against oxidation, which can disperse liposoluble materials (e.g., vitamin D3). Applications include the preparation of specialized health care creams and cosmetics (Project 8).

T.-W. Cross' group focuses on identifying gut microbiome factors that respond to sex hormones to achieve optimal health, primarily using gnotobiotic mouse models. The group recently published a study showing that the gut microbiome responds to alteration in female sex hormone status and exacerbates metabolic dysfunction. A follow-up study was conducted to identify how neuropeptides modulation in the brain may drive changes in the gut

microbiome. Another project aims at designed the gut microbiome to elicit unique metabolic functions with health disparity to identify differential gut microbial modulation of nutrients, particularly soy isoflavones, on reproductive development (Project 16).

B. Hamaker's group mainly conducts research in the area of food carbohydrates and health, focused on activation of the satiety-inducing gut-brain axis feedback system through ileally-digestible carbohydrates for potential weight management (same system as the new GLP-1 receptor agonist drugs), and dietary fibers and the gut microbiome. On slowly digestible carbohydrates, they are studying in mice the combined action of ileal-digesting starch and fermentable fiber to increase plasma GLP-1 levels (Project 19). In the fiber-microbiome area, they have made progress in developing protocols to match a prebiotic fiber to an existing beneficial, or probiotic-type, bacteria residing in the gut, and even for suppression of pathogenic bacteria (Projects 17, 18). They are also studying potential synergistic effects of mixtures of fibers on the gut microbiota, compared to single fibers (Project 18). Their group also conducts clinical trials on dietary carbohydrates and postprandial and physiological effects (Project 20).

S. Lindemann's research program extended ecological principles by which dietary fiber structure influences microbiome composition and function observed within *in vitro and in vivo* settings, with the goal of elucidating mechanisms by which fibers can be shaped to modulate gut microbiota. To this end, the lab focused this year on bran and bran-derived fibers. Consumption of bran from grains, including arabinoxylans, contributes a significant amount to the dietary flux of polysaccharides in the gut, as well as on simpler oligosaccharides (inulins) as easily modulated structures. This year, his lab demonstrated that native and debranched sorghum arabinoxylan contribute linearly to microbiome composition and function in sequential fermentations (Project 31). They have since expanded their focus to encompass diverse arabinoxylans from different cereal species and genotypes. In (Project 32), the lab observed that bran phenolics liberated may exert impacts on the ecology of fermenting communities, as different species are variable in their inhibition and enhancement of growth using these compounds. Work continues to identify the phenolics liberated, the molecular transformations being performed, and the species involved. In addition, they performed a pilot human trial that reveals habituation in gut microbiome fermentative responses to cereal brans. Further, Project 33 linked inulin chain length and branching to fermenting microbial communities in a way that supports predictive modeling. Such work can be extended to understand microbial competition for inulin and their impact on resilience of human fecal communities using chemical biology and stable isotope labeling approaches. In addition, Project 34 identified a new process for generating oligosaccharide-loaded starches with altered pasting and gelatinization behavior, expanding on Project 35 that aimed to identify mechanisms by which organisms sense cooperators and competitors and divide labor in polysaccharide fermentations.

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. Her research program continues to investigate the role of gut microbiota associated with healthy and disease states in the anti-colitic and anti-inflammatory properties of plant flavonoids (Project 45, 46). Findings demonstrated that the health benefits of anthocyanins and phlobaphenes are dependent on the microbial composition and vary from donor to donor. Improving interactions between polysaccharides and anthocyanins was also shown to improve the stability, colonic bioavailability and bioactivity of anthocyanins (Project 47). In another ongoing Project (48), studies were conducted on the role of Ulcerative colitis-associated gut bacterial dysbiosis on fiber fermentation and tolerance. Dysbiosis resulted in reduced gas production and short-chain fatty acid production. Simple soluble fibers were less tolerated compared to complex fibers. This year we initiated a new Project (49) to investigate the role of plant bioactive compounds, especially fibers, on Vitamin D receptor regulation.

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.

M. Ferruzzi's group has continued to focus on plant bioactive phytochemicals and human health including reporting outcomes on clinical trials with berries on bone outcomes (*American Journal of Clinical Nutrition*) and inflammation (*Nutrients*). In this past year, collaborative work with B. Hamaker was also published on the composition of plant ingredients leveraged in food-to-food fortification *(NFS Journal*), as well as a perspective on entrepreneur-led fortification strategies (*Global Food Security*).

Emerging Food Processes

O. Campanella's group investigates how the efficiency of processing techniques is influenced by food material composition, including protein, polysaccharides, and lipids. This includes a strong focus on utilization of waste streams. In the past year, studies were undertaken on the rheological and microstructural characterization of doughs and frozen doughs and their effects on further processing (Project 1). Several projects determined the effects of processing conditions and formulations on product quality and nutrition of plant proteins-based foods and beverages (Projects 2B, 2C, 2D, 2E, 3). Twin-screw extrusion was used to convert brewer's spent grains and incorporate it into functional fibers for use in snack-foods, which has been extended to the modification of cellulosic and other fibers for animal feed and foods (Projects 4, 5). For valorization of byproducts from the fish, meat, and dairy industries, hydrolysates formed during fermentation processes are being investigated as suitable ingredients for feed and food applications (Projects 9, 10). Process modeling and experimental work, including AI, is also being utilized to study the texturization of proteins and proteins in combination with other food macromolecules (Project 12).

The presence of mycotoxins in foods and feeds is an ongoing global food safety problem still unsolved. Destruction of mycotoxins has been investigated by other researchers but the extension to larger scale processing still is under development. Current work is being done to understand the effects of detoxification agents, such as ozone and UV light, on other properties of foods, as well as the design of suitable treatment using computer modeling and experimental work (Project 11).

T. Carvajal's research team is pioneering the creation of a comprehensive framework for assessing cutting-edge particle production technologies, with a particular focus on their application within the food and nutraceutical industries. Recent research aims to develop a microencapsulation system that utilizes electrostatic spray drying (ESD) to encapsulate hydrophobic natural compounds effectively (Project 18). This system is designed to not only bolster the stability of these substances but also significantly enhance their digestibility and bioavailability. This technology's adaptability will be further explored to gauge its practicality with both existing and novel materials.

B. Hamaker and O. Campanella's groups collaborated on studies related to improving plant-based protein meat and cheese analogues with corn zein and starch, and published three papers in the year (Project 21).

O. Jones' research identifies structures in colloids comprised of proteins and polysaccharides that contribute to useful functions in foods, beverages, or packaging materials. A project funded by the Whistler Center for Carbohydrate Research determined the effects of hydrolytic enzymes and high moisture extrusion on the rheological properties and composition of a pinto bean flour (Project 22). This project, recently concluded, showed that enzymatic hydrolysis of pectin or beta-glucan could occur in the barrel during high-moisture extrusion, increasing soluble fractions and protein solubility of the bean flours. A second project determined the pH conditions for association between high-acyl gellan gum and whey protein isolate in dilute aqueous mixtures, the impact of association on aggregation during heat treatment, and resulting foaming properties after heating (Project 23).

E. J. Oh's group is delving into the fermentation of non-conventional carbon sources using metabolically engineered yeast strains. This approach aims to generate value-added chemicals (Project 43) and alleviate symptoms associated with functional bowel disorders (Project 44). Synergistic fusion of metabolic pathways is central to the success of bioprocessing renewable biomass. When operated under conditions that demand stress tolerance, high productivity, and the generation of a diverse array of target bioproducts, the complexity increases. The group's innovation lies in its ability to integrate pathways that ferment non-glucose sugars with the creation of stress-tolerant, non-conventional microbes through the application of CRISPR/Cas9 genome editing techniques. They have successfully engineered a yeast platform that can concurrently metabolize

non-glucose sugars sourced from lignocellulosic and pectin-based biomass. Furthermore, the team is pioneering the development of novel engineered yeast strains. These strains are specifically designed to selectively remove unwanted carbohydrates during the dough fermentation process, potentially reducing symptoms of irritable bowel syndrome (IBS) and improving gut health for those affected.

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. Recent work was completed on changes in phenolic compounds and antioxidant activity in sourdough bread containing whole wheat or whole rye flour (Project 53). The study showed that the content of bioactive compounds and anti-nutritional factors was impacted by milling conditions, particle sizes, and starter cultures. Another project developed biodegradable food packaging material from corn coproducts (Project 54). Polymeric material was extracted from corn bran and dried distillers' grain to prepare films with good flexibility. Hydrophobicity was enhanced by a chemical-enzyme modification. Work has also been done to valorize hemp and hemp materials. In one study, high dietary fiber plant-based protein ingredients were developed from industrial hemp grain using enzymatic hydrolysis (Project 55). The high fiber hemp protein materials will be utilized in a cold extrusion process to create plant-based meat analogs. In another study, cellulose is being extracted from different varieties of industrial hemp stalk for use in the production of biodegradable superabsorbent material and replacement of commercial cellulose gums, such as carboxymethyl cellulose (Project 56). Thus far, several different varieties have been tested and each variety produces a unique material with different functionality.

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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 polysaccharide

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

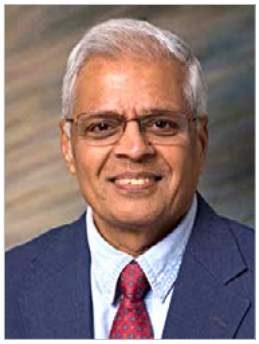
Teresa Carvajal

General Research Areas

- Surface science of materials carbohydrates, more specifically sugars and starches, and other food polymer-like components, fibers and proteins.
- Physical and physico-chemical characterization of relevant materials to food, pharmaceuticals and biological systems
- Food, Pharmaceutical, and Biological Processes

Specific Research Areas

- Exploring and exploiting physical (particle morphology) and surface chemical factors governing particulate interactions
- Relationships between surface-structure and process-performance of food and pharmaceutical powders, composites, films
- Concepts of particle and powder technology
- Assessment of surface particle interactions on powder flow, mixing/de-mixing agglomeration, caking, sintering



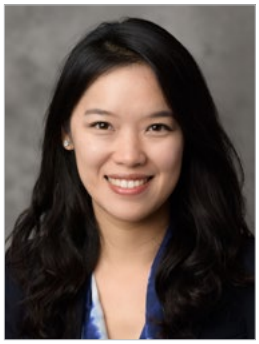
R. Chandrasekaran

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



Tzu-Wen Cross

General Research Areas

- Nutrition and the gut microbiome
- Health and disease with sex biases
- Germ-free and gnotobiotic animal models

Specific Research Areas

- Gut microbial metabolism of dietary compounds with estrogenic potentials
- The interactions between nutrition and the gut microbiome on metabolic dysfunction and fertility
- Gut microbial regulation of sex hormone homeostasis

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
- Organocatalytic (or catalyst-free) derivatization of macromolecules
- Structuring of plant-based foods

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, fibor and interaction
- 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 currently the CEO of GreenChemSolution consulting firm. Leads R&D and formulation services for consumer goods, food, cosmetics, pharmaceutical, and ingredient companies. Specialized consulting services on green chemistry, biodegradable natural polymers, hydrocolloids, surface and interface science, surface modification, and self-cleaning technologies to SMEs and major corporations. He is a co-founder of The Alliance for Research, Innovation, and Education for Africa, a nonprofit organization serving Africa. Before this position Dr. Gizaw was R&D director-principal scientist at Procter and Gamble Co. A technical leader for chemistry transformative platform technologies in corporate R&D. Dr. Gizaw is a 26-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 led technology development for beverages (Sunny D) and Snacks (Pringles), then moved to the Fabric Care Strategic Innovation and Technology division, where he was responsible for development of strategic technologies for cleaning and fabric feel (Downy & Tide), etc. For the last several years Dr. Gizaw has focused his research on the physical chemistry of wetting phenomena to develop disruptive technologies for cleaning and beautifying under resource-constrained environments (water, energy, ingredients). Before joining P&G, Dr. Gizaw received his doctoral degree from Purdue University in synthetic carbohydrate chemistry structure and function.

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

Frederico Barros received his BS degree from Universidade Federal de Vicosa (Brazil), and currently is a professor at the same university. He earned his MS and PhD degrees from Texas A&M University. He joined Dr. Hamaker's group as a visiting professor for his sabbatical year in September 2023. His research is mainly focused on investigating the effects of starch/condensed tannins complexes, phenolic compounds and dietary fibers on intestinal health.

Sung Keun Jung spent his sabbatical year in 2023 in Dr. Hamaker's lab researching the effect of fiber from Korean medical plants on the gut microbiota. He also wrote a perspective article on standardization of prebiotics with attention to industrial needs. Sung Keun is a professor at Kyungpook National University in South Korea.

Visiting Scientists

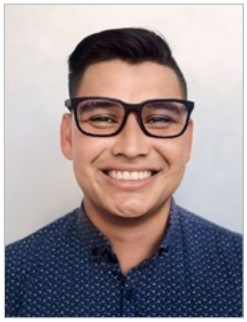
Mariana Guzmán is a visiting scholar in Dr. Lindemann's lab. She joined the team in spring 2023 through the Undergraduate Research Experience Purdue–Colombia Program (UREP-C). She earned her BS in Agroindustrial Production Engineering and Bioproduction Engineering from La Sabana University, Colombia. She is currently assisting with modeling fructooligosaccharide degradation by gut microbial communities. She will start her master's in nutrition science in fall 2024, under the mentorship of Dr. Lindemann, as she extends her research as part of the Interdepartmental Nutrition Graduate Program (INP).

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. Mauer and Hamaker'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.

SeHyeon Jang was a one-year visiting scholar from Kyungpook National University, South Korea, in Dr. Hamaker's lab. As part of her MS studies there, she conducted research on dietary fibers from Korean medicinal plants on structural characterization and response of human gut microbiota.

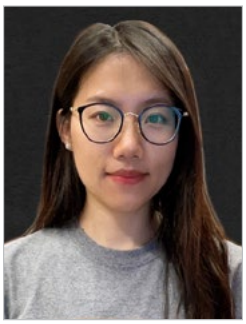
Marcos Leon Bejarano received his BS in Clinical Biologist Chemist from Universidad de Sonora in Mexico, where he completed his master's degree in Biosciences (Biotechnology in Natural Resources) as well. He is a PhD candidate in Materials Sciences at Universidad de Sonora. He joined as a visiting scholar in Dr. Simsek's group in June 2023. His research is focused on the use of plant byproducts as a source of bioactive compounds and their combination with biopolymers for the development of medical materials and functional foods.

Laise Trindade Paes was a visiting scholar for one year in Dr. Hamaker's lab in a sandwich-PhD study program in Food Science and Technology at the Federal University of Viçosa (Brazil), where she previously earned her MS in the same field. Laise's research primarily revolves around exploring the in vitro and in vivo health benefits of toasted sorghum flours, with a particular emphasis on gut health aspects. Throughout her tenure at Purdue, she actively contributed to various projects, using and gaining expertise in animal and clinical studies, and conducted comprehensive fecal fermentation analyses.



Hector Adan Romero Hernandez received his BSc in Biochemical Engineering at the National Technological Institute of Mexico (TecNM). He obtained a MSc in Science in the development of biotic products from the National Polytechnic Institute (IPN) of Mexico, and currently is a PhD student at the same Institute. In 2023 he joined Dr. Hamaker's lab as a visiting scholar for five months (July-November). His research focused on the study of starch-polyphenol complexes, the structure and digestibility of starch.

Ainhao Vicente was a six-month visiting scholar in Dr. Hamaker's lab from the University of Vallolidad, Spain. As a collaboration with her PhD professor, Dr. Ronda, her work focused on changes in starch structure and functionality with acoustic treatments.



Meihui Yu graduated with a 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 a PhD student 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. She is currently working as a lab manager at Jiangnan University. Her field of interest was developing new starch-based food materials as prebiotic fibers.

Graduate Students

Adriana Maribell Aguilar Torres is a PhD student in the Martinez laboratory at Aarhus University (Denmark) since 2021. She holds a MS in Molecular Nutrition and Food Technology from Aarhus University and a BS in Food Science from 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).

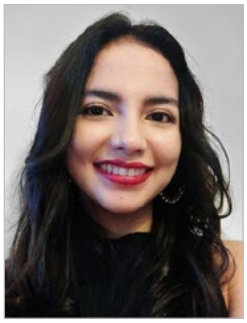
Miguel Alvarez Gonzales is a PhD student in the Lindemann laboratory. Miguel obtained his BS in Food Science and Technology from Zamorano University (Honduras) and his MS degree in Food Science from Purdue University with an emphasis in carbohydrate chemistry. He is currently researching structure and function of carbohydrates, chromatographic techniques, molecular biology techniques, and bioinformatics to characterize wheat bran interactions with the gut microbiome.

Paola Andino is a MS student in the Reddivari laboratory. She completed her BS in Food Science and Technology at Zamorano University (Honduras). She joined Dr. Reddivari's lab as a visiting scholar in 2022 and began her research on fiber. Paola returned to Purdue University as a graduate student in 2023. Her current research focuses on evaluating the role of gut bacterial dysbiosis in fiber fermentation and tolerance.

Sajal Bhattarai is a PhD student in the Lindemann laboratory. He received a BS in Food Technology from Tribhuvan University (Nepal) and a MS in Biological Sciences from South Dakota State University. He completed undergraduate research in water-based edible wood smoke flavors devoid of polycyclic aromatic hydrocarbons and completed his master's thesis on sustainable and strong ligno-cellulosic films as UV-resistant and antioxidant food packaging material. His PhD research is exploring the principle behind the division of labor among the gut microbiota members when fed with sorghum arabinoxylans.

Kasper Brandhøj Skov is a PhD student in the Martinez laboratory. He earned his MS in Chemistry and Biotechnology Engineering from Aarhus University (Denmark) 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.

Nuseybe Bulut is a PhD student in the Hamaker lab. She completed her BS degree in Food Engineering from Istanbul Technical University (Turkey) in 2014. She received her MS in Dr. Hamaker's program in 2019, studying the fabrication of plant cell wall-like materials and their impact on the human gut microbiota. She continues her studies with Dr. Hamaker in the area of dietary fiber and the gut microbiome.



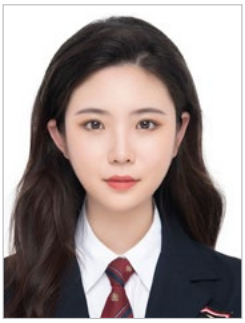
Laura Castellanos Suarez is a PhD student in the Campanella lab. She completed her BS and MS in Chemical Engineering from Universidad Industrial de Santander (Colombia). Currently, she is developing and evaluating an enriched protein ingredient for the food and feed industries. The ingredient is derived from fermenting acid whey waste and mechanically separated poultry using an optimized eREX approach.

Anna Clapp Organski is a PhD student in the Cross lab. She received her BS in Human Nutrition, Foods, and Exercise with a concentration in Dietetics from Virginia Tech in 2018 and joined the Cross lab in 2019. Her research objective is to illuminate the interplay between the gut microbiome and sex hormones homeostasis. The long-term goal of this work is to identify microbial targets for therapeutics, such as pre- and pro-biotics, aimed at treating sex-hormone sensitive diseases.

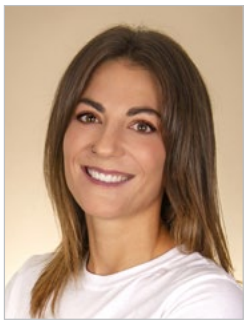
Dila Donmez was a PhD student in the Campanella laboratory until January 2024. She obtained her BS and MS in Chemical Engineering from Middle East Technical University (Turkey). Her MS thesis was on Pickering emulsion production in a stirred tank. Dila's doctoral research studied encapsulation of fish oil within glycated phospholipids, employing both batch processing and reactive-extrusion methods.

Sarah Eckrote is a PhD student in the Reddivari laboratory. She completed her BS in Biology from Purdue University in May 2023. Her undergraduate research focused on blueberry phenolic compound-pathogen interactions in relation to gut barrier integrity in weaning stress of piglets. She joined the Reddivari Lab in August 2023 to pursue a PhD in Food Science concentrating on foods for health. Her current research aims to understand polysaccharide-anthocyanin interactions and their potential use as therapeutic agents in ulcerative colitis and IBD patients.

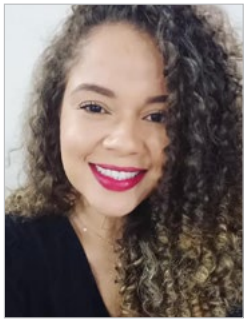
Vidarshani Ellepola is a PhD student in the Campanella laboratory. She earned her BS in Tea Technology and Value Addition from Uva Wellassa University (Sri Lanka) and a MS in Food Science and Technology from the University of Peradeniya (Sri Lanka). After completing her degrees, Vidarshani served as a lecturer in the Department of Export Agriculture at Uva Wellassa University. In 2022, she was awarded the Fulbright master's scholarship to pursue further studies at Ohio State University. Her current research focuses on the encapsulation of vitamin D3 using glycated phospholipids.



Fang Fang is a PhD student in the Martinez laboratory. She received her BS in 2019 and her MS in 2022 from Nanchang University (China), both in Food Science and Technology. Her MS research determined the effect of different thermal processing on the *in vitro* digestion and fermentation characteristic of different whole grains. At Aarhus University, her research 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.



Maria Franco Marcos is a PhD student in the Martinez laboratory. She earned her BS and MS degrees in Biology in 2012 from the University of Leon (Spain), specializing in plant physiology and seed technology. Her research focuses on enhancing nutrition, substituting additives, and improving the physical and technological quality of baked products, with a specific emphasis on addressing the complex phenomenon of bread staling. Maria specially focused on the exploration of the integration of fibers and hydrocolloids, such as psyllium, into wheat dough/bread systems to understand their impact on water and biopolymer dynamics. Currently, she investigates the bioavailability and digestibility of polyphenols, through their incorporation into bakery products. Besides her academic pursuits, she has actively worked in the food industry for 10 years as the general manager of family businesses (La Tahona de Sahagún, Spain), dedicated to artisan bakery and pastry production.



Jaqueline Souza Guedes is a PhD candidate in Food Science and Technology at the University of São Paulo (Brazil) and a visiting scholar in the Campanella laboratory. Her project modifies starches for 3D printing, focusing on the development of foods for people with chewing and swallowing difficulties (dysphagia) and using modifying technologies considered "environmentally friendly." such as dry heating treatments or mixtures with juices and proteins to obtain plant base foods.

Marcello Guerrero is a MS student in the Lindemann laboratory. He obtained his BS in Food Science and Technology at Zamorano University, Honduras. He was a visiting scholar in the laboratory in fall 2022. His research focuses on ecological interactions in the gut microbiome with polysaccharides of different sizes. Additionally, many of the techniques and skills that Marcelo is applying include genetic studies and engineering, to further learn about the specific mechanisms involved in polysaccharide degradation by gut bacteria.

Wanxiang Guo is a PhD student in the Martinez laboratory. She received her BS in Food Science and Engineering from South China Agricultural University in 2018. She got her MS in Food Science and Technology from South China University of Technology in 2021. Her MS research determined the effect of processing on the stability of anti-nutritional factors in soymilk. She is now 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.

Victoria Gutierrez is a MS student in the Lindemann laboratory. She received her BS in Food Science and Technology from Zamorano University (Honduras) and was a visiting scholar at Purdue University in 2023, analyzing the degrading capacity of monocultures on sorghum arabinoxylan. She returned to Dr. Lindemann's laboratory in fall 2023. Her research, supported by National Science Foundation, assesses the division of labor within the gut microbiota synthetic community and their capacity to degrade sorghum arabinoxylan.

Jose Haro is a PhD student in the Reddivari laboratory. He completed his BS in Animal Science and his MS in Animal Production at Universidad Nacional Agraria La Molina (Peru). His prior work included several agriculture projects in nutritional ecology, impact of livestock in climate change, and transformation of native food resources. He joined Dr. Reddivari's lab as a "Bicentenario" Scholarship

Fellow (Peruvian government) 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.

Sune Huus is a MS student in the Martinez laboratory. He received his BS in food technology and application from Business Academy Aarhus (Denmark) in June 2022. He is now studying the food grade fibrillation of starch and the influence of fibrillated polysaccharides on plant-based meats produced from high moisture extrusion.

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

Anael Kimble is currently a PhD student in the Jones laboratory. She received her BS in Food Science from McGill University (Canada) in 2017 and worked in the food industry for a few years. She joined Purdue University in 2021 and recently completed her MS, studying reactive extrusion of bean flour with polysaccharide-specific enzymes.

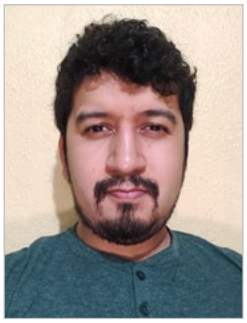
Chih-Chun (Ariel) Kuo is a PhD student in the Campanella laboratory. She received her BS in Nutrition and Health Sciences from Taipei Medical University (Taiwan) and her MS in the Department of Food Science and Human Nutrition at Iowa State University. During her MS, she worked on developing biopolymer-based delivery systems using 3D printing technology for probiotics 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 ingredients from animal byproducts using integrated bioprocessing technologies.

Louie Le was a MS student in the Kokini laboratory. She completed her BS in Food Science at Purdue in 2021. She joined Dr. Kokini's group in 2020 as an undergraduate research assistant and continued her MS research on nonlinear rheological properties of foods and plant-based proteins. She recently defended her thesis.

Dahye Lee is a PhD student in the Oh laboratory. She completed her BS and MS degrees in Food Engineering and Biotechnology from 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. Her current research engineers *Saccharomyces cerevisiae* metabolic pathways and produce value-added chemicals from agricultural and forestry residues.

Chenhai Li is a MS student in the Oh laboratory. He received his BS in Food Science from Purdue University in 2023. His research focuses on discovering unknown metabolic pathways in yeast xylose utilization and applying CRISPR/Cas9-based genome engineering to the acid-tolerant yeast *Issatchenkia orientalis* for enhancing biomass fermentation ability and producing value-added chemicals.

Rosa Lopez is a PhD student in the Hamaker laboratory. She completed her BS in Biotechnology at the 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**.**



Iván Misael López Rodulfo is a PhD student in the Martinez laboratory. 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 studying non-covalent interactions between plant cell walls and compounds of interest, such as flavonoids.

Hector Lozano Perez is a PhD in the Carvajal laboratory. He was an undergraduate visiting scholar in the Department of Agricultural and Biological Engineering at Purdue University in 2015. In 2016, he received his BS in Pharmaceutical Sciences from the Universidad Nacional de Colombia. He gained practical experience as a Quality Assurance Inspector within the pharmaceutical industry in Colombia. He earned his MS in ABE at Purdue University in 2020. His current PhD research focuses on the dynamics of starch particle interactions with enzymes. In addition, he is investigating the flow properties of plant-based proteins, employing advanced surface characterization techniques to gain deeper insights into material behavior. His research approach includes probing the physical, chemical, and surface properties of particles and powder with their role in performance.

Duery Fernando Mayta Apaza is a MS student in the Campanella laboratory. He earned his BS in Food Engineering from Universidad Mayor de San Andres (Bolivia). Prior to joining the lab at Ohio State University, Duery earned experience as a plant manager specializing in cereal storage and processing from 2015 to July 2018. Also in 2020, he obtained a MS degree in Business Administration at the Universidad Privada Boliviana. His current research for his MS degree is centered around enhancing the processability and digestibility and cereal fibers through reactive extrusion for human food and animal feed.

Heather Milliron is an MS student in the Reddivari laboratory. She completed her BS in Food Science and Crop Science from Purdue University in May 2023. Her undergraduate research looked into various efficient methods of phenolic compound extraction from potato peel waste. She worked

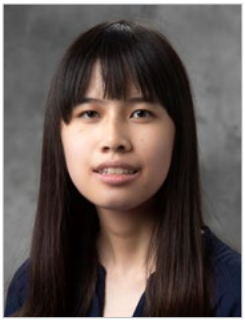
as an intern at Cargill, improving flavor replacement and shelf-life of alternative protein products. Her current research is to understand the effect of various combinations of plant extracts against inflammation.

Edward Moncada is a PhD student working in the Reddivari laboratory. He received his BS in Food Science and Technology from Zamorano University (Honduras). He first came to Purdue as a visiting scholar in 2019 and returned in 2021. His research, supported by Whistler Center-funded projects, focuses on assessing dietary fiber tolerance, the role that gut bacterial dysbiosis plays in fiber metabolism, and the endogenous polyphenol-polysaccharide interactions in starch absorption and fiber fermentation.

Kamrun Nahar is a MS student in the Yao Lab. She received her BEng in Biomedical Engineering from National University of Singapore in 2015. Kamrun spent six years working in the food industry on plant-based food product development, quality, and functionality before joining Dr. Yao's group in 2022. Kamrun's current research focuses on functional plant-based materials for emulsification and (micro)encapsulation.

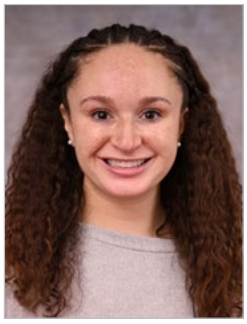
Farzaneh Nasrollahzadeh was a PhD student in the Martinez lab and graduated in 2023. She received her BS in 2013 and MS in 2016 in Food Science and Technology from Ferdowsi University of Mashhad (Iran). She started her PhD in Food Biophysics in 2019 at the University of Guelph (Canada) on structuring of plant-based foods with less refined plant proteins using high moisture extrusion. During her doctoral studies, she visited 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 laboratory. 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 has also worked as an intern at B2S Life Sciences developing a COVID-19 antibody test. He joined Dr. Reddivari's group in August 2021 to research the role various anthocyanins play in improving gut barrier integrity in piglets during early weaning stress.



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

Isaiah Osei Duah Junior is a PhD student in the Cross Lab. He completed his BS in Doctor of Optometry from the Kwame Nkrumah University of Science and Technology (Ghana) in 2021, where he worked to unravel the role of dietary carotenoids on vision and cognition. His current research revolves around understanding how dietary fibers shape the gut microbiome to impact immune and reproductive health.

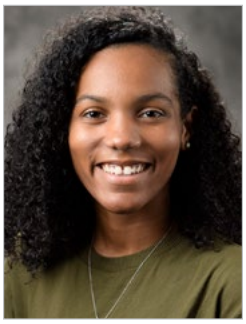


Theresa Parr is a MS student in the Campanella laboratory. She received her BS in Chemistry from Notre Dame College of Ohio in 2022 while playing Division II basketball. She joined Dr. Campanella's group in spring 2023. Her research determines the impact of high moisture extrusion on with the rheological and textural properties of ingredients prepared with alternative plant-based protein sources.

Anurag Pujari is a PhD student in the Lindemann laboratory. He obtained his BS in Industrial Microbiology and his MS in Microbiology from the University of Pune (India). He joined the Diet-Microbiome Interactions Laboratory in 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.

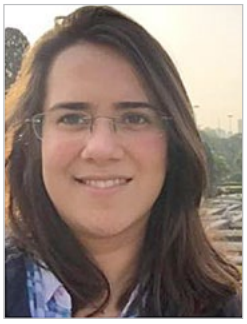
Adam Quinn is a PhD student in the Lindemann laboratory. He received his BS and MS from Brigham Young University. His doctoral research has investigated impacts of wheat genotypes on gut microbiota fermentation within the context of fiber and microbiome interactions. More recently, he has studied the effects of whole grain consumption on the functionality of gut microbiomes in humans.

Rajsri Raghunath is a PhD student in the Lindemann laboratory. She obtained her BS in Food Science from 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, such as dietary habits and gender.



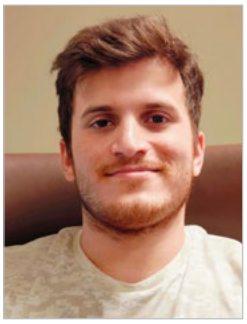
Monica Richmond is a MS student in the Hamaker laboratory. She graduated in 2019 from North Carolina State University, receiving two BS degrees in Food Science and Bioprocessing Science. Currently, Monica is determining the effects of viscosity on the gut microbiome regarding the utilization of dietary 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 laboratory. She earned her BS in microbiology at the University of Maryland, College Park. Currently, her research investigates the influence of bacterial dysbiosis on vitamin metabolism and assesses dietary based interventions in restoring vitamin function.



Shirley Clyde Rupert Brandão is a PhD student in the Campanella laboratory. She received her MS in Chemical and Biochemical Process Engineering at the Federal University of Pernambuco (Brazil). Her MS thesis determined how infrared drying increased the process efficiency by reducing the drying time and affected the quality parameter. In 2022, she joined Dr. Campanella's group where she applies computational fluid dynamics (CFD) to better understand the mass transfer and reaction when ozone gas is applied to prevent mycotoxin production 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.

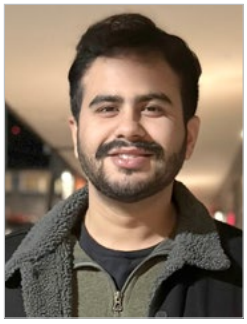


Hrithik Shetty is a PhD student in Campanella lab. He received his B.Tech in Food Engineering and Technology from the Institute of Chemical Technology, India, in 2021 and joined the Campanella lab in the same year. His research focused on developing models for equilibrium water activity and studying water dynamics to estimate the effect of moisture transfer between ingredients on the physical properties (stickiness) of vegetable chip mixes. He is currently working on finite element modelling of HME extruder cooling die, employing phase field and rheological models to optimize the texturization process of plant-based meat analogs.

Chong Teng is a PhD student in the Campanella laboratory. 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. His research in Dr. Campanella's group focused on developing an animal fat tissue analog using plant-based materials and investigating the iron binding capacity of plant proteins modified by enzymatic hydrolysis, as well as the mechanism underlying the protein-iron chelating reaction.

Ankur Upadhyay is a MS student in the Campanella laboratory. He graduated from ICT, Mumbai (India) in 2022 with a BS in Food Engineering and Technology. He joined Dr. Campanella's group in 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 laboratory. She received her BS in Agro-industrial Engineering from Universidad Pontificia Bolivariana (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 the enhancement of flavor and texture of plant-based extruded meat analogues.



Kartik Verma is a PhD student in the Campanella laboratory. He earned his BS in food technology from Panjab University, Chandigarh (India) and his MS in Food Science at The University of Tennessee. His MS thesis developed mathematical models for solid-state microwave ovens, aiming to enhance the uniformity of the microwave heating process. Kartik joined Dr. Campanella's group in fall 2023 where he is developing mathematical models of the extruder cooling die to optimize the texturization process for plant-based meat analogs.

Luping Xu is a PhD student in the Oh laboratory. She received her BS in 2018 and her MS in 2021 in Food Science from Purdue University. She interned at PepsiCo in summer 2020, working on plant-protein application in direct expanded products. Her MS thesis focused on the development of a mammalian cell-based sensor for pathogen detection. She then worked at Acerand Therapeutics as a scientist, focusing on *in vitro* characterization of small molecule drug for targeted cancer therapy. In 2022, she joined Dr. Oh's group to develop bioengineered probiotic yeast strains aiming at reducing enteric pathogen colonization while promoting gut health.

Dan Zhang is a PhD student in the Campanella laboratory. 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.

Pengjun Zhang is a MS student in the Cross laboratory. She received her BS from the Department of Behavioral Health and Nutrition at Purdue University in May 2023. She joined the lab to study sex hormones and the gut microbiome. Her current research focuses on how feeding *Bifidobacterium adolescentis* IVS-1 that readily digests lactose and galactooligosaccharides improves lactose digestion and tolerance through alteration of the microbiome.

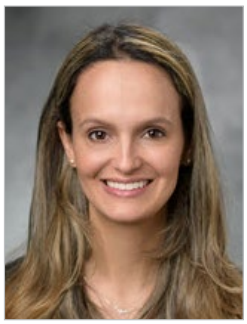
Xinruo "Tina" Zhao is a MS student in the Hamaker laboratory. She received her BS from the Department of Food Science at Purdue University in 2021. She joined the lab to study how fiber influences gut microbiome and *C. difficile* infection.

Rui Zhu is a PhD student in the Mauer laboratory. She received her MS from Purdue University in August 2023. While in the Jones laboratory she determined the effect of associative interactions with gellan gum and heating on the foaming properties of whey proteins. Her current research is on the formation of novel starch granule-sugar inclusion complexes with desirable structure and functional applications in those food products.

PhD Postdoctoral Research Associates

Rwivoo Baruah obtained his PhD from the Indian Institute of Technology, Guwahati, Assam, India. He worked as 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 research focuses on the consumption of exopolysaccharides (EPS) from cyanobacterial communities by gut microbiota, the enzymes involved and their safety studies.

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.



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 research focuses on the alignment of dietary fibers' chemical and physical structure to promote bacterial groups in the gut related to human health. In August, she joined the faculty as a research assistant professor.

Mirian de Campos Costa received her BSc in Nutrition Science from the Universidade Federal de Vicosa (UFV/Brazil), with a collaborative period at Southern Illinois University Carbondale. She then earned her MSc in Nutrition Science and DSc in Food Science and Technology from UFV/Brazil. In 2021, she joined Dr. Hamaker's group for a two-year training period as a visiting scholar as part of her doctorate and, in 2023, became a postdoctoral researcher at the same lab. Mirian has experience with human nutrition, especially clinical trials involving bioactive compounds and slowly digestible carbohydrates. Her research is mainly focused on how those nutrients impact human health regarding their effects on appetite, metabolic markers, and gut microbiota in individuals with or without obesity.

Pablo Gallego-Lobillo obtained his PhD in Food Science and has investigated 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. In Mario Martinez' team, he researches 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, on 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 super-absorbing material for the food industry. Besides that, Laila is working on hemp seed quality assessment for different cultivars to justify its usage in functional food development. Laila is enthusiastic about developing new materials and modifying their structure to tune specific properties while maintaining environmental sustainability.

Peter Jackson earned his BSc in Human Nutrition from Bournemouth University (UK). He earned his MSc in Food Science from the University of Reading (UK). His PhD (University of Reading, UK) focused on exploration of the prebiotic effect of inulin – ranging from the effect of the food matrix on prebiotic efficacy right through to prebiotics effects on the gut-brain axis. He joined Dr Lindemann's lab in July 2023 as a postdoctoral researcher where his work focuses on understanding differences in the rate and extent of change of the gut microbiota between individuals in response to inulin supplementation.

Deokyeol Jung completed two BS degrees in Food Science and Biotechnology and in Mathematics at Kyungpook National University (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.

Oguz Kaan Ozturk received his PhD (2019) in the Food Science and Human Nutrition Department from the University of Illinois at Urbana-Champaign, where his research focused on modeling of water transport in food products during different processes, including drying and cooking. He joined Dr. Hamaker's lab in April 2019 as a postdoctoral research associate and worked on projects related to the structure and functionality of proteins and starches, with his focus being the functionalization of plant-based proteins and their use in the production of alternative products. In August 2023, he joined the faculty of Department of Food Science and Human Nutrition at the University of Illinois an assistant professor of food processing.

Lorena Silva Pinho holds a postdoctoral position at the Campanella Lab, leveraging her extensive academic background in food engineering, including a master's and PhD. Her expertise lies in food ingredient encapsulation utilizing hydrocolloids, complemented by a robust skill set in physicochemical analysis, quality control, food consulting services, and the innovation of food products. Her current research focuses on advancing

the frontier of meat analog development through enzymatic reaction extrusion. Lorena is actively exploring novel components to enhance the texture and nutritional profile of meat analogs. Her work contributes to the scientific understanding of food engineering and holds significant implications for the rising sector of alternative protein sources.

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 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.

Rubesh Raja holds a PhD from the Indian Institute of Science, Bangalore. His expertise spans various areas such as bio-math modeling, therapeutic modeling, systems biology. He joined Dr. Lindemann's group for postdoctoral work in May 2023. His current research focuses on modeling synthetic communities, particularly their growth and competition for consuming polysaccharides like fructo-oligosaccharides, arabinoxylans, and exopolysaccharides.

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 (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.

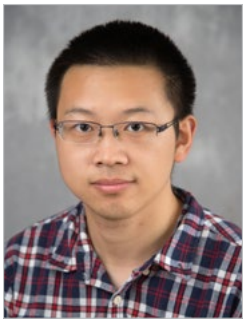
Busra Gultekin Subasi received her PhD in Food Science and Engineering from Istanbul Technical University in Turkey, a collaboration with the Technical University of Denmark in 2021. She worked as a postdoctoral researcher at Chalmers University of Technology, Sweden focusing on a holistic biorefinery approach to plant sources, mainly for protein fractions. She joined Dr. Martinez`s research group in 2023 to investigate food structuring and biophysics through extrusion technology. Her research interests are mainly plant-based and hybrid food structuring, valorization of industrial food byproducts, non-thermal food processing and protein modification, improvement of techno-functional properties of biological macromolecules, using data science and machine learning approaches for data-driven techno-functional properties predictions.

Clay Swackhamer joined Dr. Hamaker's lab as a postdoctoral research associate in August 2022. Clay completed his BS degree in Biological Engineering at Pennsylvania 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 investigated 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, and the use of computational methods in fiber-gut microbiota response.

Pablo Torres-Aguilar was 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. In July 2023, he joined the University of California, San Francisco as a Fogarty-NIH fellow under the mentorship of Dr. Craig Cohen, to conduct field research in western Kenya.

Antonio Vela Corona earned his PhD in Food Science from University of Valladolid (Spain). His research centered in the physical modification of gluten-free flours by ultrasound treatments. In 2023, he joined Dr. Hamaker's group for his postdoctoral work in the USAID-supported Peru-HUB extension project, administered by Dr. Deering in the department. His current research focuses on the development of new food products using locally grown produce in San Martin region (Peru), as well as the impact of fibers found in Peruvian whole foods on the gut microbiome.

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.

Whistler Center Staff

Dane Deemer is project manager for Dr. Lindemann's lab. He is a computational biologist specializing in developing software solutions for diverse biological problems. Dane bridges the gap between life scientists and computer scientists, facilitating the translation of biological challenges into computational tools. He primarily works on command line tools and graphical interfaces, as well as exploratory data analysis to guide further research efforts. He is passionate about using technology to boost research efficiency and create a greater sense of scientific community through the Data Network.

Melissa Jones is the Whistler Center's coordinator; she began this role in October 2023. She received her bachelor's degree in business administration from Midland University. Melissa is enjoying working with graduate students and postdocs. She is looking forward to meeting our members in 2024.

Tanja Kirkeby is a research assistant in the Martinez lab. She earned her MSc in Chemistry and Biotechnology Engineering from Aarhus University in June 2023. In her master's thesis, she studied methylotrophs and the possibility of utilizing metabolic engineering to construct a strain capable of overproducing essential amino acids while being grown solely on inexpensive one-carbon compounds such as methanol. Currently she works on how to enzymatically synthesize structured high-molecular polysaccharides.

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. 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.

Yuxin Wang is a current lead scientist and lab manager of the Lindemann lab. She obtained her PhD from the Institutes for Nutritional Sciences, Chinese Academy of Sciences in 2017. After that, she did her postdoc training at UMass-Amherst and UC-Davis. She focused on the effect and mechanisms of the eicosanoid signaling pathway and the metabolites in colon permeability, and colon diseases. She worked as an assistant project scientist at UC-Davis; there she worked on establishing the cellular system to determine the mechanism of PROTAC small-molecule degraders. Currently, Yuxin plans to set up the in vitro cellular system to determine the effect and mechanisms of microbiome metabolites and pathogens that affect the colon monolayer and the immune system.

Elise Whitley graduated from Purdue University with a degree in Food Science in May 2023. She joined the Simsek lab in June 2023 as a research assistant in the Department of Food Science. Elise studied Spanish and completed her minor after studying for two months in Mallorca, Spain. Previously, she worked on projects concerning the gut microbiome, anti-inflammatory plant bio actives, and effects of polysaccharide fermentation in the colon. She is currently focusing on projects with interests in carbohydrates and their possible functionality in underused crops and their byproducts.

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. 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. Application of Numerical Methods and Complex Rheology in Understanding the Physical Properties of Frozen Bread Dough and Gluten-Free Dough
2. Plant-based Meat Analog Research
   A. Development of a Plant-based Animal Fat Analog Produced by an Emulsion Gel of Alginate and Pea Protein
   B. Characterization of Iron-binding Capacity in Pea Protein Hydrolysates
   C. Prediction of Structural Properties of High-moisture Meat Analogues using Gelling Properties of Pea Protein-pectin Dispersions
   D. Enzymatic Reactive Extrusion (eREX) of Pea Proteins for Improved Sensorial and Nutritional Properties
   E. Lipids and Structure Development in High-moisture Extruded Plant-based Meat Analogs
3. Properties of High Moisture Extruded Ingredient Enriched with Hemp Flour and Fiber
4. Valorization of Brewers' Spent Grains (BSG) by Co-rotating Twin-screw Extrusion
5. Fiber Modification by Reactive Enzymatic Extrusion Focused Animal Feed Applications and the Incorporation of Fibers in Snacks
6. Using Glycation of Lecithin-Sugar to Protect Polyunsaturated Fatty Acids (PUFA) by Utilizing the Maillard Reaction in Reactors and using Reactive Extrusion, with Application to the Food and Feed Industries
7. Iron Fortification using Glycated Soybean Lecithin, Incorporation on Plant Protein-based Foods
8. Encapsulation of Vitamin D3 using Glycated Lecithin Conjugates
9. Valorization of byproducts from the Meat, Fish, and Dairy Industries with Novel Manufacturing Processes
10. Valorization of Byproducts Meat, and Dairy Industries using Fermentation and Novel Manufacturing Processes
11. Development of Processes using Ozone and Pulsed UV for Detoxification and Degradation of Mycotoxins Present in Food
12. Development and Validation of a Multiphysics Model to Characterize the Formation of Protein Fibrils and Optimization of the Texturization of the Plant-based Meat Analogs

Carvajal

13. Potential of Surface Characterization in Developing Formulation and Processing Regimes for Performance and Stability.
14. Explore and Exploit the Effects of Powder Surface Composition on Material Performance, as a Function of Source, Processing and Impact on Enzymatic Hydrolysis
15. Development of Novel Plant-based Formulations using Electrostatic Spray Drying

Cross

16. Gut Microbial Metabolism of Soy on Health and Disease

Hamaker

17. Alignment of Dietary Fibers to Support Beneficial Gut Bacteria
18. Dietary Fiber Mixtures and Design for Effectiveness
19. Slowly Digestible and Resistant Carbohydrates and the Gut-brain Axis
20. Clinical Studies on Dietary Carbohydrates, Postprandial Glycemia, and Physiological Effects
21. Plant-based Proteins and Zein Viscoelasticity

Jones

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

Kokini

24. Applications of Structural Bioinformatics in Understanding Molecular Origins of Pea Protein Gelation and Emulsification
25. Exploration of Creep Ringing Phenomena in Cold Denatured Pea Protein Emulsions with Xanthan Gum
26. Design of Cold Extrusion Processing and Structure-Function Relationships for Pea Protein Functionalization

27. Development of the Sequence of Physical Processes (SPP) Methodologies for the Study of Food Systems in the LAOS and MAOS Regions
28. Development of Relationships Between Protein Secondary Structure and Fundamental LAOS Parameters in Thermoset Protein Gels
29. Mechanistic Understanding of Protein-Protein Interactions in Pulse Flour Bread Doughs
30. Application of Machine Learning Algorithms in Understanding the Development of Color and Gloss in Plant-based Protein Edible Coatings

Lindemann

31. Bran Arabinoxylan Chemical Structure Effects on Fermentation by Gut Microbiota
32. Genotype, Particle Size, and Processing Effects on Wheat Bran Fermentation and Phenolic Biotransformation by Human Gut Microbiota
33. Structure Effects on Competition for Oligosaccharides by Gut Microbiota
34. Oligosaccharide-Starch Interactions Influence on Digestibility and Fermentation
35. Division of Labor in Polysaccharide Degradation

Martinez

36. Understanding the Nature and Implications of the Physical Binding Polyphenols and Dietary Polysaccharides
37. Establishment of Green Chemistry Routes to Enhance the Performance of Polysaccharides
38. Scalable Mimicry of the Myofibrillar Hierarchy using Plant Proteins
39. Novel Biotechnological Route for the Exploitation of Soluble Fibers from Plant Processing Waste
40. Compatibilization of Polysaccharides into High Performing and Chemically Safe Bioplastics

Mauer

41. Effects of Potential Sugar Replacing Small Molecules on Starch Functional Properties

Narsimhan

42. Equilibrium Swelling of Suspension of Starch Granules in the Presence of Xanthan when Subjected to Heating

Oh

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

Reddivari

45. Anti-colitic Activity of Anthocyanins in Humanized IL-10 KO Mice with Bacterial Dysbiosis
46. Role of Anthocyanins in Early Weaning Stress-induced Gut Inflammation
47. Role of Polysaccharide and Polyphenol Interaction in Anti-colitic Effects of Anthocyanins
48. Effect of Fiber Physicochemical Properties and Host-specific Conditions in Fiber Metabolism
49. Food Bioactive Components and Vitamin Receptor Regulation

Simsek

50. Stone Milling Conditions and Starter Culture Source Influence Phytic Acid Content and Antioxidant Activity in Whole-grain Sourdough Bread
51. Enhancing Mechanical Properties and Water Interactions of Arabinoxylan Films from Corn Bran through Enzymatic-chemical Modification
52. Valorization of Hemp Seed Waste for Production of Functional Food Ingredients
53. Extraction of Cellulose from Industrial Hemp for Production of Food Packaging

Yao

54. Preparation of Naturally Occurring, Plant-based Emulsifiers and (Micro) Encapsulation Wall Materials
55. Performance of Plant-based Emulsifiers in Stabilizing Emulsions of Orange Oil
56. Innovative Formulations of Plant-based Meat Alternative

Project Summaries

1 Application of Numerical Methods and Complex Rheology in Understanding the Physical Properties of Frozen Bread Dough and Gluten-Free Dough

P.I.: Osvaldo Campanella

Researcher: Shengyue Shan, PhD student

Objective: The overall objective of this dissertation study was to advance the understanding of protein-starch-water interactions within dough systems using physical methods. This method would be applied for the study of frozen doughs.

Progress: Specific heat smoothing methods were developed and compared in the numerical solution of the heat transfer partial differential equation. Specifically, a solution was found for a freezing process where there is a significant discontinuity in the apparent specific heat near the fusion temperature. The effects of repeated freeze-thaw cycles on yeast-risen and yeast-free frozen bread doughs were investigated by a series of rheological tests. It was found that the detrimental effects of freeze-thaw cycles were more pronounced in the extensional tests for both dough types. The deterioration mechanism of yeast-free bread doughs under different freezing rates and duration of frozen storage were investigated via fundamental rheological methods and microstructural changes evaluated by Fourier transformation infrared spectroscopy and environmental scanning electron microscopy. The interaction between water and starch was altered by the freezing process and frozen storage, which impacted greatly the dough's rheological properties. Whey protein fibrils were incorporated to mimic the fibrous network of gluten. The rheological properties and microstructure of the developed gluten-free doughs were evaluated and compared with gluten doughs by Atomic Force Microscopy. Overall, this research illustrated that the application of numerical methods and complex rheology can provide insights into the rheological changes and their relationships with the interactions among components in dough systems. Results from this research can be used to understand food matrices with similar composition and develop structure-function improvement strategies of food ingredients and processes aimed to preserve the rheological properties of frozen doughs.

2 Plant-based Meat Analog Research

A. Development of a Plant-based Animal Fat Analog Produced by an Emulsion Gel of Alginate and Pea Protein

P.I.: Osvaldo Campanella

Researcher: Chong Teng, PhD student

Collaborator: Da Chen (Purdue University)

Objective: The objective of the project was to develop a plant-based animal fat analog that mimics the slow-rendering effect and the elastic texture of actual animal fat tissues.

Progress: Fat analogs were created using alginate, pea protein, and soybean oil and other fats. Its appearance, microstructure, thermal stability, and molecular structure were evaluated. Formulations were successfully produced without phase separation, containing 15% to 70% lipids. The color of the product resembled the light yellow of actual beef fat trimmings. Microscopic images showed that the pea protein formed an interfacial film around the oil droplets, preventing the gel structure from leaching out at room temperature. Under mild heating, the rate of oil loss from the product was comparable to that of genuine beef fat, demonstrating its potential to mimic the appearance and slow-rendering melting characteristics of real animal fat. The project was completed, and the outcomes were disseminated through publications and a dissertation.

B. Characterization of Iron-binding Capacity in Pea Protein Hydrolysates

P.I.: Osvaldo Campanella

Researcher: Chong Teng, PhD student

Objective: Evaluate the change of iron-binding capacity of pea protein hydrolysates produced with different enzymes and investigate the mechanisms underlying the iron-binding process

Progress: Pea protein isolates were prepared from dry split peas using an isoelectric point-freeze drying method. Alcalase, trypsin, and esperase were employed to enzymatically treat pea proteins. The degree of hydrolysis, molecular weight distribution, and iron-binding capacity of the hydrolysates prepared at various hydrolysis times were

investigated. The results indicated that hydrolysates produced with alcalase exhibited the highest degree of hydrolysis and iron-binding capacity, attributed to the generation of smaller peptides. Moreover, iron was found to induce aggregation of the hydrolysates by diminishing intermolecular electrostatic forces. A manuscript on these findings is currently in preparation. Applications of this research are on iron incorporation on plant protein-based high moisture extrudates.

C. Prediction of Structural Properties of High-moisture Meat Analogues using Gelling Properties of Pea Protein-pectin Dispersions

P.I.: Osvaldo Campanella

Researcher: Dan Zhang, PhD student

Collaborator: Da Chen (Purdue University)

Objectives: This project aims to investigate the effects of addition of low-methoxyl pectin and calcium chloride on the rheological properties and microstructure of pea protein gels. It is hypothesized that by analyzing the relationship between results of the gelling characteristics of extrudates with their microstructure and texture, the number and cost of extrusion tests would be largely reduced, thus improving the cost-effectiveness of meat analogue production.

Progress: The work on the gel systems has been finished, and two related publications, "Pectin as a natural agent for reinforcement of pea protein gel" and "Effect of pH on the gelling properties of pea protein-pectin dispersions" were released in *Carbohydrate Polymers* and *Food Hydrocolloids* in 2022 and 2024, respectively. Another paper titled "Effect of calcium chloride on the gelling properties of pea protein-pectin dispersions" is in preparation. We are still working on the effects of pectin and calcium chloride on the structure of pea protein following high-moisture extrusion. Gelling capacity of these formulations assessed by rheological methods is being used to forecast the structural properties of pea protein-based high-moisture extruded meat analogues enriched with fibers such as pectin.

D. Enzymatic Reactive Extrusion (eREX) of Pea Proteins for Improved Sensorial and Nutritional Properties

P.I.: Osvaldo Campanella

Researchers: Lorena Pinho, MS Student

Collaborator: Da Chen (Purdue University)

Objectives: This research aims to investigate the effect of calcium and enzymes on the gelling properties of pea protein/fiber systems as well as to optimize the enzymatic reaction extrusion parameters to produce plant-based meat analogs with enhanced texturization and protein bioavailability.

Progress: Plant-based meat analogs are popular as sustainable and healthy protein sources. However, there is still a need for improvement in their texture and nutritional values. One potential solution is using the enzymatic reactive extrusion (eREX). This process partially hydrolyzes proteins at high concentrations to improve their physicochemical properties and digestion. In the current research, rheological properties of pea protein/fiber systems are being explored, and the eREX conditions have been optimized for protein content, enzyme-to-protein ratio, temperature, and screw speed to produce whole-muscle-type meat analogs with the best texturization capacity. The texture, microstructure, and protein-protein interactions have been analyzed. The product's nutritional value is also being assessed, including an analysis of the amino acid profile.

E. Lipids and Structure Development in High-moisture Extruded Plant-based Meat Analogs

P.I.: Osvaldo Campanella

Researchers: Ana M. Velásquez-Giraldo, PhD student; Dr. Dennis Heldman, Co-advisor (the Ohio State University)

Objective: This dissertation research aims to establish processing conditions that support acceptable texturization of plant-based extruded meat analog formulations with increased lipid content.

Progress: Conferring meaty texture and flavor to plant-based meat analogs continues to pose technological challenges, as plant proteins tend to carry off-flavors, and lack the tenderness, juiciness, and characteristic structure of animal meat products. High Moisture Extrusion is a technique that can produce plant-based texturized or fibrous food products. The present project explored the addition of lipids and a lipid substitute during HME to enhance the texture of plant-protein meat analogs. Also, the link between the viscoelasticity parameters of the formulations and the texturization performance during pilot-scale extrusion was studied. Furthermore, this project quantified the resulting texturization, both at the micro and macrostructure level, using confocal laser scanning microscopy, surface profilometry, and X-Ray micro-computed tomography coupled with computational image analysis.

3 Properties of a High-moisture Extruded Ingredient Enriched with Hemp Flour and Fiber

P.I.: Osvaldo Campanella

Researcher: Theresa Parr, MS student

Collaborators: Chris Simmons and Rodriguez Saona (the Ohio State University)

Objectives: This thesis research aims to create a plant-based food ingredient from a novel protein source via high-moisture extrusion and examine the textural and sensorial properties.

Progress: High Moisture Extrusion is being used to create texturized food products from plant-based sources derived from byproducts of food and bioprocesses. Presently, the rheological properties (e.g., gelling) were determined for various formulations. One pilot-scale extrusion trial has been conducted. In the future, this project will examine the textural properties as well as the tribological properties of extrudates.

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

P.I.: Osvaldo Campanella

Researcher: Veeramani Karuppuchamy, PhD student

Objectives: This project explores the application of twin-screw extrusion in conversion of brewers' spent grains (BSG) from waste to food ingredient. The specific aim is to increase the amount of BSG in expanded snack applications that results in enrichment of dietary fibers and proteins.

Progress: BSG was first characterized and it was found that there was a disagreement in solvents used to evaluate amount of lipids in BSG with Soxhlet method. As many as 10 different solvents were used for this purpose. However, the lipid extraction can be significantly influenced by solvent selection and extraction time. Optimal yields of BSG lipids were obtained with ethanol extraction for three hours. Fatty acids of extracted lipids are being analyzed by gas chromatography. Spectroscopic techniques are also being investigated as a means to reduce the time taken to estimate BSG composition. Samples of local breweries and national suppliers were used to establish calibration models for near-infrared spectra of lipids and proteins present in BSG. Next steps will focus on the use of these fibers with different composition to produce a variety of high fiber snacks using extrusion expansion.

5 Fiber Modification by Reactive Enzymatic Extrusion Focused Animal Feed Applications and the Incorporation of Fibers in Snacks

P.I.: Osvaldo Campanella

Researcher: Duery Fernando Mayta Apaza, MS student

Collaborator: Rafael-Jimenez Flores (the Ohio State University)

Objectives: The research aims to establish processing conditions and assessment of enzyme suitability to improve digestibility in fibers like corn stover, corn grits and others through reactive and enzymatic extrusion using different approaches developed in biofuels research.

Progress: Reactive enzymatic extrusion of biological material was previously used to enhance digestibility of fibers for applications in animal feed. This enhancement aims to improve overall digestion efficiency, with a specific emphasis on enhancing cellulose digestibility in ruminants. Enzymatic modification by reactive extrusion is also being considered to functionalize other fibers for human food applications.

6 Using Glycation of Lecithin-Sugar to Protect Polyunsaturated Fatty Acids (PUFA) by Utilizing the Maillard Reaction in Reactors and using Reactive Extrusion, with Application to the Food and Feed Industries.

P.I: Osvaldo H. Campanella

Researcher: Dila Donmez, PhD Student

Collaborators: Juan Pablo Russi (One Idea, LLC), Alejandro E. Relling (the Ohio State University)

Objectives: The main goal is to scale up a patented batch process for encapsulation of fish oil within Maillard-reacted lecithin-dextrose matrix to a sustainable reactive extrusion process, ensuring high-throughput production of protected polyunsaturated fatty acids (PUFAs).

Progress: This research aims to improve the production of encapsulated fish oil, specifically focusing on the protection of omega-3 polyunsaturated fatty acids (PUFAs). It addresses challenges in ruminants by developing a rumen bypass lipid and focuses on preventing lipid oxidation

foods. Encapsulation of fish oil was performed using three different approaches: a batch reactor without the application of shear, a high-pressure reactor (simulating extrusion conditions), and an extruder. The impact of process parameters was assessed regarding the oxidative stability and physicochemical properties of fish oil-loaded samples. This study has contributed to the field by advancing our understanding of reactive-extrusion technology and its application in fish oil encapsulation. Our work not only showcases the effectiveness of the Maillard-reacted lecithin-dextrose matrix in preserving fish oil quality but also sets the stage for further innovations in encapsulation efficiency and storage stability. This research has the potential to revolutionize how we approach sustainable and effective methods for preserving sensitive bioactive compounds, making a meaningful impact on the future of food and nutraceutical industries.

7 Iron Fortification using Glycated Soybean Lecithin, Incorporation on Plant Protein-based Foods

P.I.: Osvaldo Campanella

Researcher: Ankur Upadhyay, MS student

Objectives: This research project aims to evaluate the efficacy of lecithin and its Maillard-reacted products in binding iron, and to investigate their impact on the texturization and iron bio-accessibility of iron-fortified plant-based extruded meat analogue formulations.

Progress: This research explores the potential of a novel iron fortification comprising crude soy-lecithin and its Maillard-reacted products with dextrose to affect the texture and bio accessibility through *in-vitro* digestion post-incorporation into extruded plant-based meat analogues. To determine the iron binding ability, a colorimetric ferrozine assay was employed. Furthermore, comprehensive characterization studies on the iron-bound and unbound lecithin and Maillard-reacted lecithin were conducted. Our characterization methods include UV-visible spectroscopy, ATR-FTIR, Hunter Lab colorimetry, zeta potential, and turbidity analysis. Additionally, a texture assessment is being performed using a texture analyzer.

8 Encapsulation of Vitamin D3 using Glycated Lecithin Conjugates

P.I: Osvaldo Campanella

Researcher: Vidarshani Priyanvada Ellepola, MS student

Objectives: The primary objective of this dissertation thesis is to encapsulate vitamin D3 to counteract the oxidation process that occurs during processing and storage, thereby mitigating its degradation.

Progress: Vitamin D3 deficiency is a global concern due to various factors like seasonality, high altitude living, darker skin tones, etc. To address this issue, many regions fortify foods and cosmetic products with vitamin D. However, vitamin D is susceptible to degradation during processing and storage. Therefore, the development of delivery systems capable of mitigating vitamin oxidation is important. The current project explores the potential of developing encapsulates using Maillard reaction-induced glycated lecithin wall material to reduce oxidation. For the study, encapsulation efficiency, amount of encapsulated vitamin D, and other physicochemical parameters are being tested. Furthermore, the study seeks to quantify both primary and secondary oxidative products of the core material, along with early Maillard reaction products, utilizing HPLC MS analysis. Additionally, work is being carried to examine product microstructure through SEM imaging.

9 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 (the Ohio State University)

Collaborators: Rafael Jimenez-Flores (the Ohio State University); Macdonald Wick (the Ohio State University); Da Chen (Purdue University)

Objectives: To advance the utilization of waste and byproducts generated in fermented meat, dairy, and fish products for use in feed and fish pellets.

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. The first objective of this project with blood and acid whey has been completed and a manuscript has been submitted to *Sustainable Food Technology*. Current work has moved to the second objective of this project, which focuses on an alternative method for fish byproducts management using lactic acid bacteria fermentation of fish byproducts to produce fish protein hydrolysate with bioactivities. In the meanwhile, extrusion conditions along with fish byproducts formulation of fish pellets production are in development for one of the objectives of the project.

10 Valorization of Byproducts Meat and Dairy Industries using Fermentation and Novel Manufacturing Processes

P.I.s: Osvaldo Campanella and Rafael Jimenez-Flores (the Ohio State University)

Researcher: Laura J. Castellanos-Suarez, PhD student

Collaborator: McDonald Wick (the Ohio State University)

Objectives: This project aims to convert waste acid whey and MSM byproducts into high-value products with substantial commercial and functional potential for application in the production of food and feed ingredients. Biotechnology-based processes are utilized to valorize meat byproducts and maximize their economic potential by fermenting mixtures of mechanically separated meat (MSM), acid whey, and selected bacterial strains and then extruding the fermented products with bioactive components and enzymes

Progress: The fermentation design was performed with four treatments. Fermentations have already been performed with temperature control, and pH was monitored. Also, the protein hydrolysate molecular weight and hydrolysis profile have been determined with electrophoresis techniques. Some bioactivities have been evaluated (anti-microbiological, antioxidant, and lytic). A literature review has conducted for the extrusion stage.

11 Development of Processes using Ozone and Pulsed UV for Detoxification and Degradation of Mycotoxins Present in Food

P.I.: Osvaldo Campanella

Research: Shirley Clyde Rupert Brandao, PhD student

Objective: The aim is to assess the effectiveness of ultraviolet light (UV-C) irradiation and ozone treatment, in the degradation of Aflatoxin present in soy beverage and Ochratoxin A found in grape juice and to understand the mechanisms of action, optimizing their application for enhanced food safety and quality assurance.

Progress: Literature review has been performed. Initial tests were performed.

12 Development and Validation of a Multiphysics Model to Characterize the Formation of Protein Fibrils and Optimization of the Texturization of the Plant-based Meat Analogs

P.I.: Osvaldo Campanella

Researchers: Kartik Verma, PhD student and Hrithik Shetty, PhD student

Objectives: This project develops mathematical models to simulate the extruder cooling die conditions that favor formation of protein fibrils in the cooling die, avoiding the trial-and-error approach.

Progress: The project is currently in the initial stages of development, having completed an extensive literature review. The researchers are now working on implementing the various physics modules and multi-physics couplings in COMSOL software. This will be followed by developing a constitutive rheological model for the protein melt. Finally, the developed model will be validated by conducting a series of pilot plant trials.

13 Potential of Surface Characterization in Developing Formulation and Processing Regimes for Performance and Stability

P.I.: Teresa Carvajal

Researchers: Ivana Penagos, Sara Perez, Junezuh Ghang

Objectives: To determine how surface characteristics of particles and powders relate to different formulation variables and processing conditions in various environments.

Progress: We are probing surface interactions at the nano- and micro-levels in order to evaluate the effects of different formulation variables and processing conditions on the surface characteristics of powders and related products. This approach will help to develop an understanding of how surface

interactions influence the behavior of materials in various environments, which is critical for product performance. Surface characterization properties of materials will be used to optimize performance for specific applications and to fulfill specific industrial needs, such as improved solubility, dispersion stability, or flowability. There is the potential to offer predictions to prevent stability issues such as agglomeration, sedimentation, or phase separation in products by understanding the interactions at the surface level. Our testing materials are powders for beverages, starches from various sources, and oligosaccharides.

14 Explore and Exploit the Effects of Powder Surface Composition on Material Performance, as a Function of Source, Processing and Impact on Enzymatic Hydrolysis

PI.: Teresa Carvajal

Researchers: Hector Lozano

Collaborator: Mario Martinez (Aarhus University)

Objective: To investigate the connection between the surface chemical composition of starch particles and the kinetic parameters of enzyme reactions.

Progress: The current research endeavor strives to develop a chemical kinetics model that correlates the surface chemical affinity of starch particles with a mechanistic comprehension of enzymatic reactions. Our research focuses on exploring the interaction between alpha-amylase and the starch present in banana cultivars, building upon the foundational work of Mario Martinez regarding gelatinized starch. We aim to analyze the interplay between enzymes and particles within their raw material state. Amylolysis requires the adsorption of enzyme on the starch particles, after which a reaction takes place on the surface of the granules. From the initial rate model of this reaction, insights can be derived that shed light on the chemical readiness of the starch surface for reaction, allowing for a quantitative assessment.

15 Development of Novel Plant-based Formulations using Electrostatic Spray Drying

PI.: Teresa Carvajal

Researcher: TBD

Collaborator: Senay Simsek

Objective: The purpose of this project is to microencapsulate hydrophobic or hydrophilic materials and enhance bioavailability, taste masking, and stability by controlling the applied voltage during electrostatic spray drying (ESD) of microparticles.

Progress: Trials have recently begun on the spray drying process. This is to be followed by the characterization of the resulting physical, surface properties (charge and composition) of dried powders. The following part would be pilot-scale ESD trials, along with collection efficiency, shelf-life stability and performance.

16 Gut Microbial Metabolism of Soy on Health and Disease

PI: Tzu-Wen Cross

Researcher: Lindsay Leonard, MS student; Abigayle Simpson, technician

Objectives: 1) to create a gnotobiotic model that can be used to assess the interpersonal variations of equol-producing capacity from the gut microbiome, 2) validate the equol-production in both male and female gnotobiotic mice, and 3) assess the SCFA production in the cecal content.

Progress: The implications of soy consumption on human health have been a subject of debate, largely due to the mixed evidence regarding its benefits and potential risks. The variability in responses to soy has been partly attributed to differences in the metabolism of soy isoflavones, compounds with structural similarities to estrogen. Approximately one-third of humans possess gut bacteria capable of converting soy isoflavone daidzein into equol, a metabolite produced exclusively by gut microbiota with significant estrogenic potency. In contrast, lab-raised rodents are efficient equol producers, except for those raised germ-free. This discrepancy raises concerns about the applicability of traditional rodent models to humans. Herein, we designed a gnotobiotic mouse model to differentiate between equol producers and non-producers by introducing synthetic bacterial communities with and without the equol-producing capacity into female and male germ-

free mice. These gnotobiotic mice display equol-producing phenotypes consistent with the capacity of the gut microbiota received. Greater short-chain fatty acid productions have been suggested to support the synthesis of equol, likely through increasing hydrogen availability from fermentable substrates to provide electron donors in the bioconversion of daidzein to equol. Therefore, we formulated the mouse diet to contain various fermentable fibers to not only facilitate the colonization of the synthetic bacterial communities but also the synthesis of equol. However, to ensure that the presence of the equol-producing strain will not alter SCFA, which may pose a confounding factor, we have assessed the level of SCFA in the cecal content of these gnotobiotic mice and confirmed that equol-producing phenotype does not alter SCFA productions. Our findings confirm the model's efficacy in mimicking human equol production capacity, offering a promising tool for future studies to explore the relationship between endogenous equol production and health outcomes like cardiometabolic and fertility. This approach aims to refine dietary guidelines by considering individual microbiome differences.

17 Alignment of Dietary Fibers to Support 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 gut resident probiotic bacteria and could have predictable response in a population.

Progress: Our group continued investigations toward understanding how to select dietary fibers that support either specific known beneficial gut bacteria or core bacterial groups. In 2023, we furthered work on selection of an aligned fiber to *Faecalibacterium prausnitzii*, a common anti-inflammatory bacterium that some laboratories are investigating as an oral probiotic. With further modification to a developed protocol for selection, we expanded last year's work to show selective promotion of *F. prausnitzii* in a range of donors using *in vitro* fecal fermentation both by amount (qPCR) and relative abundance (16S rRNA sequencing). This supports the idea that prebiotic fibers can be identified to support gut resident probiotic bacteria.

In related work, sugar beet pectin, which contains esterified ferulic acid, was treated with alkali followed by laccase to form crosslinked matrices. Different treatment conditions showed that a range of physical structures can be made that have differing fecal fermentation effects regarding short-chain fatty acid production and promotion of bacteria. Defined processing techniques may be a future way to obtain targeted fiber fermentation outcomes, such as high butyrate production or support of particular beneficial gut bacteria.

18 Dietary Fiber Mixtures and Design for Effectiveness

P.I.: Bruce Hamaker

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

Collaborators: Ali Keshavarzian (Rush University Medical School, Chicago); 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: Following our work with our partners at Rush Medical School, Chicago, showing improvement in Parkinson's disease-associated biomarkers with our designed fiber mixture to support key gut bacterial groups (Hall et al., *Nature Communications*, 2023), we conducted a comprehensive study on fiber mixtures and how they act on the gut microbiota. Sixteen fibers of different composition were selected based on bacterial groups they might support, and fecal fermentations were carried out showing a range of microbiota effects in terms of bacteria supported and short-chain fatty acids produced. Two mixtures were made containing five fibers each and individual fibers and mixtures were evaluated for response in 10 different donors. Interestingly, certain combinations showed synergistic effect in terms of increasing target beneficial bacterial groups over the sum of the individual fibers, as well as increase in short-chain fatty acids. Suppression of potentially undesirable bacteria, such as in the Proteobacteria phylum, also were enhanced by certain mixtures. These results suggest that science-backed prebiotic fiber mixtures could be more efficacious and targeted than single fiber therapies.

X. Zhao finished her MS studies on the potential use of dietary fibers to suppress the growth of *Clostridium difficile* using an *in vitro* fecal fermentation experimental design. We collaborated with A. Keshavazian at Rush Medical School and showed a promising approach to controlling *C. difficile* blooms following antibiotic treatment, which is a pressing problem in hospital environments.

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

P.I.: Bruce Hamaker

Researchers: Rosa Lopez, PhD student; Jongbin Lim, visiting scientist

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

Progress: We have continued our past animal research showing slowly carbohydrates with digestion in the small intestine ileum increase plasma GLP-1, communicate with the brain appetite control center through changes in gene expression of appetite stimulating and suppressing neuropeptides, and decrease food intake affecting weight gain (on an obesogenic diet) or loss (on a weight-reducing diet). In this year, R. Lopez conducted an animal study to understand the relative contributions and potential additive effect of ileal-digesting carbohydrates and fermentable dietary fiber on appetite-regulating gut hormones. While fermentable fiber clearly increased plasma GLP-1, the ileal-digesting carbohydrate effect was less clear in this experiment. We are following up this work with further research directed at maximizing appetite-controlling gut hormones from dietary carbohydrate triggers.

20 Clinical Studies on Dietary Carbohydrates, Postprandial Glycemia, and Physiological Effects

P.I.: Bruce Hamaker

Researchers: Mirian Costa, Postdoc; Rosa Lopez, PhD student; Laise Trindade Paes, Visiting Scholar

Objective: To test carbohydrate-based material approaches to improve postprandial glycemia, appetite, gut microbiome responses.

Progress: We conduct human studies on dietary carbohydrates through use of the Clinical Research Center facility at Purdue University and have over the last decade published a number of clinical nutrition articles based on our work. In 2023, we conducted a contract research clinical trial for an industry partner as an ongoing service to academic and industry partners.

21 Plant-based Proteins and Zein Viscoelasticity

P.I.s: Bruce Hamaker and Osvaldo Campanella

Researchers: Oguz Ozturk, Postdoc

Objective: To understand viscoelasticity of corn zein networks and improvement of texture of meat and cheese analogues.

Progress: In the last year of two funded projects on corn zein viscoelasticity, we published two articles in *Food Hydrocolloids* (Ozturk et al., 2023; Salgado et al., 2023) showing potential to used isolated zein as a cohesive and viscoelastic agent for plant-based protein food analogues made from pea and soy proteins. Formulations were made to match textural properties of commercial meat and cheese products, with texture profiles nearly matching that of the products themselves. A review paper was also published in Future Foods (Ozturk and Hamaker, 2023) on texturization of plant protein-based meat alternatives.

22 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: Pinto bean flours were extruded at high and low moisture contents along with pectinase- or beta-glucanase-rich enzyme mixtures to identify improvements in aqueous solubility, protein solubility, and viscoelasticity of pastes with 30% moisture content. Extrusion with both enzymes at 40% moisture content led to the greatest change in aqueous solubility of the extruded flour and the greatest change in protein solubility. Treatment with

beta-glucanase increased viscoelasticity of pastes to a greater extent in some treatments, whereas pectinase preparations generally had more impact on solubility of components. High-moisture extrusion trials of meat analogue formulations were performed using a blend of wheat gluten, soy protein, and bean flours to identify the ability of bean flour to partially or wholly replace soy protein. Surprisingly, bean flour provided comparable anisotropic index from cutting tests and a similar consistency in meat analogues when replacing soy protein, regardless of whether enzymes were included. Meat analogue trials then indicated that the particular extrusion conditions and bean flour provided good functionality in gluten-based meat analogues, although the enzymatic treatments were not ultimately useful in this application. The researcher on this project completed her master's degree and has since been compiling the study into a manuscript.

23 Associative Complexes of Dairy Proteins and Gellan Gum

P.I.: Owen 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 associations with whey protein isolate in dilute aqueous mixtures were identified between pH 7 and 2, with soluble complexes forming just above pH 6 and phase-separating complexes forming below pH 5.5. Heat treatment of co-soluble mixtures, soluble complexes, and phase-separating complexes led to protein aggregates on length scales of nanometers to a few micrometers; gellan gum reduced the size of aggregates and was identified as attached to the aggregate structures when formed from heated complexes. Protein aggregates had good foaming properties, and both overrun and foam stability were improved when protein was heated with greater quantities of gellan gum at pH 5. Atomic force microscopy of isolated foam layers showed protein aggregates with adhered gellan gum were present at the foam interfaces and potentially responsible for improved foaming. This work was submitted for publication. Since graduation, the student has begun a new research project in Dr. Mauer's laboratory, staying in the Whistler Center for Carbohydrate Research.

24 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

Objectives: 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.

25 Exploration of Creep Ringing Phenomena in Cold Denatured Pea Protein Emulsions with Xanthan Gum

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 that occurs 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 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.

26 Design of Cold Extrusion Processing and Structure-Function Relationships for Pea Protein Functionalization

P.I.: Jozef Kokini

Researchers: 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.

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

P.I.: Jozef Kokini

Researchers: 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.

28 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.

29 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.

30 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 towards 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.

31 Bran Arabinoxylan Chemical Structure Effects on Fermentation by Gut Microbiota

P.I.: Steve Lindemann

Researchers: Tianming Yao, Postdoc; Anurag Pujari, PhD student; Rajsri Raghunath, PhD student

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

Progress: T. Yao extended on his previous experiments that revealed substantially different targeting of enzymatically debranched (arabinofuranosidase-treated) white sorghum

arabinoxylan (SAX) compared with the native structure by performing sequential fermentations in which the native and debranched SAX were mixed. Interestingly, his experiments revealed that the abundances of microbiota generally relate linearly to the relative loading of each polysaccharide. This same affect generally also related to metabolic outputs of fermentations as well. Metagenome-assembled genomes are now being generated to determine whether the members of these communities differ in their functional potential. A. Pujari continued his experiments to generate a high-throughput cloning and screening system to identify extracellular glycoside hydrolases (specifically, arabinofuranosidases) that are functional against particular arabinoxylan (AX) structures using enabled growth as an endpoint, beginning by expressing a single proof-of-concept GH43 putative arabinofuranosidase from *B. cellulosilyticus*. R. Raghunath began a new experiment to determine how different AX structures across cereals differentially select for microbial communities; her goal is to test large panels of AXs from different cereal species, classes, and genotypes against the same human microbial inocula to identify the structural features that drive selection for different microbial species and metabolic outputs.

32 Genotype, Particle Size, and Processing Effects on Wheat Bran Fermentation and Phenolic Biotransformation by Human Gut Microbiota

P.I.: Steve Lindemann

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

Collaborators: Bruce Hamaker, Lavanya Reddivari

Objectives: 1) Determine the degree to which microbial fermentation of a bran particle depends upon its size and the milling methods used to generate it, 2) identify mechanisms driving differential microbial compositional and metabolic responses to bran particles varying in physical structure, and 3) identify microbial mechanisms of bran phenolic biotransformation and its impact on ecology of fermenting communities.

Progress: This year, M. Alvarez extended on his observations that milling methods differentially liberate bran polyphenols and that metabolism of those polyphenols is differential across particle sizes of brans. Working with an undergraduate student, Youssef Errihani, Miguel identified that wheat bran phenolics exerts selective growth benefits on specific strains, while generally being inhibitory to others. The concentrations of bran phenolics that display toxicity vary among microbial species and strains, suggesting these molecules may impart growth benefits to some community members and hinder others. Finally, growth enhancements on bran phenolics suggest either microbial utilization as a substrate or as an electron sink. Experiments are ongoing to determine which organisms are involved in these biotransformations and what mechanisms they employ. Additionally, A. Quinn performed a pilot human intervention crossover experiment with wheat and sorghum brans to determine whether dietary habituation with these fibers would improve *in vitro* fermentation of these substrates. Although there is variability among subjects, taken together the data suggest that habituation is impactful on the output rates of fermentations, though the effect seems to have some cross-activity across both cereal brans. These data are now being used by Adam to generate a prototype functional microbiome biosensor to measure gut microbiome fermentative performance and identify human gut microbiomes that are deficient in fermentation activities.

33 Structure Effects on Competition for Oligosaccharides by Gut Microbiota

P.I.: Steve Lindemann

Researchers: Anurag Pujari, PhD student; Rubesh Raja, Postdoc; Marcelo Guerrero, MS student; Mariana Guzmán, Visiting Scholar; P. Jackson, Postdoc; Y. Wang, Staff scientist

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: We extended our previous experiments on inulin chain length to generate mathematical models for growth and competition for oligosaccharides based upon their structures. Extending on observations that inulin chain length causes cross-subject alterations in microbiome structure and metabolism, we attempted to understand competitive interactions among three species selected at the end of fermentations, *Klebsiella pneumoniae* OTU1, *Escherichia coli* OTU3, and *Bifidobacterium dentium* OTU6. M. Guzmán identified growth parameters

for these individual bacteria, which were used by R. Raja to construct a multi-species cybernetic model predicting competition amongst organisms for different chain lengths. M. Guerrero continued to develop a labeling strategy to permit easy quantification of head-to-head competition among strains, as well as using evolutionary strategies to identify which mutations are advantageous for consuming higher DP inulins. A. Pujari continues to develop a kestose-based activity-based probe for chemical biology analyses in collaboration with Dr. Aaron Wright at Baylor University. P. Jackson began two new lines of experimentation: 1) developing an apparatus for ^{13}C labeling of plant biomass (beginning with inulins) and 2) using inulins to measure the resilience of the human gut microbiota to a defined dietary perturbation. Y. Wang joined in 2023, and has developed polarized Caco-2 and HT-29 monolayers that display active partitioning of microbial metabolites, such as short-chain fatty acids.

34 Oligosaccharide-Starch Interactions Influence on Digestibility and Fermentation

P.I.: Steve Lindemann

Researchers: Paige Smith, MS student; Tianming Yao, Postdoc

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: This year, we finished the study to determine the structural basis of oligosaccharide interactions with diverse starch types. P. Smith performed extensive experiments to identify both which oligosaccharides exerted the strongest impact on starch gelatinization and pasting behavior and determined what temperatures and concentrations were most beneficial to alteration of starch properties. These experiments generated a protocol that reproducibly produces an OS-loaded starch type with altered properties. This process is under consideration for patenting. Initial trials on digestibility did not appear to result in any differences compared with unloaded starches, but experiments are ongoing to determine whether OS can alter rate or fate of enzymatic digestion. If so, we still plan to investigate using L-cells and gut microbes to determine whether there are alterations in function.

35 Division of Labor in Polysaccharide Degradation

P.I.: Steve Lindemann

Researchers: Tianming Yao, Postdoc; Sajal Bhattarai, PhD student; Victoria Gutierrez, MS student; Rubesh Raja, Postdoc; Rwivoo Baruah, Postdoc

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: We continued this 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 cyanobacterial biofilms. Concurrently, we have isolated 23 members from SAX-degrading communities to generate combinatorial synthetic communities to investigate rate and extent of polymer degradation. S. Bhattarai and V. Gutierrez are measuring growth performance on SAX and its component sugars to generate metabolic community models, in collaboration with Hyun-Seob Song at University of Nebraska-Lincoln. Victoria demonstrated that a synthetic consortium containing all members degrades SAX with very high reproducibility and stability, in contrast to sole members. R. Raja built an algorithm for automatic interpretation of mass spectra in linkage analyses and constructed a draft model for polysaccharide fermentation in which structures can be alternately represented. R. Baruah developed extraction techniques for cyanobacterial biofilms and tested their fermentability as well as generated a new protocol for enzymatic synthesis of polysaccharides varying in molecular weight. Though the tested cyanobacterial polysaccharides did not ferment well in interaction with gut microbiota, the viscogenic and thermostability properties make this a potentially useful industrial polysaccharide.

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

P.I.: Mario Martinez

Researchers: Julia Bechtner, Postdoc; Pablo Gallego-Lobillo, Postdoc; Ivan Lopez, PhD student; Fang Fang, PhD student; Adriana Maribel Aguilar-Torres, PhD student; Maria Franco, PhD 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 between 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 LC-ESI-QTOF-MS/MS. In the first part of the project (Lopez-Rodulfo, et al. 2024), structure-dependent partitioning and bioaccessibility of polyphenols at individual polyphenol and subclass level was investigated by performing an untargeted screening for the semi-quantification of polyphenols. Coupling the upper gastrointestinal tract Infogest 2.0 model to centrifugal sedimentation/filtration and UHPLC-ESI-QTOF-MS/MS analysis provided a more accurate semi-quantification of polyphenol bioaccessibility. Cold pressing of apples (as a model system), typical process to fabricate apple juice, revealed three clusters of polyphenols, explained by subclass-level structures and their location within the whole apple tissue. Pomace emerged as a substantial reservoir of polyphenols that strongly interacted with plant cell walls during oro-gastric digestion, but polyphenol structure-based bioaccessibility clusters were only observed in in apple, not in pomace. Results highlighted the importance of the PCW supramolecular structure at overrunning the effects of polyphenol chemical make-up on non-covalent binding and bioaccesibility.

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

P.I.s: Mario 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 harnessing 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. The second approach of this project resulted in an efficient and sustainable, starch esterification with acetic anhydride (AA) and the optimization of the process avoiding initiators in terms of molar ratios, time, and temperature (Portillo-Perez, et al. 2024). Different combinations of choline chloride (ChCl) with several hydrogen bond acceptors (urea, tartaric, malonic, and malic acids) were used as both chaotropic solvents and reaction promoters for starch acetylation. The reaction system comprising 1:1 molar ChCl:Urea and AA showed good miscibility at 100°C after 30 min, representing a seemingly homogeneous reaction system while better preserving starch molar mass. Side products emerging from solvent-reagent interactions, such as starch carbamate and acetylurea, were identified by CP/MAS 13C-NMR, 2D HSQC and 2D HMBC. Reaction optimization resulted in no side products, fast reaction rates (36 min), high DS (2.87) and starch loads (20 wt%), and increased reaction throughput and atom economy.

38 Scalable Mimicry of the Myofibrillar Hierarchy using Plant Proteins

P.I.: Mario Martinez

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

Collaborators: Niki Alexi (Aarhus University); Konstantina Sfyra (Aarhus University)

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: The first part aimed to understand the effect of protein isolation technologies (fractionation) on the compositional, colloidal and nutritional properties of the protein fractions from a risk resilient protein source (hemp) (Nasrollahzadeh, et al. 2022). The second part aimed to evaluate potential principles leading to anisotropy during high moisture extrusion using less-refined protein fractions (Nasrollahzadeh, et al. 2023). Results of these studies indicated that the food structuring of plant protein fractions during thermomechanical processing is related to both molecular and colloidal mechanisms acting in concert and involving proteins, polysaccharides, and multivalent ions. Although the specimens possessed unique and promising textures that were obtained without the need of using ultra-pure plant protein, the Warner-Bratzler force of our developed prototypes, common textural parameters inversely correlated with the tenderness of meats, was still lower than those from animal meats. Thus, the third part focused on investigating the potential of multifunctional protein fillers and the combination of top down (extrusion) and bottom-up (fibrillation) approaches to close the tenderness gap between animal meat and plant-based foods (Nasrollahzadeh, et al. 2023). The last part of the first project investigated the extent to which instrumental parameters of plant-based meat texture relate to sensory texture and mouthfeel attributes, giving insights to actual perception (Nasrollahzadeh, Alexi, et al. 2024). A holistic evaluation of plant-based meat analogues (PBMAs) with meat benchmarks revealed significant correlations ($p < 0.05$) between instrumental texture (WBSF, TS) and water distribution (WD) and sensory texture and mouthfeel attributes. Specifically, Warner-Bratzler Shear Force (WBSF) and tensile strength (TS) were linked to perceived hardness, compactness, chewiness and mouthcoating, whereas WD parameters measured by low-field NMR were linked to mouthfeel attributes, such as perceived undissolved particles, mouthdrying, mouthwatering and mouthcoating. We will now further work on combining novel approaches to remove the textural shortcomings of plant-based foods thanks to the Novo Nordisk Foundation.

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

P.I.s: Julia Bechtner, Mario Martinez

Researchers: Julia Bechtner, Postdoc; Tanja Kirkeby, Research Assistant

Collaborators: Clarissa Schwab (Aarhus University)

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.

40 Compatibilization of Polysaccharides into High Performing and Chemically Safe Bioplastics

P.I.s: Mario Martinez

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

Collaborators: Emmanouil D Tsochatzis (EFSA), Georgios Theodoridis (Aristotle University of Thessaloniki)

Objectives: The overall aim of this project is to stablish the structure-function relationships and compatibilization principles of heterogeneous polysaccharide mixtures to develop high-performance and fully biodegradable packaging materials.

Progress: The first part of this project showed that pectin is definitively a promising naturally occurring biopolymer that could be used in the development of bioplastics. The developed starch-pectin films showed comparable mechanical strength and stiffness to

some high-performance petroleum-based plastics, such as conventional oil-based PP and HDPE films. Nevertheless, our results showed that the choice of an appropriate pectin structure could not be overlooked, depending on the final application, or the performance that needs to be improved (Bai, et al. 2023). Then, we investigated how thermomechanical mixing our developed organocatalytic acetylated starch with matrix polysaccharides could influence the preparation and performance of hot-pressed blend films (Bai, et al. 2024). Results also showed that careful selection of the matrix polymer is essential, because less compatibilization and interfacial adhesion with the hydrophilic matrix polymer may negate the advantages of fewer available hydroxyl groups. For instance, sugar beet pectin showed higher miscibility and compatibility with acetylated starch in the hot-pressed films, especially with highly acetylated starch, than citrus peel pectins and NPS (ATR-FTIR imaging). Lastly, we aimed at identifying semi-volatile or non-volatile components that migrate from polysaccharide-based food contact materials (FCM) by performing a compliance migration testing using official food simulants representing foods that have hydrophilic or lipophilic character, followed by an untargeted screening of semi- and non-volatile compounds using ultra-high-performance liquid chromatography trapped Ion Mobility Spectrometry time-of-flight mass spectrometer (UHPLC-TIMS-TOF–MS/MS). To do so, representative polysaccharide films were tested, including films from pure pea starch, combinations of pea starch, organocatalytic acetylated pea starch fabricated in our laboratory, and pectin. Results from this study showed that the low number of compounds migrating from polysaccharide-based biopolymers do not entail a significant risk for human health, enhancing the future potential of polysaccharides, including those subjected to organocatalytic acetylation, to fabricate food contact packaging materials (Tsochatzis, et al. 2023).

41 Effects of Potential Sugar Replacing 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

42 Equilibrium Swelling of Suspension of Starch Granules in the Presence of Xanthan when Subjected to Heating

P.I.: Ganesan Narsimhan

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

Collaborator: Owen Jones

Objective: To characterize the effect of xanthan gum on equilibrium swelling behavior of starch suspensions when subjected to heating.

Progress: Starch is a biopolymer that is extensively used in many food formulations and non-food applications such as paper and pulp, pharmaceuticals, paints etc. It is important to understand the swelling behavior of starch granules when heated above the gelatinization temperature since it influences the viscoelastic properties and flow behavior of resulting starch paste. Xanthan gum is a commonly employed polysaccharide in many applications as a thickener to control the swelling and pasting behavior of starch. Previously developed model for starch swelling (Desam et. al., *Journal of Food Engineering*, 2018, 222, 237-249) that is based on Flory's polymer theory has been extended for the prediction of equilibrium swelling of starch granules in the presence of xanthan. The model assumes that starch granules are impervious to xanthan and considers the effect of osmotic pressure of xanthan on starch swelling. It also accounts for the depletion forces between highly swollen granule due to exclusion of xanthan in thin film between granules. For very dilute starch suspensions, depletion forces are not important and starch swelling is found to be smaller as a result of osmotic pressure that opposes swelling at higher xanthan concentrations. At higher starch concentrations, however, depletion forces predominate at higher extents of starch swelling

and lower xanthan concentrations thereby resulting in exclusion of xanthan in thin film. As a result, there is little reduction in starch swelling. At higher concentrations, however, swelling is reduced because of osmotic pressure and partial xanthan exclusion between granules. Model predictions of equilibrium swelling of normal maize starch at different xanthan concentrations agreed well with experimental data at starch weight percent of 0.1 and 1.0. At higher starch weight percent of 2 and 5, the model overpredicted equilibrium swelling at low xanthan concentrations though the agreement was found to be better at higher concentrations. At much higher starch weight percent of 8, according to the model, the system could not attain chemical equilibrium. These discrepancies can be attributed to overprediction of depletion attractive force since the current model did not account for favorable xanthan-water enthalpic interactions. This can also be attributed to a distribution of depletion forces resulting from (i) molecular weight distribution of xanthan and (ii) granule size distribution both of which were not considered.

43 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: Essential genes for the metabolic pathways of xylose, L-arabinose, and D-galacturonic acid were amplified from other microorganisms (*Pichia stipitis*, *Ambrosiozyma monospora*, *Aspergillus niger*, and *Trichoderma reesei*) through PCR. The expression cassettes for these three pathways were integrated into the genome of *Issatchenkia orientalis* using the CRISPR/Cas9 system. We successfully constructed an engineered *I. orientalis* strain capable of consuming three non-conventional carbon sources: xylose, arabinose, and galacturonic acid.

44 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: We hypothesize that enhancing the secretion of enzymes by baker's yeast will lead to more efficient degradation of undesirable oligosaccharides and increased CO_2 production, thereby reducing the overall fermentation time. To introduce the desired genetic mutations into the yeast genome, we utilized two well-established mutagenic techniques: Ethyl Methanesulfonate (EMS) and ultraviolet (UV) radiation. Subsequent to EMS or UV-mediated mutagenesis, the cultures on inulin (a type of fructan) plates were incubated at 30°C until discernible colonies emerged. We conducted screening by examining colony size on inulin agar plates. After each mutagenesis cycle, large colonies were isolated and subsequently inoculated into an inulin-exclusive medium to assess comparative growth kinetics. However, these mutants failed to demonstrate any significant improvement in inulin utilization relative to the unmodified control yeast strain. The concomitant presence of glucose, fructose, and sucrose within the inulin substrate utilized in the growth medium could potentially support yeast strain proliferation, independent of their invertase secretion capability. To counteract this confounding factor, we implemented a carbohydrate extraction technique involving the precipitation of these sugars with 80% ethanol or acetone. Following this, the manipulated inulin samples were analyzed using High-Performance Anion Exchange Chromatography. Subsequent results exhibited a marked reduction in glucose, fructose, sucrose, and certain lower Degree of Polymerization inulin fractions post-ethanol or acetone intervention. This strategy is expected to significantly streamline the selection process in upcoming mutagenesis attempts.

45 Anti-colitic Activity of Anthocyanins in Humanized IL-10 KO Mice with Bacterial Dysbiosis

P.I.: Lavanya Reddivari

Collaborators: Surinder Chopra

Researchers: Jose Haro, PhD student; Vignesh Nathan, PhD student

Objective: Evaluate the role of colitis-associated gut bacterial dysbiosis in altering the anti-inflammatory activity of 3-DF and 3-HF in a whole food matrix using IL-10 -/- mice.

Progress: Six-week-old gnotobiotic IL-10 -/- mice [C57BL/6] were colonized with human fecal microbiota from three non-Ulcerative Colitis (UC) and three UC patients. Mice were assigned to five dietary treatments: a purified control (P), 25% maize near-isogenic line expressing no phlobaphenes (PHLO) or anthocyanins (ANTH) (A), 25% maize expressing PHLO (B), 25% maize expressing ANTH (C), and 25% maize expressing ANTH and PHLO (D). After 7 weeks, mice were given dextran sodium sulfate (DSS) to induce colitis. Digestive tract organs, intestinal permeability, relative expression of colonic inflammatory markers, tight junction proteins, mucin, and gut microbiota composition were evaluated.

DSS increased the colon weight /length ratios in mice regardless of the microbiota. Reduction in cecum size and elevation of the expression of IL-1β and IL-6 was observed in mice with non-UC microbiota, while Muc2 was reduced by DSS in mice with UC microbiota. Although dysbiosis did not exacerbate the expression of NF-κB, IL-1β, Muc-2, and IL-6 in diet P, flavonoids did, depending on the donors' microbiota. Diet D reduced NF-κB expression compared to C, regardless of the gut microbiota. However, IL-1β and IL-6 were higher in diet D in non-UC microbiota mice.

Overall, UC induction with DSS and the anti-colitic activity of PHLO and ANTH is suggested regardless of dysbiosis but in a donor-dependent manner. Data collection on other biomarkers and gut microbial composition is in progress.

46 Role of Anthocyanins in Early Weaning Stress-induced Gut Inflammation

P.I.: Lavanya Reddivari

Researchers: Vignesh Nathan, PhD Student

Objectives: Evaluate the capability of blueberry phenolic extracts to mitigate gut barrier disruption during early weaning stress in piglets

Progress: Weaning is considered a stressful period in piglets with detrimental effects on gastrointestinal tract function leading to diminished gut barrier integrity and inflammation. Previous research in the Reddivari Lab has showcased the effectiveness of blueberry polyphenols as a means to control these side effects utilizing a porcine epithelial cell model *in vitro*. This year, the study was replicated *in vivo* utilizing twenty early-weaning stressed piglets fed a standard diet or a diet supplemented with 10% freeze-dried blueberry powder. Analysis of intestinal permeability, inflammation, and antioxidant status are currently underway to elucidate the potential of the bioactive compounds as a potential feed additive.

47 Role of Polysaccharide and Polyphenol Interaction in Anti-colitic Effects of Anthocyanins

P.I.: Lavanya Reddivari

Researchers: Sarah Eckrote, PhD student

Collaborators: Yuan Yao

Objective: Analyze polysaccharide-anthocyanin interactions and their potential uses as protective and therapeutic agents in UC-induced IL-10-/- mice.

The goal of this project is to determine the function of polysaccharide-anthocyanin interactions and their role in stabilizing anthocyanins after consumption and during digestion. Anthocyanins are recognized for their antioxidant capabilities and regulation of inflammation, but also for their lack of stability in high temperatures and high pH solutions. Increasing the interactions between polysaccharides and anthocyanins in a whole food matrix can increase the stability of the phenolic compound potentially allowing more anthocyanins to reach the colon and the gut microbiota residing there. Currently, a complex comprised of blueberry anthocyanins and a supplemented undigestible polysaccharide has been created and is in the testing phase. The complex is being tested on its stability during upper digestion along with its ability to aid in protecting IL-10-/- mice from DSS-induced Ulcerative Colitis.

48 Effect of Fiber Physicochemical Properties and Host-specific Conditions in Fiber Metabolism

P.I.: Lavanya Reddivari

Researchers: Edward Moncada, PhD Student; Paola Andino, MS Student

Collaborators: Bruce Hamaker, Timothy Johnson (Purdue University)

Objectives: 1) To address the influence of fiber solubility, structure complexity and fermentation rate in fiber tolerance and metabolism. 2) To determine the role of gut bacterial dysbiosis and gut inflammation in fiber efficacy.

Progress: Resistant maltodextrins (RMD), high methoxyl pectin (HMP), chicory inulin (ChIn), and wheat bran (WB) were selected based on their different physicochemical properties. Fibers were then subjected to several *in-vitro* fermentation using fecal samples from healthy donors and individuals diagnosed with mild and severe ulcerative colitis (UC). Results showed that HMP proved to be the most efficient short-chain fatty acid producer after 48 hours of *in-vitro* fermentation. HMP increased alpha diversity within the UC donors, whereas ChIn appeared to be negatively influencing the bacterial diversity. Further, HMP promoted the growth of butyrate-producing bacteria. RMD increased *Klebsiella spp.*, a pathogenic bacterium during in vitro fermentation using fecal inoculum from both healthy donors and patients with UC. In an in vivo study, mice were colonized with either a fiber-intolerant (FI) individual fecal microbiota or with colitis-associated microbiota. Mice were then subjected to a 15% fiber-supplemented diet for a two- or eight-week experimental period to address the effect of bacterial dysbiosis and inflammation on fiber metabolism. Mice colonized with FI fecal microbiota appeared to be sensitive to RMD consumption showing an increased expression of IL-6 within the first two weeks. Additionally, even short-term consumption of RMD and ChIn reduced the expression of Claudin-1, signs of a compromised gut barrier integrity. During the eight weeks, these two fibers exhibited exacerbated inflammation symptoms by increasing IL-6, along with reduced Muc-2 and Claudin-1 expression. Short-chain fatty acid production stimulated by RMD and ChIn long-term consumption did not seem to be influential in reversing their adverse effects. A less complex structure is a common property for RMD and ChIn, which seems to be an influential physicochemical characteristic in fiber tolerance. In addition, HMP possessing a high structure complexity, showed promising results by increasing butyrate production and maintaining gut barrier integrity without exacerbating any inflammation symptoms.

49 Food Bioactive Components and Vitamin Receptor Regulation

P.I.: Lavanya Reddivari

Researcher: Kayla Roy, PhD student

Objective: Investigate the role of dietary bioactive compounds in restoring Vitamin D receptor (VDR) expression during inflammation

Progress: Individuals with colitis have higher rates of Vitamin D deficiency which can exacerbate colonic inflammation. Vitamin D's activity is regulated through the Vitamin D Receptor (VDR). We observed that mice that were induced with DSS colitis and mice that underwent fecal microbiota transplantation with ulcerative colitis-associated microbiota had a lower gene expression of VDR relative to healthy counterparts. To assess the ability of food bioactive to restore VDR expression, we analyzed a variety of dietary interventions in colitic animal models. We found that dietary fibers, but not anthocyanins nor phlobaphenes could restore VDR expression during inflammation.

50 Stone Milling Conditions and Starter Culture Source Influence Phytic Acid Content and Antioxidant Activity in Whole-grain Sourdough Bread

P.I.: Senay Simsek

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

Collaborators: Jonathan Bethony (Seylou Bakery, Washington, DC)

Objectives: This study was aimed at studying the effect of the milling method, particle size, and starters on antioxidant capacity and phytic acid content in flour and sourdough bread.

Progress: There is interest in whole-grain sourdough bread related to evidence of increased nutrient availability and antioxidant compounds. Antioxidants play a remarkable role in the body's defense system against reactive oxygen species. In contrast, phytic acid has adverse effects as it reduces the availability of minerals. Jayani carried out this research study to compare the phytic acid content and antioxidant activity of stone-milled whole-grain flour and sourdough bread made with two different starter cultures. The phytic acid content of all the bread samples was significantly ($p < .05$) lower than the flour samples they were produced from. Significant

($p < .05$) differences were observed in sourdoughs' phenolic contents and antioxidant capacities with different starter cultures. The antioxidant capacity of polyphenols extracted from bread samples was negatively correlated with the coarse particle size fraction and positively correlated with the fine particle size fraction. The phytic acid content and antioxidant capacity of the bread were affected by the starter culture. Processing whole-grain flour into sourdough bread reduced the phytic acid content and improved the antioxidant activity.

51 Enhancing Mechanical Properties and Water Interactions of Arabinoxylan Films from Corn Bran through Enzymatic-chemical Modification

P.I.: Senay Simsek

Researcher: Abdulrahman Khalid Yousef Alahmed, PhD student (North Dakota State University); Kristin Whitney, Staff

Objectives: The first objective of this study was to evaluate effect of lipase-acetate application on the surface of corn polymer films and their physical and mechanical properties. The second objective is to produce hydrophobic arabinoxylan film materials and evaluate how the arabinoxylan films interact with water and soil in aerobic biodegradation.

Progress: AX based-films can enhance mechanical characteristics of biodegradable materials when the films are used for food packaging. The mechanical properties of AX films for use in the food packaging industry have to be properly explored to demonstrate the viability of film use for food packaging materials. Abdul extracted the polymeric material from the corn processing byproducts of dry milled corn bran (DCB), wet milled corn bran (WCB), and dried distillers grains (DDG) by acid-alkali method. Creation of the packaging materials was established using the polymer extract, with laccase, and sorbitol, which was modified by suspending the surface of the film in a lipase-acetate solution. The mechanical characteristics determined included thickness, tensile properties, tear resistance, and puncture resistance. Thickness and tensile properties of films made from DCB and DDG were significantly ($P<0.05$) increased compared to their control AX films. The films of WCB decreased in thickness and improved in tensile properties, but insignificantly ($P>0.05$) from its unmodified films. A significant ($P<0.05$) increase in tear resistance was observed when all film surfaces were suspended in the lipase-acetate mixture. Puncture resistance was enhanced, but not significantly ($P>0.05$), for the modified films compared to unmodified films produced from DCB, WCB, and DDG. The films were positively affected by modification with the lipase-acetate solution, making modified films bendable, flexible, and more resistant to deformation when stretched compared to unmodified films. Work on determination of water interactions and biodegradability are ongoing for this project.

52 Valorization of Hemp Seed Waste for Production of Functional Food Ingredients

P.I.: Senay Simsek

Researcher: Kristin Whitney, Staff; Elise Whitley, Staff

Objectives: This project aims to optimize the quality of hemp cake from different oil press conditions to produce plant-based proteins. We will develop a high-fiber plant-based protein by improvement of the nutritional quality of hemp cake for further processing.

Progress: Enzymatic treatment will increase the soluble dietary fiber in the plant-based proteins to generate a plant-based protein without separating the protein from the dietary fiber of the hemp cake. Ultimately enzyme treatments will result in the creation of high-fiber plant-based protein for use in producing meat analogs. This project is the beginning stage of the development of plant-based protein ingredients with good nutritional value with high dietary fiber content. After obtaining hemp cake from a Hemp processing facility which uses an optimized process for hemp oil extraction, Kristin was able to conduct enzymatic processing trials on the hemp cake. Our enzymatic treatments using different combinations of cellulase, xylanase, and pectinase enzymes have resulted in seven unique products. The enzymatic treatments were applied to solubilize the insoluble dietary fiber which is a large component of hemp cake. Enzymatic treatments were conducted under conditions which maintain the integrity of the hemp protein. The solubilization of the dietary fiber will allow us to create a functional ingredient with high protein and dietary fiber for use in plant-based meat alternatives. The initial enzyme trials allowed us to understand that the cell wall material of the hemp cake is resistant to hydrolysis and a long and intensive treatment will be required to hydrolyze the insoluble dietary fiber. This work has shown that future investigation on different types of enzymes may be of benefit for producing functional protein

ingredients from hemp cake. Currently, Elise Whitley is working on characterization of the enzyme treated samples and conducting extrusion trials to produce plant-based protein and meat analog ingredients.

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

P.I.: Senay Simsek

Researcher: Laila Hossain, Postdoc

Collaborators: Marguerite Bolt (Purdue University)

Objectives: The objective of this work is to utilize cellulose extracted from industrial hemp stalk to produce value added materials such as biodegradable packaging

Progress: L. Hossain has continued working on a project to add value to industrial hemp grown in Indiana in collaboration with M. Bolt (Hemp Extension Specialist, Agronomy). 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. Work has been done to characterize the yield and structure of cellulose and hemicellulose from the industrial hemp stalks. Laila has also continued 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. We found that cellulose from different varieties perform differently as superabsorbent 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. Laila has continued to determine the functional characteristics of this material and biodegradability studies are underway.

54 Preparation of Naturally Occurring, Plant-based Emulsifiers and (Micro) Encapsulation 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 was made on the extraction process. Research is in progress to characterize and maximize both the quality and quantity of materials that govern the emulsification and encapsulation properties, respectively.

55 Performance of Plant-based Emulsifiers in Stabilizing Emulsions of Orange Oil

P.I.: Yuan Yao

Researcher: Kamrun Nahar, MS student

Objective: To study the emulsification properties of plant-based emulsifiers, using orange oil as model

Progress: This project is sponsored by USDA grant titled "Novel, Plant-Based Wall Materials for Spray-Dry Microencapsulation: Manufacturing, Characterization, and Performance Evaluation". Orange oil was selected as the model oil to study the properties of plant-based emulsifiers. Ongoing studies, at both fundamental and practical levels, are on formation of Pickering emulsions that may contribute to the stability of emulsions of low-density oils such as orange oil.

56 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. 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. Miao, M. **BeMiller, J.N.** (2023). Enzymatic approaches for structuring starch to improve functionality. *Annual Review of Food Science and Technology, 14*, 271-295.

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Martinez, M.M.

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See paper in Hamaker (Torres-Aguilar et al.)

Mauer, L.J.

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Reddivari, L.

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See paper in Ferruzzi (Debelo et al.)

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Simsek, S.

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100. Van Rooyen, J., Marini, F., Orth, S.H., Oyeyinka, S.A., **Simsek, S.**, Manley, M. (2023). Effect of wheat roasting conditions and wheat type on short-wave infrared (SWIR) spectral data of whole and milled wheat by ANOVA-simultaneous component analysis. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy,* 303, 123160.

101. Van Rooyen, J., **Simsek, S.**, Oyeyinka, S. A., Manley, M. (2023). Wheat starch structure–function relationship in breadmaking: A review. *Comprehensive Reviews in Food Science and Food Safety*, *22,* 2292-2309.

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102. **Chen, J., Yao, Y.** (2023). Phytoglycogen to enhance the solubility and *in-vitro* permeation of resveratrol. *Food Biophysics, 18,* 433-442.

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

January

Campanella, O.H. Food Material Science at the Department of Food Science and Technology, The Ohio State University. General Mills, Minneapolis, MN.

Moncada, E., Bulut, N., Li S, **Hamaker, B., Reddivari, L.** Selection of dietary fibers for gut health based on their physicochemical properties. Crohn's and Colitis Congress, Denver, CO.

Roy, K., Moncada, E., Reddivari, L. The onset and severity of ulcerative colitis in IL-10 -/- mice is not dependent on fecal microbiota transplantation from ulcerative colitis patients. Crohn's and Colitis Congress, Denver, CO.

February

Lindemann, S.R. Polysaccharide fine structure controls the ecology and function of human gut microbial communities. Biology Seminar Series, Baylor University, Waco, TX.

Roy, K., Moncada, E., Reddivari, L. Bacterial dysbiosis does not increase colitis severity or onset in IL 10 -/- mice. Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN.

March

Campanella, O.H. Applications of texturization of biopolymers to produce nutritious and high-quality food products. 4th Annual Research Spotlight Meeting. University of Minnesota, Minneapolis, MN.

Campanella, O.H. Food processing and extrusion program for food innovation at the Ohio State University. Clextral Extrusion Demo Meeting. Tampa, FL.

Ferruzzi, M.G. Food processing primer: Describing why we process foods and setting a foundation for our discussion of "ultra". Workshop for developing a research roadmap about processed foods, food processing, and human health in the context of the US food system. Hot Springs, AR.

Hamaker, B.R. Carbohydrate processing and glycemic response. Workshop for developing a research roadmap about processed foods, food processing, and human health in the context of the US food system. Hot Springs, AR.

Hamaker, B.R. Dietary fiber structure-function relationship with the gut microbiota for human health. USDA Human Nutrition Research Center, Beltsville, MD, online.

Hamaker, B.R. Peruvian foods and health. USAID Peru UNALM Project. Lima, Peru.

Martinez, M.M. Construyendo un futuro resiliente, sostenible y saludable. XXXV Jornadas Técnicas de la AETC. Jerez de la Frontera, Spain.

Martinez, M.M., Portillo, K.G. Catalyst-free esterification of wheat starch. 2nd Greenering International Conference. Valladolid, Spain.

Reddivari, L. Physico-chemical properties and physiological effects of dietary fiber. Whistler Center for Carbohydrate Research Webinar. Purdue University, West Lafayette, IN.

Whitney, K., Simsek, S. Enhancing utilization of hulled wheats: Quality and composition. USDA NC-213 Annual Meeting. West Lafayette, IN.

April

Campanella, O.H. The creation of functional structures in starches and starch/non-starch polysaccharides mixtures by the application of controlled shear forces. 74th Starch Convention. Detmold, Germany.

Hamaker, B.R. The next generation of prebiotics, matching prebiotics for support of probiotic-type bacteria. Global Prebiotic Association Webinar, online.

Lindemann, S.R. The devils in the details: different microbial and metabolic fates arise in fermentation of divergent fiber fine structures. Nutrition and Dietetics Seminar Series. Florida International University, Westchester, FL.

Martinez, M.M. Explotación de biopolímeros de biomasa vegetal dentro de los limites planetarios. Sostenibilidad en la Industria Agroalimentaria: Algo está cambiando. Palencia, Spain.

Portillo, G., Skov, K., Martinez, M.M. Environmentally friendly functionalization of starch via green deep eutectic solvents. 74th Starch Convention. Detmold, Germany.

Spotti, M.J., Henriksson, T., Moldin, A., **Martinez, M.M.** Influence of molecular structure of wheat varieties in hydrogel thermal and rheological properties during storage. Nordic Rheology Conference. Aarhus, Denmark.

May

Andino, P., Moncada, E., Johnson, T., **Hamaker, B., Reddivari, L.** The effect of gut bacterial dysbiosis on fiber fermentation and tolerance in an ulcerative colitis patient. Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN

Hamaker, B.R. Consistency of response of prebiotics for population benefit. Whistler Center Technical Conference, West Lafayette, IN.

Hamaker, B.R. Targeted prebiotic fibers for gut health. RP Food Conference. Istanbul, Turkey.

Lindemann, S.R. Dietary fiber, gut microbiota, and health interactions. Efes University, Efes, Turkey.

Lindemann, S.R. Teaching science and engineering through project-based courses. Necmettin Erbakan University, Konya, Turkey.

Lindemann, S.R. Using fibers to manipulate microbiome signaling via the gut-brain axis. Dokuz Eylul University, Izmir, Turkey.

Martinez, M.M. Structuring plant-based foods using less refined plant proteins. Whistler Center Technical Conference, West Lafayette, IN.

Oh, E. J., Advancing sustainable food production through synthetic biology. Whistler Center Technical Conference, West Lafayette, IN.

Oh, E. J. Development of microbial platforms capable of co-fermenting non-conventional substrates for enhanced production of value-added chemicals. Department of Food Bioscience and Technology, Korea University, Seoul, South Korea.

Reddivari, L. Physicochemical properties of dietary fiber in fiber intolerance. W4002 multistate meeting on Nutrient Bioavailability – Phytonutrients and Beyond. Honolulu, HI.

Roy, K., Moncada, E., Reddivari, L. Fecal microbiota transplantation from an ulcerative colitis patient promotes mucus thinning and colonic inflammation in IL-10-/- mice. Midwest Microbiome Symposium. Ohio State, Columbus, OH.

June

Aguilar-Torres, A.M., Catalano, J., **Martinez, M.M.** Multidimensional spectroscopy unravels the nature and intensity of polysaccharide-polyphenol interactions. Northern Lights on Food - Conference IV. Lund, Sweden.

Campanella, O.H. Fabrication, characterization, and potential applications of texturization of biopolymers to produce nutritious and high-quality food products. 14th International Conference of Engineering and Food, ICEF14-2023. Nantes, France.

Castellanos-Suarez, L., **Campanella, O.H**, Jiménez-Flores, R. Optimization of fermentation parameters to valorize byproducts from the dairy and poultry industries. ADSA® Annual Meeting. Ottawa, Ontario, Canada.

Donmez, D., Russi, J.P, Relling, A.E, **Campanella, O.H.** Oxidative stability of encapsulated fish oil by non-purified soy-lecithin and dextrose. 14th International Conference of Engineering and Food, ICEF14-2023. Nantes, France.

Ferruzzi, M.G. Processing (and other) considerations in delivery of bioactive benefits from foods. Institute for the Advancement of Food and Nutrition Sciences (IAFNS) annual meeting. Washington, DC.

Hamaker, B.R. Rural incubation of women millet and sorghum processors in Niger creates businesses with potential to improve nutrition. International Sorghum Conference. Montpellier, France.

Hamaker, B.R. Targeting prebiotics for support of gut resident probiotic bacteria. International Scientific Association of Probiotics and Prebiotics (ISAPP) annual meeting. Denver, CO.

Kuo, C.C., Jiménez-Flores, R. **Campanella, O.H.** Valorization of byproducts from meat and dairy industries through fermentation to obtain protein hydrolysates. 14th International Conference of Engineering and Food, ICEF14-2023. Nantes, France.

Lindemann, S.R. Applying to U.S. graduate schools in the biomedical sciences. Yildiz Teknik University, Istanbul, Turkey.

Lindemann, S.R. Dietary fiber, gut microbiota, and health interactions. Yildiz Teknik University, Istanbul, Turkey.

Lindemann, S.R. Is there an effective approach to rational design and validation of prebiotics to target members of the microbiota? International Scientific Association for Prebiotics and Probiotics (ISAPP) annual meeting. Denver, CO.

Martinez, M.M. Structuring plant-based foods using less refined plant proteins. Organized by IQS - Universitat Ramon Llul, BIET. Barcelona, Spain.

Oh, E.J., Development of microbial platforms capable of co-fermenting non-conventional substrates for enhanced production of value-added chemicals. Department of Bio Fermentation Convergence Technology, Kookmin University, Seoul, South Korea.

Russi, J.P., **Campanella, O.H.,** Relling, A.E. Effect of a non-polar mycotoxin binder on milk mycotoxin concentration and milk production in commercial dairy farms, preliminary results. ADSA® Annual Meeting. Ottawa, Ontario, Canada.

July

Andino, P., Moncada, M., Johnson, T., **Hamaker, B., Reddivari, L.** Fiber fermentation and tolerance in UC patients: role of gut bacterial dysbiosis. Nutrition 2023, American Society for Nutrition. Boston, MA.

Durmus, Y., **Simsek, S.** Influence of hazelnut skin, cross-linked starch, and oxidized starch on the nutrition properties and in vitro starch digestibility of sourdough bread. Institute of Food Technologists Annual Meeting. Chicago, IL.

Ferruzzi, M.G. Overview of factors that modify absorption and metabolism of phenolics from plant foods. National Academy of Sciences Committee on Microbiome and Health. Washington, D.C., online.

Hamaker, B.R. Dietary fiber and food processing links to the gut microbiome and human health. National Academy of Sciences Committee on Microbiome and Health. Washington, D.C., online.

Haro Reyes, J., Reddivari, L. Anti-colitic activity of phlobaphenes and anthocyanins in humanized IL-10 -/- mice with bacterial dysbiosis. Nutrition 2023, American Society for Nutrition. Boston, MA.

Kimble, A., Campanella, O.H., Jones, O.G. Enzymatic hydrolysis of bean flour fibrous polysaccharides by reactive extrusion. Institute of Food Technologists Annual Meeting. Chicago, IL.

Main, T., **Whitney, K., Simsek, S.** The future of food in 3-dimensions: Automation of spherification through 3-D food printing. Institute of Food Technologists Annual Meeting. Chicago, IL.

Moncada, E., Bulut, N., Li, S., Johnson, T., **Hamaker, B., Reddivari, L.** Dietary fiber utilization depends on fiber physicochemical properties and gut bacterial dysbiosis. Nutrition 2023, American Society for Nutrition. Boston, MA.

Nathan, V., Eckrote, S., Li, S., **Reddivari, L.** Effect of crude blueberry phenolic extracts on improving gut barrier integrity and inflammation *in vitro*. Nutrition 2023, American Society for Nutrition. Boston, MA.

Reddivari, L., Moncada, E., Li, S. Role of fiber physicochemical properties in fiber intolerance. Nutrition 2023, American Society for Nutrition. Boston, MA.

Whitney, K., Olson, B., **Simsek, S.** Processing of oats in relation to composition of oat beverage bases. Institute of Food Technologists Annual Meeting, Chicago, IL.

August

Campanella, O.H. Fabrication, characterization, and applications of innovative extrusion to produce quality foods. Lund University, Sweden.

Guo, W., **Spotti, M.J., Portillo-Perez, G., Martinez, M.M.** Degradation of the wheat endosperm matrix and constituting biopolymers during baking and its role on the performance of stale bread as packaging material. 8th International Polysaccharide Conference of EPNOE. Graz, Austria.

Kasper Brandhøj Skov, Guillermo Portillo, Mario M. Martinez. Acetylation of anhydroglucose to enhance the hydrophobic performance of stale bread as packaging material. 8th International Polysaccharide Conference of EPNOE. Graz, Austria.

Oh, E. J., Development of microbial platforms capable of co-fermenting non-conventional substrates for enhanced production of value-added chemicals. Korea Research Institute of Bioscience and Biotechnology (KRIBB), The UST Global Mentoring Conference. Daejeon, South Korea, online.

Portillo-Perez, G.A., Skov, K., Martinez, M.M. Catalyst-free acetylation of starch using green deep eutectic solvents as reaction promoters. 8th International Polysaccharide Conference of EPNOE, Graz, Austria.

Spotti, M.J., Franco, M., Moldin, A., Henriksson, T., **Martinez, M.M**. Influence of amylose and amylopectin molecular structure on self-assembly and wheat bread-staling. 8th International Polysacharide Conference of EPNOE, Graz, Austria.

Veeramani Karuppuchamy, V., Nuguri, S., Rodriguez-Saona, L., **Campanella, O.H.** Application of Fourier transform infrared spectroscopy for determination of brewers' spent grain composition. Cereals and Grains Annual Meeting. Schaumburg, IL.

September

Ferruzzi, M.G. Phenolics in human milk and early dietary exposure. 12th Annual Probiotics, Prebiotics and Botanicals. Rome, Italy.

Hamaker, B.R. Alignment of dietary fibers with gut bacteria for robust and predicted response. TNO Symposium in honor of Jan-Willem van der Camp, Optimising food and fibre composition, keynote speaker. Leiden, Netherlands.

Hamaker, B.R. Phenolics and carbohydrate interactions. Implications for digestion as well as gut microbiota. Probiotics, Prebiotics & New Foods - Rome Congress. Rome, Italy.

Whitney, K., Simsek, S. Structural diversity of arabinoxylans. Midwest Carbohydrate and Glycobiology Symposium. West Lafayette, IN.

October

Aguilar-Torres, A., Martinez, M.M. Multidimensional spectroscopy unravels the nature and intensity of polysaccharide-polyphenol interactions. 3rd Food Chemistry Conference. Dresden, Germany.

Campanella, O.H. Research in food materials science, a vehicle for effective and sustainable processing. XVIII Congreso Argentino de Ciencia y Tecnología de Alimentos, Asociación Argentina de Tecnólogos Alimentarios. Buenos Aires, Argentina.

Guo, W., Portillo-Perez, G., Spotti, M.J., Martinez, M.M. Molecular and supramolecular investigation of stale bread and its upcycling as packaging biomaterial. 3rd Food Chemistry Conference 2023. Dresden, Germany.

Hamaker, B.R. Carbohydrates and health. Council of Food Science Administrators Meeting and Association of Nutrition Departments & Programs (CFSA/ANDP) joint meeting, keynote speaker, Purdue University, West Lafayette, IN.

Hamaker, B.R. Novel starch functionalities related to amylopectin internal chains. Starch Round Table biannual meeting. Schaumburg, IL.

Hamaker, B.R. Potential weight loss effect with ileal-digesting starch. Cereals & Grains 23. Schaumburg, IL.

Hamaker, B.R. Targeted prebiotics for precision nutrition and health-related outcomes. Interdepartmental Nutrition Program seminar series, Purdue University, West Lafayette, IN.

Hong, T., **Simsek, S., Whitney, K.**, Xu, X. Dynamic behavior of zein-gluten interaction during extruded noodle processing. Global Food & Nutrition Security and Human Health. West Lafayette, IN.

Hong, T., **Simsek, S.**, Xu, X. Comparative study of soluble soybean polysaccharides on bread staling under acidic conditions. Global Food & Nutrition Security and Human Health. West Lafayette, IN.

Lindemann, S.R. Targeting cereal fibers to gut microbiota: Fine structure matters. University of Nebraska Food for Health Center, Omaha, NE.

Lopez-Rodulfo, I.M., Tsochatzis, E.D., Martinez-Carrasco, P., Stentoft, E.W., **Martinez, M.M.** LC-ESI-QTOF-MS/MS-based hierarchical clustering of (poly) phenol binding to the plant cell wall explains cold-pressing extractability and in vitro bioaccessibility. 3rd Food Chemistry Conference. Dresden, Germany.

Oh, E.J. Enhancing carbohydrate profiles: the power of microbial fermentation, Whistler Center for Carbohydrate Research short course. West Lafayette, IN.

Reddivari, L. Fiber intolerance: Does fiber type matter. Graduate group in Nutritional Biology Research Seminar. University of California, Davis, CA.

Skov, K.B., Portillo, G., Martinez, M.M. Catalyst-free acetylation to enhance the hydrophobic performance of stale waste bread as packaging material. 3rd Food Chemistry Conference 2023. Dresden, Germany.

Spotti, M.J., Franco, M., Moldin, A., Henriksson, T., **Martinez, M.M.** Influence of amylose and amylopectin molecular structure on self-assembly and wheat bread-staling. 3rd Food Chemistry Conference 2023. Dresden, Germany.

Whitney, K., Kulathunga, J., **Simsek, S.** Antioxidant properties and phytic acid content of whole wheat flour and sourdough bread prepared with different starter cultures. Cereals & Grains 23, Schaumburg, IL.

Whitney, K., Kulathunga, J., **Simsek, S.** Impact of grain type used for starter culture source on composition and digestibility of sourdough bread. Cereals & Grains 23, Schaumburg, IL.

November

Campanella, O.H. Research in food materials science and its effect on processing. 50 years of the Foundation of the Centro de Investigación y Desarrollo en Criotecnología (CIDCA). University of La Plata, La Plata, Argentina.

December

Campanella, O.H. Understanding structure-function properties of fibers for the development of foods. Faculty of Sciences and Technology, Universidad Mayor de San Simon, Bolivia.

Lindemann, S.R. Targeting cereal fibers to gut microbiota: fine structure matters. Arkansas Children's Nutrition Center, Little Rock, AR.

Juul, L., **Skov, K.B.**, Nissen, S., Hammershøj, M., **Martinez**, **M.M.**, Trine K. Dalsgaard. Properties of sea lettuce protein in high moisture extrudates. Nordic Rheology Conference 2023. Aarhus, Denmark.

Franco, M., Spotti, M.J., Gomez, M., **Martinez, M.M**. Understanding the anti-staling mechanisms of hemicellulose mucilage from Plantago ovata seeds (psyllium). Nordic Rheology Conference 2023. Aarhus, Denmark.

C. Graduate Degrees Awarded

Spring 2023

1. Shengyue Shan, PhD, *The application of numerical methods and complex rheology in understanding the physical properties of frozen bread dough and gluten-free dough,* Ohio State University
2. Chong Teng, PhD, *Advancements in plant-based fat analogs and iron-binding pea protein hydrolysates: structural, textural, and nutritional characterization,* Ohio State University

Summer 2023

3. Rui Zhi, MS, *Enhancing air-water interface stability with heat-treated whey protein isolate (WPI)/ high acyl gellan gum (HAGG) complex particles*

Fall 2023

4. Abdulrahman Khalid Yousef Alahmed, PhD, *Enhancing mechanical properties and water interactions of arabinoxylan films from corn bran through enzymatic-chemical modification.* North Dakota State University
5. Wenqiang Bai, PhD, *Organocatalytic acetylation of pea starch and its compatibilization with matrix polysaccharides to fabricate biofilms*
6. Zhuoran Chen, MS, *functional plant-based protein*
7. Dila Donmez, PhD, *encapsulation of fish oil within Maillard reacted lecithin-dextrose matrix using a batch reactor and reactive-extrusion process,* Ohio State University
8. Harrison Helmick, PhD, *Bioinformatic modelling and functionalization of pea protein through cold denaturation with applications in extrusion, gelation and emulsification*
9. Anael Kimble, MS, *Reactive extrusion of bean flours*
10. Anh Nghi Minh Le, MS, *analyzing nonlinear rheological properties of food through Fourier transform coupled with Chebyshev decomposition and sequential physical processes methodologies*
11. Phuong Mai Lea Nguyen, MS, *The impact of fine chemical structures of resistant dextrins on maintenance of gut microbiome diversity and function* in vitro *and* in vivo
12. Allison Ann LeMinh, MS, *Effects of extraction and drying methods on pea and lentil protein isolate structure, function, and application in a gellan gum structured grapeseed oil gel,* Ohio State University.
13. Farzaneh Nasrollahzadeh, PhD, *Structuring plant-based foods using less refined plant proteins and high moisture extrusion,* University of Guelph
14. Paige Smith, MS, *Preconditioning starch in oligosaccharides to modify starch functionality*
15. Emil Wedding, MS, *Assessment of static and semi-dynamic in-vitro digestion models and their applicability in polyphenol research,* Aarhus University
16. Xinruo Zhao, MS, *Dietary fibers suppress Clostridium difficile in in vitro human fecal fermentation*

D. Recognitions, Awards, and Honors

Julia Bechtner
Marie Skłodowska-Curie Individual Fellowship

Osvaldo Campanella
2022-2023 Distinguished International Research and Engagement Award. College of Food, Agricultural, and Environmental Sciences. The Ohio State University

Sarah Eckrote
Presidential Doctoral Excellence Award

Jose Haro
American Society for Nutrition - Young Investigators Underrepresented in Nutrition Competition - Second Place

Harrison Helmick
B.J. Liska Outstanding Teaching Assistant Award

Veeramani Karuppuchamy
Third place in 2023 Hayes Forum poster presentation

Peanut Proud Graduate Scholarship

Ohio Valley section IFT Scholarship

President – Phi Tau Sigma – Buckeye Chapter

Student representative – IFT Food Safety and Quality Management division

Mario M. Martinez
Research Consolidation 2023 (State Research Agency, Spanish Government)

Edward Moncada
Institute of Food Technologists - Student Oral Competition Carbohydrate Division - Finalist

American Society for Nutrition - Young Investigators Underrepresented in Nutrition Competition – Finalist

Lavanya Reddivari
Jack Long Outstanding Undergraduate Teaching Award, Department of Food Science, Purdue University

University Faculty Scholar – Purdue University 2023

E. Special Events

Whistler Center Short Course, October 3-5, 2023

As is our tradition, the course is designed to provide one day on carbohydrate fundamentals followed by two days of advanced special topic sessions. All sessions were done hybrid and were recorded so that our off-site members could attend or later 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 3, 2023

- 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 4, 2023

- Can dietary carbohydrates create an Ozempic-like weight loss effect? B. Hamaker
- Hydrocolloids and functionality (Parts I & II), J. Keller
- Starch material properties, L. Mauer
- Computational approaches to big data in gut microbiome studies, S. Lindemann, C. Swackhamer, D. Deemer
- Complex carbohydrate structure analysis (non-starch), B. Reuhs
- Dietary polysaccharide and phenolic interactions in gut health, L. Reddivari
- Enhancing carbohydrate profiles: the power of microbial fermentation, E. Oh

October 5, 2023

- Modification of starch for enhancement of functional and nutritional properties, S. Simsek, Y. Yao
- Predictive modeling of multiphase systems, G. Narsimhan
- Polysaccharide phase separation – coacervation and incompatibility, O. Jones
- Formulating plant-based extruded foods, M. Martinez

F. Webinar Series

The Whistler Center webinar series is given to member companies and others who have purchased our Educational Package.

Mario Ferruzzi
Director, Arkansas Children's Nutrition Center, University of Arkansas for Medical Sciences
(Bio)fortification of grains: Progress, synergies and interactions that impact delivery of provitamin A carotenoids
January 17, 2023

Lavanya Reddivari
Associate Professor, Department of Food Science, Purdue University
Physico-chemical properties and physiological effects of dietary fiber
March 21, 2023

Mario Martinez
Associate Professor, Department of Food Science, Aarhus University, Denmark
Exploitation of biopolymers from edible crops withing planetary boundaries
May 31, 2023

Yuan Yao
Professor, Department of Food Science, Purdue University
Carbohydrates in meat alternatives: methylcellulose, starch, and others
July 25, 2023

Steve Lindemann
Associate Professor of Food Science, Purdue University
Omics approaches and their use in studying food, nutrition, and the gut microbiome
September 20, 2023

Tzu-Wen Cross
Assistant Professor, Department of Nutrition Science, Purdue University
The use of gnotobiotic animal models in food and nutrition Research
November 2, 2023

2023 Belfort Lecture

2023 Belfort Lecturer

Christophe Courtin

Food and Microbial Technology
Department of Microbial and Molecular Systems
KU Leuven

Dietary Fibre and Prebiotics for Health Foods: a Personal Perspective from a Cereal Scientist

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 2023 Belfort Lecturer, Dr. Christophe Courtin, is Full Professor of Food Biochemistry at the Laboratory of Food Chemistry and Biochemistry at KU Leuven in Leuven, Belgium. His research focuses on cereal starch, non-starch carbohydrates, and dietary fiber. This includes research on the enzymes that degrade these polysaccharides and their fermentation in the context of cereal processing and health. Groups of dietary fibers under study in Dr. Courtin's program include arabinoxylans, arabinoxylan oligosaccharides, fructans, cellulose, and β-glucan. There is a research emphasis on basic structure and properties of carbohydrates (as individual molecules and as components of complex 3D structures) and their technological and health functionality in cereal-based processes and products. Research on fermentation of polysaccharides focuses on the interaction between yeast and (sour)dough at the level of dough rheology, fermentation substrates, enzymes, inhibitors, aroma, end-product quality and nutrition. Over the past two decades, Dr. Courtin has graduated 39 PhD students, authored or co-authored over 320 peer-reviewed papers, invented or co-invented patents in 12 patent families, and received several awards, including the Harald Perten Prize in 2021. In 2022, he organized the 8th International Conference on Dietary Fibre in Leuven with ICC. Dr. Courtin coordinates HealthFerm, a recently approved Horizon Europe 23-partner project. He also serves as vice-dean of faculty at KU Leuven.

WHISTLER CENTER
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Food Science