Book of Abstracts

15th Annual
Grain Science Graduate Student Research Symposium

October 26th, 2023

International Grains Program (IGP) Institute Conference Center

Proposal Presentations

9:45 Characterization and evaluation of soybean meal in extruded diets for dogs and cats. **Kallee Dunn. Advisors: Greg Aldrich, PhD. and Elisa Karkle, PhD.**

Only 0.5% of the global soy is used in pet food due to a negative reputation in the pet food industry regarding anti-nutritional factors (ANFs) and indigestible oligosaccharides (OS). These ANFs can have a detrimental effect on nutrient digestibility, while the highly fermentable nature of OS can result in flatulence and soft stools in companion animals. However, soy OS may serve as prebiotics and promote gut health. The optimal dosage to promote such effects in dogs and cats is still unknown. Exploring the use of SBM as a value-added ingredient in dog and cat diets can help improve its reputation within the pet food industry and, in turn, benefit the soybean industry. The goal of this proposal is twofold. In phase one we aim to characterize SBM regarding its nutritional composition, ANFs, OS and in vitro fermentation abilities. A total of 10 SBM will be sourced from different suppliers across the US. The SBM samples will be characterized for their chemical composition and viscosity both after hydration in distilled water and after an in vitro enzymatic digestion (simulated small intestinal digestion). Substrate degradation and postbiotic production of SBM will be investigated using an in vitro canine and feline inoculum model (simulated colonic fermentation). In Phase two, we aim to investigate the in vivo effects of SBM inclusion in diets fed to dogs and cats on nutrient digestibility and gut health outcomes to determine the optimal inclusion rate of SBM for promoting gut health benefits. A standard digestibility trial will be conducted, and fecal samples will be collected for analysis. This project will help support the future usage of the ingredient in formulas, allowing product developers and consumers to have more precise knowledge about the ingredient, as well as opportunities to provide alternatives to pet food companies. It will also provide helpful data about the gastrointestinal tract health of animals that consume diets with this ingredient. The overall goal is to transform the value of SBM in pet food by using scientifically based data so perceived negative attributes can be redirected into more positive outcomes.

9:56 Valorization of wheat bran: Wheat bran proteins and bioactive peptides. **Michael Stump. Advisor: Yonghui Li, PhD.**

Over the past several decades, significant efforts have been made towards the valorization of industrial agricultural waste and byproducts. These materials are typically inexpensive and abundant, making them potentially attractive feedstocks for more economically valuable products. One strategy currently being explored is the extraction of protein from wheat bran: a major byproduct from wheat milling. Wheat bran has significant nutritional value, containing on average 15 percent protein by weight. Due to its unappealing qualities as a food ingredient in human diets though, it is primarily used as an additive for livestock and animal feeds. However, we propose that the extraction of wheat bran proteins through chemical processing methods could enable their successful incorporation into human diets by separating the undesirable components from the pure protein. In addition to use as a food additive, there has also been a surge in the study of bioactive peptides for use in pharmaceuticals and in the emerging area of nutraceuticals, or ‘functional foods.’ Many bioactive peptides have been demonstrated to have beneficial biological activity in humans and animal models. Among these are antioxidant and anti-aging effects through several different biochemical mechanisms. Some notable examples

target oxidative species and free radicals in the body, while others exhibit endocrine-modulatory activity, stimulation of collagen and elastin biosynthesis, and even cell regeneration and DNA repair. Bioactive peptides are also very attractive from a clinical perspective, as they have been shown to have low toxicity profiles in vitro and in vivo, have shown promising results in clinical tests, and can be produced relatively easily from natural protein sources. The use of wheat bran proteins as a low-cost feedstock for the production of potentially bioactive peptides is currently being explored as an attractive alternative to their preparation via more expensive synthetic methodologies.

10:07 Swine digestive efficiency of feed containing sorghum and sorghum dried distillers grains with and without the presence of a specific microflora. **W. Garret Friesen. Advisor: Chad Paulk, PhD.**

In the swine industry, feed costs account for approximately 60% of production costs. As a result, the swine industry is consistently in an economic struggle with the increasing cost of feed production. As ingredient prices increase, significant impacts are found on economic gain from farrow to finishing stages. Due to the high cost found in feed ingredients and manufacturing, producers are willing to identify compromises in nutritional aspects of diets to increase profitability. Yellow corn is currently the most highly utilized cereal grain in swine feed production, along with its by-product from ethanol fermentation, corn distillers dried grains with solubles. Due to the rising prices and demand, determining an alternative, cheaper starch and energy source is becoming increasingly vital for swine production economics.
Sorghum grain, or milo, is not a new grain to livestock production; however, it is becoming increasingly popular as an alternative ingredient to corn. Thus, comes the need for further research into sorghum grain and sorghum distillers grain solubles in swine production as an alternative for corn use. Digestibility and nutritive quality are very important aspects to consider in swine diet formulation. To understand the digestibility of these feedstuffs, an apparent ileal digestibility study will be conducted with use of 12 growing pigs, at the Kansas State University Swine Teaching Center.

Six dietary treatments will be manufactured to allow comparison between traditionally used corn, sorghum grain, sorghum distillers grain solubles, and a Nu Life custom feed additive included in these diets. These diets will be arranged so that digestibility values may be determined for amino acids, crude protein, starch, fat, NDF, and ADF. Data collected will help determine the relative feeding value and performance indicators when using sorghum grain products in swine diets. Once these baseline digestibility values are determined, further experimentation will be possible to understand production on an industrial scale. This data will further the understanding of sorghum grain utilization in swine production and give opportunity for development of future research endeavors.

10:18 Effect of pellet die on standardized and apparent ileal digestibility of amino acids in diets fed to growing pigs. **Diego Lopez. Advisor: Chad Paulk, PhD.**

Heat damage is common in animal feed, and it can affect the concentration and digestibility of nutrients. Amino acids (AA) are especially vulnerable to high temperatures due to Maillard

reactions where the carboxyl and amino groups react with sugars occasionally rendering the AA undigestible. Nevertheless, heat processing is a common step used during feed processing (e.g., conditioning). During pelleting, feed that has been preconditioned is compressed through a pellet die with variable lengths and diameters (L:D), which can create friction and increase the temperature further. Therefore, the objective of this experiment would be to elucidate the effects of pellet dies with different L:D ratios on the ileal digestibility of AA. For this study, a total of 12 pigs would be surgically fitted with a t-cannula at the ileum to allow the collection of digesta. A basal control diet will be formulated to meet the requirements of growing pigs and mixed into a batch that will be divided into 3 equal batches. Two of the batches will be pelleted using pellet dies with different L:D ratios, while the third diet will remain as mash. Lastly, a nitrogen-free diet will be formulated to allow for the calculation of the endogenous losses of N. Therefore, a total of four diets will be formulated and used in a 4x4 Latin square design. Pigs will be randomly allotted to one dietary treatment and housed individually in pens equipped with a feeder and a nipple waterer. Each diet will be fed for seven days which will be divided into a 5-d adaptation period and a 2-d collection period. Pigs will be fed three times the energy of maintenance (i.e., 106 kcal of ME/kg of BW0.60) and the ileal digesta will be collected for 8h on day 6 and 7 by attaching a plastic bag to the cannula and replacing it every 30 minutes or when full. Ileal and diet samples will be analyzed for AA concentrations and ileal digestibility will be calculated. At the conclusion of the experiment, it is expected to further understand the effect of pellet die parameters on nutrient digestibility of swine feed.

10:29 3D Printing Plant-Based Proteins. **Aidan Cairns. Advisor: Sajid Alavi, PhD.**

There has been an increasing demand for alternative and plant-based protein products due to environmental concerns, dietary preferences, and the need to feed the growing population of the world. There has also been an increase in consumers who identify as “flexitarians” who still eat animal products but seek to decrease their consumption and occasionally replace animal products with plant-based ones. These consumers still enjoy and are often seeking the texture and flavor of meat, but from a more sustainable source. Research on developing products to fill these needs has been ongoing, and there has been success in replicating ground meat products using ingredients such as texturized vegetable protein (TVP). There has been less success in creating replicas of whole muscle products. This is due to the difficulty of imitating the structure and texture of such products. 3D printing is a newer processing technique being explored in the food industry that has the potential to recreate the structure of meat using plant-based ingredients. This study aims to further explore that potential. Phase I will include using a variety of plant-based protein sources along with hydrocolloids and starches to determine formulations suitable for 3D printing products with a similar texture and appearance to meat products such as steak, chicken breast, or fish fillet. This similarity will be examined using a texture analyzer and microscopic structure analysis. The functionality and printability of ingredients and formulations will also be assessed. The raw ingredients will be tested using a Phase Transition Analyzer, Differential Scanning Calorimeter, Rapid Visco Analyzer, and a Least Gelation Concentration test. The printability of ingredients and formulations will be assessed by the ink’s accuracy in printing, tendency to surge, and if the ink holds its shape throughout the print. Phase II of this study will explore hardware refinement, process, color, and flavors for the best sensory appeal. Hardware refinement would involve experimentation on different printers. For example, a printer

with multiple nozzles could be used to create layers of “fat” and “tissue”. This product would then be evaluated by a descriptive panel to determine product acceptability.

10:40 Elevating plant-based meat: Innovating texture and precision with chemistry, engineering, and machine learning in the transformation of minimally processed legumes. **Shirin Sheikhi Zadeh. Advisor: Sajid Alavi, PhD.**

This research investigates into advancing plant-based meat production by combining minimal processing techniques, machine learning, and physics-informed modelling. Focusing on legumes like chickpeas, yellow peas, and red lentils, the study aims to improve raw material functionality, process control, and end-product quality. Specific objectives include novel techniques for obtaining minimally processed legume protein concentrates, comparative chemistry studies, and investigations into functionality and cross-linking potential. Pilot-scale extrusion will be employed for texturization, and image processing algorithms will integrate for in-depth microstructure characterization of the end product. The research seeks to establish benchmarks for protein chemistry and functionality in new-generation plant-based meats, emphasizing the significance of pulse crops as alternative protein sources. Dry fractionation of yellow peas and chickpeas will be used for its potential in addressing challenges associated with traditional extraction methods. The study will also be addressed the taste and texture limitations of current plant-based meats, emphasizing the importance of understanding protein physicochemical and functional properties. In addition, the research will explore the complexities of extrusion texturization mechanisms and proposes the integration of physics-informed machine learning to enhance predictive modelling, decision-making, and process control. The incorporation of image analysis for microstructure characterization adds a crucial dimension to the study, aiming to provide real-time insights into texture characteristics for continuous monitoring and control. The ultimate goal is to guide in generational advances in plant-based meat manufacturing, informed by a comprehensive understanding of protein processing, microstructure, and the innovative application of cutting-edge technologies.

Oral Presentations

11:00 Sourdough acidification depending on substrate availability. **Andrew Dorsch. Advisor: Hulya Dogan, PhD and Elisa Karkle, PhD.**

It was once very common for households around the world to cultivate and tend to their own active sourdough mother in which to use as leavening in fresh baked bread. That was until the late 1800’s when baker’s yeast become readily available for commercial use. Yeast became the main leavening agent within the baking industry and for home bakers. This changed the consumer expectation when it came to biologically leavened baked goods.

There is now a push towards more traditional baking methods that incorporate longer fermentation time into the baking process. This achieves flavors and provides health benefits associated with traditional sourdough. Bakers are hesitant to sacrifice time saved through the use of yeast for the sourdough benefits. Fermentation of the sourdough requires 24-48 hours to achieve a desired pH of 4.0.

There are three classifications of sourdough that are commonly utilized in the baking industry; Type I being restarted using part of a previous fermentation, Type II being adapted strains to start fermentation usually on industrial scale, and Type III which is dried and added to the dough without a traditional fermentation process (Stolz, 1995). Each process utilizes a variety of Lactobacillus species to create similar end products that we recognize as sour. These lactic acid bacteria, or LAB, help with the acidification and leavening of the dough.

It has been observed that substrates with high bran acidify quicker than those with low bran. KSU's research involves the fermentation of various fractions of hard red winter wheat that were milled and then segregated based on particle size. These fractions are then inoculated with an LAB strain commonly found in sourdough. The samples are fermented for 48 hours, the pH being taken every 4 minutes. Samples for TTA and HPLC were taken at hour 8, 18, 24, 30, and 48. Samples collected for the HPLC were analyzed to determine lactic acid production and maltose usage. It was found that the inclusion of bran did decrease the amount of time needed to achieve a pH of 4.0 if samples also had enough carbohydrate available for the metabolism of the LAB.

11:11 Functionality of kernza (intermediate wheatgrass) in sourdough fermentation and bread quality. **Brianna Iorga. Advisor: Elisa Karkle, PhD.**

Kernza, or intermediate wheatgrass (*Thinopyrum intermedium*), is a perennial wheat being developed as a wheat alternative for environmental and economic factors. With its extensive root system and ability to have a positive impact on carbon sequestration, there is potential for this grain to help create a more stable food system. Kernza is a suitable candidate for sourdough fermentation, due to its high protein, ash, and starch content. The objective of this project was to develop, characterize, and compare the final product impact of sourdoughs produced with Kernza versus a wheat control. Pin milled whole grain Kernza, two different cultivars (K6 and K7), or whole wheat flour were utilized to create a spontaneously fermented solid-state sourdough. pH and total titratable acidity (TTA) were measured daily over a 10-day period. Lactic acid, acetic acid and ethanol were quantified using HPLC (column Bio-rad 87P and 87H). Baking tests were conducted following AACC Method 10-10.03, with refined wheat flour at 100% (flour basis) and 20% (flour basis) of mature sourdough. Baked loaves were analyzed for volume (AACC Method 10-16.01), pH and TTA, firmness at day 1 and 5 post-bake (modified AACC Method 74-09.01), and shelf-life at room temperature. Both mature Kernza sourdoughs had no significant difference in pH compared to the wheat sourdough (P-value=0.08) but did show significant difference for TTA (P-value=0.00006). The development of acidity over the 10-day fermentation time was greater for both K6 and K7, indicating higher fermentation capacity. For the baked loaves there was no significant difference between both Kernza cultivars and the wheat control for loaf volume (P-value=0.76), firmness at day 1 post-bake (P-value=0.83), and firmness at day 5 post-bake (P-value=0.37). Both the whole wheat and K7 had an average of 5 days to visual mold, while K6 had an average of 6 days, despite the significantly higher concentration of acids in the baked Kernza loaves (P-value=0.0007). The data indicates that whole grain Kernza can replace whole wheat in a spontaneous sourdough process with a reduction in fermentation time, and no negative changes to the baking process or final bread quality. Visual examination of the breads revealed minimal differences in appearance. As

applications of Kernza are further explored, this grain can be a piece in fulfilling the growing demand for grains.

11:22 pLM4Alg: Protein language model-based predictors for allergenic proteins and peptides. **Zhenjiao Du. Advisor: Yonghui Li, PhD.**

The rising prevalence of allergy demands efficient and accurate bioinformatic tools to expedite allergen identification and risk assessment while also reducing wet experiment expenses and time. Recently, pre-trained protein language models (pLMs) have successfully predicted protein structure and function. However, to our best knowledge, they have not been used for predicting allergenic proteins/peptides. Therefore, this study aims to develop robust models for allergenic protein/peptide prediction using five pLMs of varying sizes and systematically assess their performance through fine-tuning with a convolutional neural network. The developed pLM4Alg models have achieved state-of-the-art performance with accuracy, Matthews correlation coefficient, and area under the curve scoring 94.1-95.5%, 0.882-0.911, and 98.3-99%, respectively. Moreover, pLM4Alg is the first model capable of handling prediction tasks involving residue-missed sequences and sequences containing non-standard amino acid residues. To facilitate easy access, a user-friendly web server (https://f6wxpfd3sh.us-east-1.awsapprunner.com/) has been established. pLM4Alg is expected to become the leading machine learning-based prediction model for allergenic peptides and proteins. Its collaboration with other predictors holds a great promise in accelerating allergy research.

11:33 Comparative analysis of the physicochemical and functional properties of plant proteins before and after extrusion texturization. **Ruoshi Xiao. Advisor: Yonghui Li, PhD.**

Plant proteins are promising alternative to animal protein sources, and public awareness of their benefits is growing. Ongoing research is intensifying its focus on using plant proteins to create meat alternatives. The use of extrusion technology can effectively generate fibrous structure from plant proteins, thereby enhancing the taste and texture of artificial meat. This study aims to understand the structural and functional changes that occur in plant proteins during the texturization process. Six different plant protein formulations based on soy, pea, and gluten before and after texturization were collected, and the extrudates were lyophilized and ground into fine powders. The samples were all analyzed for SDS-PAGE profile, secondary structure, surface hydrophobicity, free and total thiol groups, free amino groups, solubility, water/oil holding capacity, emulsification/foaming capacity and stability, least gelation concentration, and in vitro digestibility.

The protein content in each formulation is approximately 70%. After texturization, the SDS-PAGE profile of the extrudates exhibited notable bands at 75 and 50 kDa, with other bands either disappearing or reducing compared to the raw materials. The α-helix structure in the texturized proteins decreased, while there was an increase in random coil and other structural elements. The texturization process resulted in a reduction of free sulfhydryl and free amino groups in the proteins to some extent. Surface hydrophobicity of the samples reduced from a range of 54-69 μg SDS/mg protein to 35-49 μg SDS/mg protein after texturization. The texturized proteins demonstrated low solubility in phosphate buffer, but the addition of various chemical buffers significantly increased their solubility, ranging from 1% to 80%. The solubility results in various

tailored buffers indicated that disulfide bonding played a more important role than hydrogen bonding or hydrophobic interaction during protein texturization. The water holding capacity decreased, while the oil holding capacity increased slightly in the extrudates. All extrudates displayed limited emulsification, foaming, and gelation properties. In vitro digestibility of the texturized samples either slightly increased or remained unchanged compared to the raw materials.

This study enhances our comprehension of protein-protein interactions and alterations in protein properties during the texturization process, offering valuable insights for future production and broader applications of plant-based protein analogues.

11:44 AlphaFold 2-based stacking deep learning model for protein solubility prediction and food application. **Hyukjin Kwon. Advisor: Yonghui Li, PhD.**

Protein solubility is a fundamental property that significantly influences the quality, stability, and functionality of protein-based products. Accurate prediction tool for protein solubility is highly desired as it can be used for screening protein candidates for food application. Currently available prediction models often rely solely on sequence information or perform binary classification tasks, which have less engineering merit than regression. In this study, AlphaFold 2 was employed to generate 3D structures of 2,983 E. coli proteins. From the predicted structures, 20 sequence and structure features were extracted and subjected to MLP (multilayer perceptron model). Using the same structures, 3 residue level features and contact maps were utilized to construct GCN (Graph convolutional network). Finally, the two models were treated as meta-predictors, whose outputs were input into a support vector machine (SVM) for building the stacking model. The stacking model achieved R2 of 0.501 and 0.454 on test and external validation datasets, respectively, displaying state-of-the-art performance. Furthermore, the model's transferability was validated on a dataset of seed storage proteins, showing promise for application beyond recombinant proteins to food and agriculture-related ones. The proposed model could be especially valuable in screening alternative protein sources.

11:55 Starch-based food 3D printing: Impact of starch source, moisture level, and sucrose inclusion on physico-chemical properties and performance. **Conrad Kabus. Advisor: Sajid Alavi, PhD.**

Food 3D printing is an emerging technology used for the creation of innovative products. Extrusion-based 3D printing deposits ‘food ink’ through a nozzle to create shapes layer-by-layer. The performance of food inks and end-product quality rely on numerous factors that impact rheology including composition and gelling behavior. This study focused on characterizing physico-chemical properties of starch-based inks and their 3D printing performance.

Food ink mixes were formulated with a raw degermed corn and wheat base to study the impact of starch source, moisture content and sucrose as a plasticizer. Water absorption index (WAI) at room temperature, phase transition anaylsis (PTA), differential scanning calorimetry (DSC) and rapid visco analysis (RVA) were used to determine physico-chemical properties of the raw materials. DSC and RVA were again used to study the printed samples, which were also were evaluated for printing accuracy and textural properties.

Sucrose decreased the viscosity of the raw materials (2591 and 703 mPa·s, respectively, for wheat base and 12% wheat sucrose inclusion, and 4655 and 1410 mPa·s, respectively, for corn base and 12% corn sucrose inclusion), which in turn lowered water absorption for the samples due to sucrose effecting the water activity of the food ink material. A decrease in viscosity initially led to a better 3D printing performance in terms of printability, but also led to poorer printing accuracy past 8% sucrose inclusion. Additionally, higher moisture levels increased flow of materials out of the nozzle head of the 3D printer, but worsened printing accuracy. Samples tested after 3D printing exhibited partial gelatinization (Corn) or complete gelatinization (Wheat) via DSC and RVA tests.

This research acts as a gateway for a new innovative food processing method as food 3D printing can produce more intricate shapes and unique textures that traditional food processing methods. The approach outlined in this study will help design high performance food inks for 3D printing. Further studies will be informed by these results to improve starch-based food 3D printing performance and accuracy.

12:06 Effects of grain source on processing energy inputs and pellet characteristics of extruded rainbow trout feed. **Tucker Graff. Advisor: Sajid Alavi, PhD.**

Rainbow trout, among other salmonids, present a challenge in aquafeed production due to their carnivorous nature; enough dietary starch must be included to bind the extruded pellets, but carbohydrate levels must be kept low due to their limited ability to utilize and digest them. Waxy grains, primarily composed of amylopectin, offer a potential solution as amylopectin is more digestible than amylose.

Four distinct diets for rainbow trout were formulated using different grain sources: wheat, red sorghum, waxy red sorghum (WR), and waxy white sorghum (WW). The study evaluated the impact of these grain sources on several key parameters.

Specific Mechanical Energy (SME) and Specific Thermal Energy (STE) values, measured in kj/kg, displayed notable variations. SME values were lowest for the waxy sorghum diets (160.7 for WR and 178.2 for WW) and highest for traditional grains (201.7 for wheat and 190 for sorghum). STE values showed a less consistent pattern, ranging from 228.5 for WR sorghum to 185 for traditional sorghum. Grain source influenced pellet expansion, with bulk densities after extrusion being lowest for wheat and sorghum (372 and 382 g/L) and highest for WR and WW sorghum (431.5 and 422.5 g/L). The Specific Expansion Index (SEI) and piece density values exhibited a parallel trend, with SEI ranging from 1.68 (wheat) to 1.30 (WR sorghum) and piece density values varying from 0.4723 to 0.6308 g/cm^3, respectively. Water absorption followed the expected trend, with WR pellets absorbing 88.8% water by weight, and wheat-based pellets absorbing 123.8%. Floating characteristics were observed in all pellets formulated from wheat and sorghum-based diets. However, WR pellets exhibited a tendency to sink, with only 58.7% remaining afloat after five minutes and 49.7% after thirty minutes. In contrast, WW pellets displayed improved buoyancy, with 74% floating after five minutes and 87.3% remaining afloat after 30 minutes, despite having similar bulk density, SEI, and piece density values.

Overall, waxy grain inclusion led to decreased SME inputs, resulting in inferior pellet qualities such as lower floatability and reduced expansion. A 12-week growth study is scheduled to start later this year to evaluate the impact on growth rates.

12:17 Kernza and sorghum as sustainable ingredients in extruded precooked pasta and quality analysis. **Julia Rivera. Advisor: Sajid Alavi, PhD.**

This research investigates the utilization of kernza, wheat, and sorghum, either individually or in combination, as primary ingredients for extruded precooked pasta. Kernza, a perennial grain known for its deep roots, presents opportunities for reducing soil erosion and enhancing carbon sequestration. In contrast, wheat, a staple in pasta production, is often associated with resource-intensive farming practices, while drought-resistant sorghum offers a sustainable alternative, particularly in water-scarce regions. This study assesses the technical feasibility of producing precooked pasta using these grains with the aim of mitigating the ecological footprint of pasta manufacturing. Six distinct pasta formulations were extruded, incorporating wheat flour, kernza flour, sorghum flour, and various 50/50 flour combinations using a pilot-scale twin-screw extruder. Comprehensive analyses were conducted on both the raw materials and extruded samples to evaluate ingredient functionality, the degree of degradation, extent of gelatinization, and texture characteristics. Precooked pasta prepared with wheat flour, as well as the wheat/kernza formulation, exhibited the highest cooking loss percentage (5.6%). In contrast, sorghum and other combined formulations demonstrated significantly lower cooking loss percentages (1.7%). This research underscores the potential to enhance sustainability and quality in precooked pasta production. Utilizing kernza, wheat, and sorghum in pasta formulations can yield products that meet quality standards while simultaneously reducing resource inputs and environmental impact. These findings offer a promising path toward a more sustainable future for pasta production, with substantial implications for the food industry. Future investigations will delve into life cycle assessments and consumer acceptance insights, further solidifying the case for adopting these innovative grain combinations in pasta manufacturing.

12:28 Wheat bran antioxidants elevate human induced pluripotent stem cells and human embryonic stem cells' growth performance. **Md Sharifur Rahman. Advisor: Xiuzhi Susan Sun, PhD.**

Md Sharifur Rahman, Guangyan Qi, Quan Li, Cheng Li, Xuming Liu, Yonghui Li, Jianfa Bai, Xiuzhi Susan Sun*

Wheat bran, a rich source of polyphenols, mostly phenolic acids including gallic acid, ferulic acid, syringic acid, etc. exhibits remarkable antioxidant potency compared to other milled wheat fractions. In this study, we investigated the impact of hydrolyzed arabinoxylan oligomers linked with ferulic acid from hard wheat bran on human induced pluripotent stem cells (hiPSC) and human embryonic stem cells (hESC). Both cell types were cultured in a three-dimensional (3D) matrix and exposed to varying concentrations (30, 100, and 500 μg/ml cell suspension) of these antioxidants extracts. Our findings revealed that hiPSCs treated with 100 μg of antioxidants per ml of cell suspension exhibited a significantly higher fold expansion (22.31±1.45) than the control (16.38±0.82). Moreover, these antioxidant-treated hiPSCs displayed an impressive 97.57±0.65% viability, maintained excellent cell morphology, and exhibited optimal spheroid size. hESCs showed slightly enhanced growth performance when exposed to 30 μg antioxidants per ml cell suspension. Furthermore, the relative expression of pluripotency markers in both

hiPSCs and hESCs disclosed that antioxidant induction also maintained the stem integrity of the cells. Therefore, our results demonstrated for the first time that wheat bran antioxidants elevate hiPSC and hESC's growth performance.

12:39 Efficacy of two amorphous silica powders applied to soft red winter wheat against the lesser grain borer, *Rhyzopertha dominica* (Fabricius). **Manivannan Selladurai. Advisor: Bhadriraju Subramanyam, PhD.**

Amorphous silica powders 1 and 2 with different elemental composition, were procured from Imerys Chemicals, Lompoc, California, and applied to wheat to determine efficacy against the lesser grain borer, *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae). The efficacy of the two silica powders was determined by exposing 25 adults to 100 g of wheat treated with 0, 0.05, 0.1, 0.15 and 0.20 g/kg. Mortality assessment was made after 14 d, and data on adult progeny production, insect damaged kernels and weight loss for each powder-concentration combination were recorded after 42 d. Percentage mortality, adult progeny production, number of insect damaged kernels and weight loss data were subjected to one-way ANOVA and mean separations were done using REGWQ procedure. Complete mortality of R. dominica adults was not achieved at any silica powder 1 concentrations; however, 100% mortality was observed on wheat treated with 0.20 g/kg of silica powder 2. Adult progeny production of R. dominica was completely inhibited by silica powder 2 concentration of 0.20 g/kg, whereas progeny production was not wholly suppressed at any silica powder 1 concentrations. Insect damaged kernels and weight loss was not observed when adults of R. dominica were exposed to wheat treated with 0.15 and 20 g/kg concentrations of silica powder 2. Silica powder 2 was consistently more efficacious than silica powder 1, and the greater efficacy of silica powder 2 can be attributed to its higher oil absorption capability.

12:50 Development and progeny production of lesser grain borer, *Rhyzopertha dominica* (Fabricius) on hulled, dehulled Kernza® and wheat. **Fizra Ahmad. Advisor: Bhadriraju Subramanyam, PhD.**

Kernza® (*Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey, KernzaTM), is a lowinput perennial cool-season intermediate wheatgrass, grown as a dual-purpose crop for highquality grazing in the winter and for nutritious whole grain in the summer. No data are available on Kernza® grain susceptibility to stored-product insects. Susceptibility of hulled Kernza®, dehulled Kernza® and hard red winter wheat to infestation by the lesser grain borer, *Rhyzopertha dominica* (Fabricius) (Coleoptera; Bostrichidae), was evaluated in the laboratory. Twenty-five mixed sex adults were exposed to 50 g replicates of each of the grain types at 28 °C and 65% relative humidity. Adult mortality along with moisture content was assessed at 7, 14, 21, 28, 35, 42, and 56 d in independent samples. Adult progeny production and weight loss assessment was done only in 35, 42, and 56 d samples. Low survivorship of *R. dominica* was observed on hulled Kernza®. Progeny production and grain damage at 35 to 56 d varied with grain type but was generally lowest on hulled Kernza®. Results suggested that hulled Kernza® appears to be an unsuitable commodity for *R. dominica* to complete their development as compared to dehulled Kernza® and hard red winter wheat.

1:01 Efficacy of grain protectants on hulled and dehulled Kernza® against *Sitophilus oryzae* (L.). **Natasha Bhattarai. Advisor: Bhadriraju Subramanyam, PhD.**

The efficacy of commercial formulations of grain protectants, deltamethrin and deltamethrin plus methoprene on hulled and dehulled Kernza® against *Sitophilus oryzae* (L.) (rice weevil), was evaluated in the laboratory. No grain protectants are currently registered for use on this perennial grass (*Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey), marketed under the trade name Kernza®. Phosphine is the only fumigant approved for treating perennial grasses. The concentrations of the protectants used were 0.5 and 1 ppm for deltamethrin and 0.5 ppm deltamethrin plus 1.25 ppm methoprene as a combination product. Mortality was assessed after 7, 14 and 21 days of the application of protectants and insect introduction. Mortality of the insects was expressed as percentage of the total insects exposed. In separate replicates, grain was infested and observed at 42 d for progeny production and weight loss. After determination of progeny production, the grains were passed through Boerner® divider to get a representative sample of 6 g for wheat and 1.5 g for hulled and dehulled Kernza®. The number of damaged kernels was assessed and expressed as a percentage. The performance of grain protectants in hulled and dehulled Kernza® was compared with hard red winter wheat. The number of damaged kernels was assessed and expressed as a percentage. The performance of grain protectants in hulled and dehulled Kernza® was compared with hard red winter wheat. The goal is to identify suitable grain protectants for use to protect Kernza® grains in storage from insect infestation.

1:12 Comparison of different methods to measure damaged starch content in pulse flours with different particle sizes. **Bei Shen. Advisors: Yong-Cheng Shi, PhD. and Yonghui Li, PhD.**

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Pulses(Chickpea, yellow pea and lentil) are highly nutritious and recommended as staple food by health organizations and dieticians because they are rich sources of different nutrients. During milling, starch granules are altered, broken, or squashed resulting in damaged starch which can significantly affect flours' quality and performance in baking and food applications.

There are two main approaches to measure damaged starch content in flour. The amperometric method (AACC 76-33.01) is often used as a rapid estimation and is based on the principle that the intact starch granules and damaged starch granules have different iodine binding capacities. The enzymatic method (AACC 76-31), available as a Megazyme Kit, is based on the principle that damaged starch granules are more susceptible to enzyme hydrolysis. In the enzymatic method, starch is hydrolyzed by fungal α-amylase into maltosaccharides and dextrins and then further hydrolyzed by α-amyloglucosidase to glucose which is quantified. The objective of this study was to use those two methods to determine and compare the damaged starch in pulse flours with different particle sizes.

Pulse kernels were milled by a laboratory scale Ross roller mill(Model 915, Ross Machine and Mill Supply, Oklahoma City, OK, USA). The rolls gap and sieve arrangement were adjusted accordingly to produce small, medium and coarse particle size samples. Particle size distributions were analyzed by Malvern Morphologi G3SE(Malvern instruments, Malvern, UK).As the damaged starch contents decreased with the increase of flour particle size in the enzymatic method, but the trend was different in the amperometric method. The damaged starch content in pulse flours were all below 2% by the enzymatic method. In contrast, the damage starch content

in amperometric method increased with an increase in flour particle size except yellow pea medium size flour. A sharp increase from 4.958% to 21.681% was observed in the amperometric method (citric acid) from chickpea flour with medium size(VMD 35.86μm)to chickpea flour with coarse size(VMD 46.12μm). Overall, the amperometric method gave much higher damaged starch content than enzymatic method. This study raised a question on how the amperometric method (SDmatic AACC 76-33.01) may be used for pulse flours, and that merits further studies.

1:23 Iodine staining of waxy sorghum kernels and the isolated sorghum starch. **Ying Huang. Advisor: Yong-Cheng Shi, PhD.**

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In normal sorghum, starch contains approximately 25% amylose and 75% amylopectin. Waxy sorghum contains essentially amylopectin in its endosperm starch and has special starch properties that could be used as value-added food ingredients and increase its value compared with normal sorghum. The objectives of this study were to identify waxy sorghum starches with high viscosity and good cold storage stability and compare their properties with waxy maize starch. A quick method was developed to differentiate waxy sorghum and normal sorghum. The amylose-free sorghum starch can be stained reddish-brown, and starch with normal amylose-amylopectin mixture stains dark blue. Thirty-five samples were identified and examined and their contamination of normal starch in waxy sorghum starch was calculated. Three methods to isolate sorghum starch were developed, which are wet milling, enzyme treatment of decorticated sorghum grains, and enzyme treatment of the whole sorghum grains. Waxy sorghum starch isolated by the enzyme treatment of decorticated sorghum grains had about 4% higher recovery than the other two methods. The starch isolated by three methods all had good purity (protein < 0.5%, ash <0.16%). Gelatinization and pasting properties of the isolated starch by three methods were also compared. The starch isolated by wet milling had about 200-400 lower peak and breakdown viscosity than the other two methods. Compared with waxy maize starch, waxy sorghum starches had higher pasting temperatures and peak viscosity.

1:34 Thermal properties of pulses flours with different moisture contents. **Jing Qi. Advisor: Yong-Cheng Shi, PhD.**

Jing Qi, Bei Shen, Yonghui Li, and Yong-Cheng Shi*

Pulses, including dried peas, lentils, and chickpeas, are known for their nutritional value and are high in protein, dietary fiber, slowly digesting starch (SDS) and resistant starch (RS). Consumption of pulses has been linked to many health benefits including protection against chronic diseases like diabetes and cardiovascular disease. The presence of dietary fiber, SDS, and RS in pulses helps reduce glycemic response, delay gastric emptying, and increase satiety after meal.

Although pulses are naturally high in RS, RS levels may be reduced after cooking or processing. Heat-moisture treatment (HMT) with low moisture content (<30%) and temperatures (80-140°C) has been used to increase the SDS and RS content of starches from corn, pea, and lentils. In

addition to increasing the RS content, HMT below the gelatinization onset temperature can also change physicochemical properties such as gelatinization, swelling and pasting properties of starches and flours, without causing starch gelatinization.

The objectives of this study were to determine the gelatinization temperatures of pulse flours at different moisture contents and establish the state diagrams. These state diagrams will guide us to select processing conditions for increasing SDS and RS content in pulse flours. Specifically, we investigated the thermal properties of yellow pea, chickpea, and red lentil flours at different moisture contents using differential scanning calorimetry (DSC) (heating the samples from 10°C to 180°C at 5°C/min, then cooling to 10°C, holding for 1 min before reheating to 180°C at the same rate).

Our results showed different thermal behaviors in pulse flours at varying moisture levels. When moisture exceeded 50%, a main peak with a small shoulder and two tailing peaks at higher temperatures appeared. We identified the peaks associated with the melting of fats by comparing defatted and whole flours. Defatted flour, treated with α-amylase at 80°C for 30 minutes at 75% moisture which hydrolyzed starch, showed denatured proteins at around 80°C. Absence of starch gelatinization peak after α-amylase digestion, aided in identifying endothermic peak from starch gelatinization. These findings helped create state diagrams for pulse flours and select HMT conditions to improve RS and SDS content, enhancing pulse-based food ingredients for healthier dietary choices.

Graduate Posters

1. Impact of cricket protein powder addition on wheat dough properties and bread quality. **Mayra Perez-Fajardo. Advisor: Hulya Dogan, PhD.**

   Use of alternative protein sources have become more popular due to a continuing rise in population, environmental concerns, and a shift in consumers' demands for eating more sustainable foods. As an emerging novel protein source, insect proteins, provide many benefits such as requiring fewer resources compared to the traditional raising of livestock and having lower greenhouse gas emissions than beef, poultry, and pork. Nutritionally, insects are high in protein content and are a good source of B vitamins. However, not much research has been done on their incorporation into food formulations. Thus, the objective of this study was to see how the incorporation of cricket protein powder would affect the dough properties and the end-product characteristics of wheat bread. Two commercially available cricket protein powders, Entomo Farms (E) and GrioPro (G) were first characterized for their functional properties by evaluating their protein solubility and water holding capacities. 10 or 20% incorporations of E and G into wheat doughs were evaluated for dough development properties, dough extensibility, and change in wheat protein composition in the doughs. Breads were baked containing 5, 10, or 20% inclusions of E or G and underwent color, texture, and staling analysis. In general, incorporation of powders G and E led to two opposite effects. Dough samples with powder E showed lower peak areas (9,432 and 17,346 mAu) of IPP compared to the control (23360 mAu) while the SPP dough samples showed higher peak areas (41,414 and 44,133 mAu) to the control (41,212 mAu). Replacement of wheat flour with powder G led to doughs with increased stability, significantly higher C1 torque (20% level), and increased water absorption. Replacement of wheat flour with powder E led to softer doughs

with decreased stability at the 20% replacement level and no significant difference in water absorption. Extensibility and loaf volume was significantly decreased as the replacement level increased for all treatments. Both powder E and G TPA results showed a significant increase in hardness at higher replacement levels with G being harder than E.

2. Effect of Ultrasound tempering on roller milling of a white non-tannin and r red-tannin sorghum. **Manoj Kumar Pulivarthi. Advisor: Kaliramesh Siliveru, PhD.**

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Sorghum, a nutritious and gluten-free cereal crop, is currently underutilized with one roadblock to increased utilization being the absence of standardized milling technology. Most existing milling methods adopted from other crops yield inferior flour quality with excessive endosperm loss. However, implementing appropriate tempering techniques prior to roller milling can enhance flour characteristics and yields. In this study, a roller milling technology was developed using a laboratory-scale roller mill to produce high-quality sorghum flour suitable for gluten-free applications. Ultrasound treatments were conducted using a probe-type ultrasound device with a frequency of 20kHz and a power level of 600W. The kernels were soaked in water (1:1 w/v) and subjected to ultrasound treatment for 1, 1.5, and 2 min, set at 75% amplitude. After the treatment, the kernels were drained, surface dried, and allowed to rest for 24 hours in sealed polythene bags to achieve a target moisture level of 17%. The effect of ultrasound tempering (UST) of a nontannin white and red-tannin sorghum varieties on milling and flour characteristics was investigated. The results were compared to sorghum milled using a standard tempering process (17% moisture, 24h). Ultrasound tempering (UST) exhibited a significant impact on milling and flour quality in terms of milling yield, particle size, damaged starch, and ash contents. UST resulted in a significant reduction in the hardness index of both the white sorghum (72.57-73.61 from 79.02 (control)) and the red-tannin sorghum (76.22-78.29 from 84.50 (control)). Notably, the milling yield of the white sorghum showed a significant increase with treatment times, from 73.31% (control) to 76.56-78.16%. The red-tannin sorghum milled using the 60-second UST resulted in a higher bran yield (5.67%) compared to the standard tempering method (1.7%), indicating an improvement in milling efficiency. The 60-second UST resulted in efficient bran separation and improved ash contents for both the white (0.87%) and red-tannin (0.69%) sorghum, as compared to their respective controls (1.05% and 1.4%). Overall, the developed milling flowsheet was suitable for both the white and red-tannin varieties, regardless of their differences in physical properties and the use of UST has significantly improved the flour quality of both samples.

3. Tempering vs soaking: Differences in the breakage behavior of single wheat kernels. **Anu Suprabha Raj. Advisor: Kaliramesh Siliveru, PhD.**

Anu Suprabha Raj, Hulya Dogan, and Kaliramesh Siliveru*

Tempering is the process of adding water to wheat before milling to toughen the bran and

mellow the endosperm. Compared to soaking, the availability of water is limited in this process. This limitation influences the moisture migration inside the kernels and, consequently, their breakage behavior. This study aims to examine the breakage behavior of wheat kernels using uniaxial compression tests with a texture analyzer (TA. XT, Stable Micro Systems, U.K). The force-deformation curves of the wheat kernels were evaluated over a 12-hour period. Soaked kernels were studied every hour, while tempered kernels (with moisture contents of 14%, 16%, and 18% on a wet basis) were analyzed at three-hour intervals. For each test, individual kernels were placed in the most stable position between two parallel plates and compressed until rupture. To ensure quasi-static compression, a loading rate of 0.1 mm/s was adopted. The compressive strength of the kernels, calculated from the peak force and the equivalent diameter (Dp) of the kernels, varied with tempering time (for soaked samples) and tempering moisture (for tempered samples). By performing quasi-static compression experiments, the compression failure force and breakage probability was comprehensively evaluated. The findings will assist in optimizing the tempering process (including time) and thereby improving its efficiency.

4. Mitigating *Salmonella* contamination in pizza dough: Cold plasma-based hurdle interventions. **Shivaprasad DP. Advisor: Kaliramesh Siliveru, PhD.**

   Wheat, a crucial part of human diets, faces a significant food safety threat due to potential microbial contamination throughout its production and processing. This vulnerability exposes wheat to various sources of intrusion, including harmful pathogens like Salmonella, posing risks to wheat-based foods. Recent incidents, like the 2022 French outbreak and the 2023 pizza recall, highlight these dangers, with investigations tracing the pathogens back to wheat flour. This underscores the ongoing threat of these harmful microorganisms in wheat products. Organic wheat flour was inoculated with Salmonella (cocktail) and dried for ~6 h at 37°C until it reached its pre-inoculated weight. Subsequently, the wheat flour was exposed to plasma generated in the air for 15 minutes. The pizza dough prepared using plasma-activated water was further subjected to in-package cold plasma treatment (generated in atmospheric pressure air at 30kV) to extend its shelf life. The reduction of the pathogenic load was evaluated by plating them on xylose lysine deoxycholate agar (XLD) after serial dilution.The study's findings revealed that pizza dough prepared from wheat flour exposed to atmospheric cold plasma and the use of plasma-activated water reduced the *Salmonella* load at least by 3 log CFU/g. Furthermore, in-package cold plasma exposure of packaged pizza dough further reduced the Salmonella load by 1 Log CFU/g. The results from this study have the potential to be utilized for developing more effective methods for improving the food safety of pizza dough against Salmonella contamination.

5. Evaluation of sorghum pericarp varieties on blood parameters and antioxidant capacity in healthy adult dogs. **Katelyn Bailey. Advisor: Greg Aldrich, PhD.**

   Ingredients that provide health benefits are popular in the pet food industry. The polyphenols present in the sorghum pericarp may offer health benefits owing to their antioxidant properties, enhancing the nutritional value of sorghum in pet food. Few pet food studies have evaluated the antioxidant capacity of sorghum differing in pericarp color. The objective of this study was to evaluate the effect of sorghum varieties on blood parameters and antioxidant capacity in dogs. Nutritionally complete experimental diets were extruded with a 50% inclusion of either rice, white sorghum A or B, or burgundy sorghum. Twelve dogs were fed dietary treatments in a replicated 4 x 4 Latin square design consisting of 14-day periods. Blood samples were taken from

each dog prior to starting the trial, for baseline antioxidant capacity, and at the end of each period. Blood samples stored at -80C until being analyzed for complete blood count, chemistry profiles (Kansas State University Veterinary Diagnostics Lab, Manhattan, KS), and oxygen radical absorbance capacity (ORAC). Data was analyzed using a mixed model with statistical analysis software (SAS version 9.4, SAS Institute, Inc., Cary, NC) with treatment and period as fixed effects and dog as a random effect. Red blood cell distribution width was highest in dogs fed white sorghum A at 12.9% and lowest in dogs fed white sorghum B at 12.7% ($P < 0.05$). The anion gap was highest for dogs fed the rice treatment at 24.6 mmol/L and lowest for dogs fed white sorghum A at 22.8 mmol/L ($P < 0.05$). Cholesterol was higher ($P < 0.05$) in dogs fed the rice treatment at 246.0 mg/dL compared to the three sorghum varieties (average, 225 mg/dL). Despite the few differences in blood parameters, all were within normal ranges for healthy dogs. There was no difference in plasma ORAC between treatments ($P > 0.05$). In conclusion, sorghum resulted in normal blood profiles and did not alter plasma antioxidant capacity compared to the rice control when fed to dogs. If antioxidant potential is desired, a concentrated pericarp (bran) extract may be necessary.

6. Impact of whole pulse flour incorporation from red bean, navy bean and cowpea on whole wheat flour bread quality. **Bipin Rajpurohit. Advisor: Yonghui Li, PhD.**

   Recent years have seen increased consumption of pulses owing to their sustainability, lower cost and increased availability. Nutritionally, pulses are good sources of protein, dietary fiber, minerals, and vitamins. Therefore, the incorporation of pulse flour in whole wheat flour may enhance its nutritional profile. The amino acids of cereals and pulses complement each other. This research aimed to study the impact of whole-pulse flour incorporation on the quality of whole-wheat flour bread. Whole pulse flour from three pulses, namely red bean, navy bean, and cowpea were substituted in commercial whole wheat flour at 5, 10, and 15%. Flour tests included proximate analysis and water retention capacity. Mixograph was done to estimate the optimum water absorption and mixing time. The rapid visco analyzer (RVA) test was done to determine flour pasting properties. Finally, baking tests were done and bread quality was determined by specific loaf volume, texture profile analysis (TPA), C cell analysis, color analysis, and sensory analysis. Differences in treatment means were determined by analysis of variance (ANOVA) and Tukey–Kramer grouping was used at a significance level of $p < .05$ using SAS Online Studio. The protein content of the composite flours was significantly increased with any level of substitution of navy bean flour (to a maximum of 17.15% dry matter basis) and 15% substitution of cowpea flour. The pulse flour substitution increased the composite flours' solvent retention capacity. However, the peak viscosity and the final viscosity of the composite flours were not affected by pulse flour incorporation. All pulse types and levels of incorporation decreased the specific loaf volume except for 5% whole navy bean flour incorporation. Bread made with 15% substitution of any pulse type and 10% cowpea flour was significantly harder than the control bread. Sensory evaluation of bread made with all treatments of navy bean flour showed no difference in overall acceptability up to 10% substitution. Overall, navy bean flour substitution up to 10% was found to be more favorable with the potential to increase protein content and the least negative effect on bread quality.

7. Extraction characteristics, physicochemical and functional properties of salt extracted pulse proteins. **Bipin Rajpurohit. Advisor: Yonghui Li, PhD.**

In recent years, there has been a huge interest in plant-based proteins owing to their nutrition and better sustainability. Pulses are an excellent source of plant-based protein owing to their high protein content, nutrition, availability, and lower cost of production. The most common wet fractionation process for protein extraction involves alkaline dissolution followed by isoelectric precipitation which involves harsh pH conditions. The aim of our study was to use the alternative salt extraction method that does not require extreme pH and investigate the physicochemical and functional properties of the extracted proteins. Sixteen different types of pulses representing wide genetic variation were selected for the study. After salt extraction, protein functionality was determined using tests namely, oil and water holding capacity (OHC and WHC), solubility, emulsification capacity (EC) and emulsification stability (ES), foaming capacity (FC) and foaming stability (FS), and gelation property. Additional tests included Differential scanning calorimetry (DSC) to determine thermal stability and sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE). For getting nutritional information, in-vitro protein digestibility corrected amino acid score (PDCAAS) and amino acid profile tests will be conducted. Most of the protein extractions had a protein recovery of more than 30% except for moth bean protein (10.2%). The highest recovery was observed for Bambara bean protein (58.8%). All the proteins had a purity higher than 80% except for red bean protein (77%) and moth bean protein (69%). The OHC and WHC of the proteins ranged from 2.03-4.06 g oil/ g protein and 0.34-4.68 g water/g protein, respectively. For EC and ES, the values ranged from 59-91% and 60-86%, respectively with red bean protein having the highest value. For FC and FS, the values ranged from 25-96% and 20-101%, respectively, with red bean protein having the highest and velvet bean protein having the lowest values. The lowest thermal denaturation temperature was for mung bean protein (87° C) and the highest was for velvet bean protein (107° C). The significance of the research lies in the comprehensive evaluation of the techno-functionality of a wide range of pulse proteins for potential food applications.

8. Comparative evaluation of microorganisms for biological treatment of hydrothermal liquefaction wastewater from sewage sludge. **Meicen Liu. Advisor: Yi Zheng, PhD.**

   Hydrothermal liquefaction (HTL) is a promising thermochemical process to convert wet biomass (e.g., sewage sludge, microalgae, food waste etc.) into biofuel. However, HTL generates a large amount of wastewater that needs to be properly treated before being discharged into the environment. Compared with anaerobic digestion and microalgae cultivation, the biological treatment of HTL wastewater (HTLWW) with other microorganisms was less studied. In addition, HTLWW biodegradation via filamentous fungi has not been evaluated previously, to our knowledge.

   In this study, three bacterial strains (*Rhodococcus jostii* strain RHA1, *Pseudomonas putida* strains ATCC 31800 and NRRL 14878) and four fungal strains (*Aspergillus niger* strain NRRL 2001, *Trametes versicolor* strain ATCC 12679, *Phanerochaete chrysosporium* strain BKM-F-1767, and a yeast isolate (identified as *Rhodotorula mucilaginosa*)) were used to treat HTLWW from sewage sludge. Screening experiments were conducted to establish the suitable pH and nutrient supplementation for each microorganism when grown in the HTLWW. Significantly enhanced growth of the bacterial strains and fungal strains can be achieved in 10-

fold and 20-fold diluted HTLWW, respectively, by adjusting pH and supplementing the combinations of P, Mg, Ca, and Fe sources as determined in the screening experiments.

The removal rate of COD and 16 major chemical compounds during cultivation of the microbial strains in sludge HTLWW were quantified. *A. niger* strain NRRL 2001 and *T. versicolor* strain ATCC 12679 were shown to be the best strains for sludge HTLWW degradation, which removed over 90% of the major organic acids and phenolic compounds in the wastewater and around 50% of COD. The biodegradation results by different microbes determined in this study can be used to develop co-culture systems that target HTLWW of different composition and upgrade HTLWW into useful products.

9. Biological upgrading of starch to anti-cancer compounds by *Thraustochytrium striatum*. **Sang Li. Advisor: Yi Zheng, PhD.**

   Thraustochytrium striatum, a marine protist can grow on starch using its own amylolytic enzyme system while producing bioactive extracellular polysaccharides (EPSs) that was found to have anticancer activities. In this study, various starches, including soluble starch, corn starch, wheat starch, waxy starch, and high-amylose starch are studied as substrates to grow *T. striatum* for EPSs production. The bioavailability of starches to *T. striatum* and starch loading are investigated on cell growth and EPSs production. The antioxidant activities of EPSs from different starchy substrates are measured and their anticancer activities are analyzed on HepG2 and Hela cells using both 2D and 3D systems and the EPSs reduced the viability of cancer cell mostly will be selected for future study. The EPSs are characterized in chemical compositions and structures to reveal the anticancer mechanisms.

10. Comparing the effects of different antimicrobial treatments on reducing the *E. coli* load of wheat during tempering. **Jared Lou Rivera. Advisor: Kaliramesh Siliveru, PhD.**

    Various interventions applied during the wheat tempering step have been developed to reduce *E. coli* contamination in wheat grains. These treatments have produced varying reductions, which allow the use of inactivation models to properly compare their efficacies. The objective for this study is to model the inactivation of *E. coli* in wheat grains under different tempering treatments. Existing data on the various tempering treatments used (acidic water tempering, heating, and bacteriophage tempering) were included in this study. The log-linear and Weibull inactivation models were then fitted into the data sets. Model fit was assessed based on the adjusted R2, and standard error (SE) values of the models. Inactivation parameters for the treatments used (D-value, delta, and time to 3-log reduction) were then compared. The Weibull model (adj R2 - 0.7177 to 0.997; SE – 0.0441 to 0.9616 log CFU/ g) was a better fit than the log-linear model (adj R2 - 0.1770 to 0.8983; SE – 0.1163 to 1.4778 log CFU/ g) in describing the inactivation of *E. coli* in wheat grains under the tempering treatments used. The Weibull inactivation parameters (delta, and time for a 3-log reduction) show that thermal treatments (delta – 0.20 to 0.51 h; 3-log reduction time – 2.11 to 5.10 h) were more effective than the non-thermal treatments used such as acidic water and bacteriophage tempering (delta – 0.3 to 1.00 h; 3-log reduction time - 6.24 h to 30.44 h). These inactivation parameters were lower ($P < 0.05$) than using water as a tempering agent (delta – 54.5 h; time for 3-log reduction – 245.8 h). The shape parameter (β) for the tempering treatments were all < 1 (0.125 to 0.675), which indicates that the reductions observed for *E. coli* decreases with longer tempering times. The results indicate that *E. coli* inactivation in wheat grains is non-linear and that thermal treatments

(alone or in combination with acidic water tempering) are more effective as faster inactivation rates (< 6 h) for *E. coli* in wheat grains can be achieved. The results from this study can be used as basis for selecting suitable tempering agents for wheat grains to reduce *E. coli* contamination.

11. Utilization of dried bakery products as an ingredient in extruded pet food. **Larissa Alves Koulicoff. Advisor: Greg Aldrich, PhD.**

    Utilizing up-cycled materials such as Dried Bakery Products (DBP) in pet food formulations presents an opportunity to improve sustainability in the pet food industry. The DBP is a human food by-product defined as a mixture of bread, cookies, cake, crackers, flours, and doughs which has been mechanically separated from non-edible material, artificially dried and ground. Due to the range of materials that go into DBP, its composition can vary depending on the location and practices of the manufacturer. This study aimed to evaluate variability among production facilities and the use of DBP in extruded pet foods. Six different manufacturing facilities supplied DBP from six different production dates. Raw materials were analyzed for nutritiona composition, total starch content, functionality and swelling properties using rapid viscoanalyzer. A mixture containing 25% DPB from each location plus 75% of a pet food mixture (48% ground corn, 29% poultry by-product meal, 12% corn gluten meal, 10% rice, 1% vitamins and minerals), and a control treatment containing the mixture only, were extruded using a lab-scale twin screw extruder with screw diameter of 18mm (Micro-18, American Leistritz, Somerville, NJ). Statistical analysis was conducted in R software using *nlme* package, and a P-value < 0.05 was considered significant. Treatment means were tested using Tukey's adjustment in *emmeans* package. Moisture, protein, fat, total dietary fiber, and nitrogen free extract were different across the six different locations ($P < 0.05$). Ash and total starch did not differ by location ($P > 0.05$). For the extruded products, specific mechanical energy was 161.3 kJ/kg for Control, 129.0 kJ/kg for California-1, 112.9 kJ/kg for California-2, 112.9 kJ/kg for Texas, 80.6 kJ/kg for Georgia, 64.5 kJ/kg for Kansas, and 48.4 kJ/kg for Maryland. Moreover, expansion of the products reflected the specific mechanical energy results. Kansas facility resulted in the lowest expansion, whereas increased for the Maryland, and was greatest for the Texas product. The Control and locations California-1, California-2 and Georgia were similar in expansion to Texas and Maryland ($P > 0.05$) plants. Extruding pet food with DBP as an ingredient was feasible, but different manufacturing locations affected ingredient composition and product expansion.

12. Effects of inoculation dosage and fermentation duration on crude protein content increase and in-vitro protein digestibility of soybean meal fermented by Aspergillus Oryzae. **Youhan Chen Advisor: Greg Aldrich, PhD.**

    Soybean meal inclusion is limited in pet food partly due to its relatively lower protein quality compared to common animal protein sources in pet diets. Fermentation of soybean meal by Aspergillus oryzae may improve the overall protein quality of this ingredient by increasing crude protein content and digestibility. Objective of this study was to determine the ideal inoculation dosage of A. oryzae and fermentation duration to improve protein quality of soybean meal. Retorted soybean meal samples were inoculated with A. oryzae at 1×104, 5×105, or 1×106 spore/g in 3 replicates. One replicate from each dosage was placed at a certain position in the incubator under controlled temperature and relative humidity, and fermented on the same starting

day. There were 3 fermentation sessions starting on 3 different days. Samples of fermented soybean meal were taken at 0, 12, 24, 36 and 48 h and dried at 65 ℃ for 36 h. A 2-way ANOVA was performed to analyze the effect of inoculation dosage, fermentation duration and their interaction on crude protein content and in-vitro protein digestibility with a significance level of 0.05 by SAS (version 9.4, SAS Institute, Inc., Cary, NC). Treatment means were separated by Tukey's test. Crude protein of soybean meal inoculated at 5×105 spore/g increased 3.29% significantly ($p=0.0286$) at 24 h (51.66%) compared to 0 h (48.37%) and continued to grow until the end while other inoculation levels did not lead to difference in crude protein content over time. There was no difference in crude protein content among fermented soybean meal harvested at 24, 36, or 48 h regardless of dosage. No interaction effect ($p=0.9712$) was detected on crude protein content. Meanwhile, in-vitro protein digestibility was similar among fermented soybean meal regardless of the dosage ($p=0.4073$), fermentation duration ($p=0.9290$) and interaction effect ($p=0.9989$). As such, inoculating soybean meal with A. oryzae at 5×105 spore/g followed by 24 h fermentation is a reasonable protocol to increase crude protein content of soybean meal without negatively impact in-vitro protein digestibility.