Book of Abstracts

14th Annual
Grain Science Graduate Student Research Symposium

November 3rd, 2022

International Grains Program (IGP) Institute Conference Center

Oral Presentations

9:45 Efficacy of silica powders on mortality and progeny production of the lesser grain borer, Rhyzopertha dominica (F.) (Coleoptera: Bostrichidae). **Manivannan Selladurai. Advisor: Bhadriraju Subramanyam, PhD.**

The lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera:Bostrichidae), is a serious insect pest of stored grains and is managed using synthetic insecticides. Such use has resulted in development of insect resistance. Inert dusts are chemically unreactive, are safer alternatives to synthetic insecticides, and resistance in insects is not an issue. This study evaluated efficacy of two silica powders for managing *R. dominica* on concrete surfaces. The particle size and shape of the two silica powders, obtained from Imerys Chemicals, Lompac, California, were analyzed using a Malvern Morphologi G3 SE instrument. Bioassays were performed by exposing adults to silica powders-treated concrete arenas in 9 cm Petri dishes at 13 concentrations ranging from 0-5 g/m2 with exposure times of 4, 8, 12, 24, 36 and 48 h. After exposure adults were transferred to 30 ml round plastic containers with 30 g of wheat to determine mortality at 7 d and adult progeny production at 42 d. Mortality and progeny production data were analyzed using three and one-way ANOVA at $\alpha = 0.05$ and mean separations were done using REGWQ procedure. Individual and pooled models were fit for the mortality and progeny production data for both the silica powders using TableCurve 2D software. Each possible pairwise comparison between exposures for each set of data was done by comparing individual models to a pooled model. The particle size diameter of silica powder 2 was significantly greater compared to silica powder 1 at D_{10}, D_{50} and D_{90} µm diameters. Between the silica powders, adults were extremely susceptible to silica powder 2 leading to complete mortality of adults and inhibition of adult progeny production at a concentration of 0.5 g/m2 after the 4 h exposure, but with silica powder 1, complete mortality and inhibition of progeny production occurred at the same concentration after a 24 h exposure. The implications of the present study indicated that the application of silica powders to concrete surfaces such as empty bins can be very effective in managing *R. dominica* population prior to storage of new grains.

9:57 Application of encapsulated and dry-plated organic acidulants to control Salmonella enterica in raw meat-based diets for dogs. **Samuel Kiprotich. Advisor: Greg Aldrich, PhD.**

There is an increasing demand for raw meat-based diets (RMBDs) for dogs, but these foods cannot be heat-pasteurized/cooked. Therefore, these diets are important vehicles for the transmission of enteric foodborne pathogens such as *Salmonella* and *E. coli* O157:H7 through cross-contamination and animal fecal excreta due to shedding. Currently available antimicrobial interventions for these diets like high-pressure pasteurization are costly and largely inefficient, thus there is need to develop relatively inexpensive and effective means to enhance the safety of these diets. Thus, objective of this study was to evaluate the antimicrobial efficacy of encapsulated and dry-plated glucono delta lactone (GDL), citric (CA) and lactic acid (LA) when challenged against *Salmonella enterica* inoculated in a model raw meat-based diet (RMBDs) for dogs. Nutritionally complete, raw diets were formulated with different levels (1.0, 2.0 and 3.0% (w/w)) of both encapsulated and dry-plated GDL, CA and LA with both the positive (PC) and the negative controls (NC) without acidulants. The diets were formed into patties of ~100g and inoculated with 3-cocktail mixtures of *Salmonella enterica* serovars, excluding the NC to achieve a final concentration of ~6.0 Log CFU/patty. Microbial analyses were performed on the inoculated diets and survivors of *S. enterica* enumerated. Both encapsulated and dry-plated CA

and LA had higher log reductions compared to GDL ($P<0.05$). However, encapsulated CA and LA at 1.0% (w/w) exhibited higher log reductions ($P>0.05$) and preserved product quality compared to the dry-plated acidulants at 1.0%. We concluded that 1.0% (w/w) of encapsulated citric or lactic acids could be successfully applied as an antimicrobial intervention in raw diets for dogs.

10:09 Influence of graded levels of microbially enhanced protein on nutrient digestibility of extruded cat foods. **Youhan Chen. Advisor: Greg Aldrich, PhD.**

Pet food ingredients that bring extra nutrition and health benefits are much better accepted than being simply an economic choice by the manufacturer. Microbially enhanced protein (MEP) from soybeans is a fermented ingredient that is believed to promote nutrient utilization. The objective of this study was to determine the effect of increasing levels of MEP on nutrient digestibility of extruded cat food. Four extruded dietary treatments differing by level of MEP in exchange for soybean meal (15%; SBM) at 5, 10 and 15% (5MEP, 10MEP and 15MEP, respectively) were randomly assigned to 12 individually housed adult domestic shorthair cats (6 castrated males and 6 spayed females) of similar age (0.9 ± 0.23 months) and body weight (4.35 ± 0.87). The study was designed as a 4×4 replicated Latin square with 9-day adaptation followed by 5-day total fecal collection for each period. Data were analyzed using a mixed model through SAS (version 9.4, SAS Institute, Inc., Cary, NC) with treatment as a fixed effect and square (i.e., replicate), period, and cat(square) as random effects. Treatment means were separated by Tukey's test. The 15MEP increased fecal moisture content ($P < 0.05$) while 5MEP and 10MEP made no difference compared to SBM. No differences were observed for food intake, fecal dry matter output, fecal score, fecal pH or apparent total tract digestibility of dry matter, organic matter, crude protein or gross energy for MEPs compared to SBM. However, crude fat digestibility of cats fed 5MEP was lower ($P < 0.05$) than cats fed with10MEP and 15MEP but not different from cats fed with SBM. These results suggest that MEP did not have adverse effects on nutrient digestibility when added to extruded diets at up to 15% in healthy adult cats.

10:21 Fecal microbiome of cats was maintained when fed diets containing corn fermented protein. **Logan Kilburn. Advisor: Greg Aldrich, PhD.**

Logan Kilburn-Kappeler[a], Tyler Doerksen[b], Andrea Lu[b], Rachel M. Palinski[b,c], and Charles G. Aldrich[a]

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Co-products from the ethanol industry may be able to provide high-quality sustainable protein sources for pet foods. Unlike traditional co-products, corn fermented protein (CFP) contains a yeast component which may provide additional benefits. The objective of this study was to determine, by exchange, the effects of the yeast in corn fermented protein on fecal microbiome in cats. The four experimental diets included a control with no yeast (CON) and diets containing either 3.5% brewer's dried yeast (BDY), 17.5% distiller's dried grains with solubles plus 2.5% brewer's dried yeast (BDY+DDGS), or 17.5% CFP (CFP). It was assumed that CFP contained 20% yeast and all treatments except CON were formulated to contain 3.5% yeast. Experimental diets were fed to adult cats (n = 11) in an incomplete 4 x 4 replicated Latin square design. Cats

were adapted to diet for 9 days followed by a 5-d total fecal collection. Fresh fecal samples (n=44) were analyzed by 16S rRNA gene pyrosequencing. Community diversity was evaluated in R (v4.0.3, R Core Team, 2019). Relative abundance data were analyzed within the 50 most abundant operational taxonomic units (OTU) using a mixed model (v9.4, SAS Institute, Inc., Cary, NC) with treatment as a fixed effect and cat and period as random effects. Results were considered significant at $P<0.05$. Predominant phyla were Firmicutes (65.2%), Bacteroidota (25.2%), Actinobacteriota (8.4%), Proteobacteria (0.64%), and Desulfobacterota (0.55%). There were significant ($P<0.05$) shifts in predominant phyla among treatments with BDY+DDGS resulting in the lowest relative abundance of Firmicutes and Actinobacteriota and highest in Bacteroidota. Alpha-diversity indices (Observed, Chao1, Shannon, Simpson) and beta-diversity metric (principal coordinate analysis) were similar for all treatments. This data indicates that CFP did not alter the overall diversity of the fecal microbiome of healthy adult cats over a 14-d period.

Key words: corn fermented protein, fecal microbiome, 16S rRNA pyrosequencing

10:33 Grain sorghum as a sustainable ingredient in aquatic feed-grinding and processing energy studies. **Tucker Graff. Advisor: Sajid Alavi, PhD.**

For about 3 billion people worldwide 20% or more of animal protein intake is through seafood. In aquaculture and aquatic feed manufacturing, requirements for sustainable and environmentally friendly ingredients, processing and practices are coming to the fore. This research focused on grain sorghum as a sustainable carbohydrate ingredient in aquatic feed and studied process sustainability from the point of view of grinding efficiency and process energy inputs. A hammer mill was used to grind grain sorghum through 3 screens (1.27, 1.02 and 0.61 mm) to obtain different particle sizes. Ground sorghum was incorporated into two nutritionally balanced diets formulated for shrimp and tilapia and processed through a pilot-scale single screw extrusion system to produce sinking and floating pelleted feed respectively. As particle size of raw diets decreased, extruded tilapia feed expansion increased (decreased bulk density from 433 to 354 g/L; increased expansion ratio from 1.4 to 2.2), while energy requirement of the process increased from 273 to 335 kJ/kg. Percent water absorption in pellets increased as particle size decreased in both sorghum and wheat (200 to 296% and 304 to 345%, respectively). This has implications for pellet quality aspects including water stability. Higher preconditioner steam loss was however observed with lower particle size of raw diets. In shrimp feed production, increase in thermal energy input into preconditioner led to decrease in expansion ratio of pellet from 1.5 to 1.2 and very little change in bulk density (range 500-510 g/L) and no noticeable improvement in pellet quality. Higher grinding intensity for grain sorghum improved tilapia feed quality but at the expense of higher energy requirements and greater losses of steam. Higher thermal energy input during extrusion did not have a noticeable impact on shrimp feed quality. In optimization of aquatic feed processing, product quality improvements should be weighed against process sustainability criteria such as energy input and losses. These data will be useful for feed processors to meet sustainability goals within their organization and also future regulations in the aquatic feed industry.

10:45 Utilizing protein functionality information to tailer qualilty of plant-based meat analogues. **Jenna Flory. Advisor: Sajid Alavi, PhD.**

In 2020, the U.S. market for plant-based foods grew at almost twice the rate of other foods and surpassed $7 billion. Plant-based meat especially has grown significantly in popularity due to

consumer focus on nutrition, animal welfare and environmental sustainability. Plant proteins are extruded to form plant-based meat or texturized vegetable protein (TVP), which can be combined with other ingredients to form patties and nuggets or used in other forms. Consumer acceptance of flavor and texture differences from animal protein is a major obstacle for plant-based meat analogues. Different plant protein sources (soy, pea, wheat) create distinct product textures. This research was aimed at identifying and manipulating these differences to reach desired texture goals. Protein functionality was determined through least gelation concentration (LGC), water absorption index (WAI), and rapid visco analysis (RVA). These results were used to create formulations that targeted three different texture objectives (soft, medium, and firm). To create a meat analogue softer in texture, an LGC >16% and WAI >4.0 is desired while an LGC <16% or WAI <4.0 should lead to a firmer product. High WAI and LGC signal cold swelling and lower WAI and LGC signal heat induced gelling. TVP produced using pilot-scale twin screw extrusion targeting a firm product had higher bulk density (274 g/L, 287 g/L) as compared to soft (160 g/L, 223 g/L). Softer textures exhibited flaky and gel-like microstructures. Firm treatments showed more layered structure, while medium textures were sponge-like with many air cells. Texture profile analysis showed that soft texture target treatments had lower hardness (1154 g, 1595 g) than firm target treatments (2231 g, 1893 g), which confirmed the validity of the protein functionality-based formulation approach. However, texture results had large standard deviations, pointing to need for improvement in testing protocol. Understanding influences of raw material functionality on meat analogue texture can be a valuable tool. For example, fish is much softer and flakier than chicken breast, and will require a different TVP formulation. Manipulating raw material formulations to develop TVP with specific texture goals can reduce research costs and time, while also improving the overall quality and consumer acceptance of plant-based meat products.

10:57 Structure, birefringence and digestibility of spherulites produced from debranched starch. **Jialiang Shi. Advisor: Yong-Cheng Shi, PhD.**

The objectives of this study were to debranch waxy maize starch by pullulanase, produce spherulites with different crystalline structures and birefringent properties by controlling crystallization conditions and determine how their structures were correlated with their digestibilities. The spherulites formed in water or 50% ethanol at 4 °C had a B-type crystalline structure. The birefringence sign was not uniform for the spherulites formed in water at 4 °C; some spherulites displayed negative birefringence. However, positive birefringence was observed for the spherulites formed in 50% ethanol at 4 °C, indicating starch chains were radially arranged. The spherulites crystallized in water at 50 °C followed by further crystallization at 4 °C had a predominate A-type crystalline pattern with positive birefringence in some particles, the highest resistant starch content (73.0%) and the highest degree of crystallinity (76%).

11:09 Formation of starch spherulites from pea starch and high-amylose maize starch. **Jing Qi. Advisor: Yong-Cheng Shi, PhD.**

Spherulites are common crystalline forms in nature and normally are crystalline materials in which crystalline lamellae or fibers are radially oriented. Previous studies have shown that spherulites may be formed from various starches such as high-amylose maize (HAMS), normal maize (NMS), and potato starches, and may be considered as resistant starch. There is, however, little study on using pea starch (PS) to produce spherulites. In industrial production, PS is generated as a co-product of pea protein. In view of the growing demand for pea protein to produce plant-based meat substitutes, beverages, snacks, etc., the pulse industry is interested in producing value-added products and finding new markets for pea starch. Pea starch has relatively

high amylose content (about 24-65%), varying with different resources. Considering that the formation of spherulites is more favorable for starches rich in amylose rather than amylopectin, we hypothesized that pea starch could be used to produce spherulites with good quality. The formation of spherulites is generally believed to require either the presence of lipid or heating to a higher temperature and then quenching. However, in this study the spherulites were immediately observed after the PS and HAMS with 25% solid content was heated to 180˚C at 5˚C/min from 10˚C, held at 180˚C for 1 min, cooled to 10˚C at 10˚C/min and held at 10˚C for 1 min. After being stored at room temperature for 1 day, although the morphological characteristics of spherulites did not change significantly, the larger endothermic peak observed by differential scanning calorimetry (DSC) indicated that more recrystallization occurred during storage. During the cooling step, formation of spherulites (recrystallization) was studied and observed by DSC. For PS, a small portion of retrogradation and the formation of spherulites were overlapped into one peak. For HAMS, due to the presence of lipids, two peaks were observed. One was the formation of lipid-amylose complex, and the other was the formation of spherulites. In addition to forming starch spherulites by using DSC, production of spherulites from HAMS and PS was scaled up and achieved by using a pressure reactor.

11:21 Developing and characterizing polyphenol and peptide antioxidants from corn distillers' grains. **Ruija Hu. Advisor: Yonghui Li, PhD.**

There has been a growing interest in developing natural antioxidants with high efficiency and low cost, such as antioxidative protein peptides/hydrolysates and phenolic compounds. Corn distillers' grain (e.g., DDGS) is a nutrient rich by-product from corn ethanol production, and it contains about 30% proteins and 1.5% polyphenols. The objectives of this study were to extract both antioxidative phenolics and protein hydrolysates from corn DDGS, and characterize their chemical composition and antioxidant performances using chemical assays and in model food systems. Water, acetone, ethanol, methanol, 1-proponal and 2-proponal were selected to extract phenolic compounds from the DDGS. Using 50% acetone or 50% ethanol resulted in extracts with the highest total phenolic content, followed by using 50% 2-proponal, 50% methanol, and 50% 1-proponal. The phenolic antioxidant extracted using 50% acetone also showed the highest DPPH scavenging activity and the highest Fe^{2+} chelating capacity. After solvent extraction, Alcalase at 0.1 Au/g of protein was used for protein hydrolysis of the DDGS residues. Peptide antioxidants from 50% methanol extracted DDGS possessed the highest TPC and Fe^{2+} chelating capacity. Peptide antioxidant from 50% 2-proponal extracted DDGS had the highest DPPH scavenging activity. The profiles of phenolic antioxidants were analyzed using a UPLC-QTOF-MS/MS system. The peptide content of the peptide antioxidants was in the range of 50-53%. The phenolic and peptide antioxidants from 50% acetone or 50% ethanol extracted DDGS were selected to prepare o/w emulsions at 1 and 2.5 mg/mL to evaluate their antioxidant performance. Commercial rosemary extract and BHT at 1 mg/mL were evaluated similarly for comparison. Comparing to the control emulsion, much lower peroxide value (POV) and thiobarbituric acid reactive substance (TBARS) value were observed for the emulsions containing either phenolic or peptides antioxidants at 1 mg/mL during incubation. Higher dose of the antioxidants resulted in better prevention on oil oxidation. Overall, our study provides evidence that the antioxidants from corn distillers' grain have great potential to be used as naturally derived antioxidants.

11:33 Towards better understanding of whole wheat flour bread-making performance. **Cheng Li. Advisor: Yonghui Li, PhD.**

Quality of wheat flour strongly influences the end-product performance and consumer acceptability. The quality criteria of white flour have traditionally been used as the primary criterion for determining the quality of whole wheat flour. However, a thorough understanding of the whole wheat flour baking quality is still lacking because of the complex nature of the bran's chemistry and composition. The objectives of this study were to comparatively evaluate the dough rheological properties and bread-making performance of white and whole wheat flours from 64 different genotypes and investigate the effect of bran composition and chemistry on the bread-making quality of whole wheat flour. Wheat samples were tempered to 14% mb. and then milled through a Brabender Quadrumat Senior mill. The chemical composition was measured, and the pasting properties and dough properties were determined by RVA and mixograph, respectively. In addition, water retention capacity, lipid content, phenolic content and composition, and fiber content of the wheat brans were analyzed. Furthermore, lipoxygenase activity, lipase activity, and peroxidase activity of the brans were assayed spectrophotometrically. The bread quality was evaluated by specific volume, c-cell, and texture analyzer. The lipid contents of the brans ranged from 4.90 to 6.97%. The water retention capacities of the wheat brans varied from 196.2 to 247.5%. The range of the total dietary fiber contents was from 29.73 to 42.29%. Significant correlations between the white and whole wheat flour were observed for both protein content and baking water absorption ($r = 0.977$ and 0.713, respectively). Pasting properties were also strongly correlated, and the correlation coefficient ranged from 0.588 to 0.883 for the different pasting parameters. The optimal mixing time determined by mixograph was also highly correlated ($r = 0.825$). The whole wheat bread volumes and the bran lipoxygenase activities were negatively correlated ($r = -0.856$). In contrast, the correlation coefficient of the white and whole bread volumes was only 0.480. In conclusion, the data indicated that analyzing white flour could be used to estimate whole wheat flour on determination of the rheological properties. However, the determination of the whole wheat bread-making performance may require additional specific quality analysis.

11:45 Incorporating chickpea flour increases dough mixing tolerance and strength of wheat flour. **Eric Nkurikiye. Advisor: Yonghui Li, PhD.**

The current global trends lead to increased demand for pulses. Pulses are very nutritious grains and highly adaptable to different environments. This presentation will portray the milling process, flow properties, and baking potential of several common pulses, and especially focusing on the dough mixing property improvements with chickpea flour. The pulse grains (chickpea, yellow pea, and lentil) were milled using a laboratory scale roller mill. The flours produced were analyzed for the flow and physical properties. The flours were then incorporated at 1, 3.75, 7.5, 15, and 30% into refined wheat flour and tested for dough and bread-making properties. Effect of incorporating chickpea flour on dough mixing properties were further analyzed using mixograph, and dough extensibility test was also performed. It was found that the chickpea flour was more cohesive and highly compressible compared to other pulse flours and wheat flour. The particle size difference did not affect the flow properties of the chickpea flour. Chickpea flour noticeably improved the dough mixing tolerance and increased dough strength when incorporated at 7.5% or below. When fractionated, the chickpea insoluble protein-rich fraction was found to be more responsible for the improved dough properties. Incorporation of chickpea flour at 7.5% or below did not affect the bread quality or sensory attributes significantly. In conclusion, chickpea

demonstrated more potential for incorporation in bread-making compared to lentil and yellow pea. Chickpea is promising to become a functional and nutritious ingredient for blending with most wheat flour. Chickpea flour incorporation could also help bakers in case of overmixing the dough.

11:57 Bioinformatics-aided bioactive peptides discovery and value-added functional ingredients development from agricultural products. **Zhenjiao Du. Advisor: Yonghui Li, PhD.**

Bioactive peptides are protein fragments with broad spectrum of biological effects such as antioxidant, antihypertensive, and anti-aging functions and gaining increasing interest from researchers regarding their great potential in the valorization of agricultural byproducts. Traditional approaches for bioactive peptide screening suffered from low efficiency, high cost, and dependence on advanced instruments and trained personnel. Recently, bioinformatics approaches as a knowledge-based method have demonstrated great potential to circumvent the aforementioned limitations and could accelerate the screening of bioactive peptides in bench studies. In this presentation, our latest studies on quantitative structure−activity relationship (QSAR) model development for predicting antioxidant bioactivity of peptides will be presented, covering the *in silico* proteolysis simulation tool development, comprehensive comparison among different machine learning strategies for model development, and application in sorghum proteins. Furthermore, our preliminary attempts in molecular docking and molecular dynamics simulation-driven screening for antihypertensive activity, antidiabetic activity, and antiaging activity will also be introduced, and the roadmap of this project for reasonable utilization of agricultural products for value addition through wet chemistry and computational chemistry will also be proposed.

Proposal Presentations

12:09 Effect of fractioning corn on digestive physiology of nursery pigs. **Diego Lopez. Advisor: Chad Paulk, PhD.**

It is well known that reducing particle size of corn used in swine diets can increase metabolizable energy of corn; therefore, leading to improved feed efficiency. This is due to an increase in surface area to volume ratio of the corn particles which allows for digestive enzymes to access nutrients. However, there are potential negative impacts of reducing particle size on feed flowability and stomach ulceration in pigs. It is hypothesized that including a small proportion of coarse corn could mitigate the flowability issue and improve digestive tract morpho-physiology without negatively impacting feed efficiency. Therefore, the objective of this experiment is to determine the effect of including coarse corn fraction in diets fed to nursery pigs. A total of 24 pigs will be used in this experiment. Pigs will be blocked by initial body weight and randomly assigned to pens with 4 pigs per pen. Each pen will be allotted to 1 of 3 dietary treatments. Dietary treatments will consist of a control diet with 100% of the corn finely ground, and two diets containing 10 and 20% coarse corn in the place of finely ground corn. After 10 days, pigs will be euthanized for sample collection. A measurement of pH will be taken from the digesta in the lumen of stomach, ileum, and colon. Samples of jejunum digesta will be collected for the measurement of digestive enzymes (trypsin, lipase, amylase, lactase, sucrase, and maltase) as well as digesta from the cecum and colon for VFA analysis. Tissue from the ileum will be gently scraped to obtain a sample that will be use for gene expression determination of pro and anti-inflammatory cytokines. Lastly, a sample of ileum and jejunum tissue will be collected and used

for morphology determination. After competition of the experiment, we expect to determine if the addition of coarse corn affected the digestive physio-morphology of nursery pigs.

12:21 Feed manufacturing and delivery logistics optimization. **Allison Blomme. Advisors: Chad Paulk, PhD & Jessica Heier Stamm, PhD.**

Feed mills are tasked with manufacturing a variety of diets while managing medication sequencing, incoming feed orders, and feed deliveries. When it comes to sequencing the feed that needs to be manufactured for the day, there are several options to organize the production schedule. Organizing by feed form (pellet or mash), medication, or delivery schedule can all generate different manufacturing schedules. There also must be enough flexibility on the schedule to allow for emergency orders when a farm is out of feed and needs a delivery immediately. This is a lot of information to be juggled by only a few people, and it relies heavily on experience and "gut" knowledge. As feed mills become increasingly automated, there is an opportunity to adopt data-driven decision making. This project will utilize a network flow model to optimize feed manufacturing, storage, and delivery to support and enhance the decision-making process. To accomplish this goal, baseline data surrounding feed production times, challenges, delivery distances, truck loading and unloading, and general feed mill operation will be collected and evaluated. These data will provide information on the key constraints for the model and establish realistic capabilities and goals for the mill. Once these baselines and constraints are defined, they can be utilized, along with daily feed orders and production costs, to generate a model to organize the daily feed production for the mill. The same data, in addition to the feed delivery capabilities and storage capacity at the mill, will be used to model a delivery schedule for the trucks to optimize routing and farm biosecurity. Finally, the production schedule model and the delivery model will be tied together to incorporate the daily orders, production capacity, storage capacity, and feed delivery requirements into one optimal feed production and delivery logistics model. If these data-driven schedules can decrease feed mill cost per ton by only 1%, that can bring a significant return to a system producing hundreds of thousands of tons in multiple mills.

12:33 Physicochemical and functional properties of pulse proteins obtained from salt extraction. **Bipin Rajpurohit. Advisor: Yonghui Li, PhD.**

We are facing the challenge of producing adequate protein in an environmentally sustainable way, for a growing population estimated to be 9 billion by 2050. In recent years, there has been a huge interest in plant-based proteins owing to their nutrition and better sustainability. Among the various sources of plant-based protein, pulses are an excellent choice owing to their high protein content, nutrition, availability, and lower cost of production. Commercially, plant protein extraction from wet fractionation involves alkaline dissolution followed by isoelectric precipitation. Information on the physicochemical and functional properties of the proteins extracted by an alternative method of salt extraction is limited in the literature. The aim of our study is 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 the extraction of proteins by dilute salt solution, the protein functionality tests namely, oil and water holding capacity, solubility, emulsification capacity and stability, foaming capacity and stability, and gelation property will be performed. Additionally, differential scanning calorimetry (DSC), sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE), surface hydrophobicity index, protein secondary structure, Fourier-transform infrared (FTIR) spectroscopy, and size exclusion chromatography- high-performance liquid chromatography (SEC-HPLC) analysis of

the proteins will be performed. For getting nutritional information, in-vitro protein digestibility corrected amino acid score (PDCAAS) and amino acid profile tests will be conducted. The research will generate valuable information on protein functionality and physicochemical properties for a wide variety of pulse proteins. After completing the screening of different pulses, we will further enhance the functionality of promising proteins through physical or biochemical modifications for broader food uses and evaluate their potential applications such as in mayonnaise, meat analogs, and extruded snacks.

12:45 Use of 3D printing for structuring starch and protein-based food matrices. **Conrad Kabus. Advisor: Sajid Alavi, PhD.**

In recent years, additive manufacturing or 3D printing of foods has emerged as a novel technology to create innovative processing methods and new products. It offers possibilities for food to be created in intricate shapes, unique textures and an alternative method for delivering nutrition. Current technology for food 3D printing utilizes combinations of different food ingredients and printing methodologies. A through literature review of state-of-the-art research in this area was conducted and used as a basis for which methodology and objectives could be formulated into a thesis project.

Food 3D printing techniques are classified into three categories that include extrusion-based printing, binder jetting, and inkjet printing. Extrusion-based printing builds food models by extruding raw materials or 'food ink' in a paste form through a nozzle with constant pressure to create shapes layer-by-layer. Inkjet printing operates by using thermal heads to dispense a stream of droplets to specified regions on a food surface. This usually requires low viscosity food inks and therefore does not find application in complex structures that need strong formability/rigidity. Binder jetting constructs foods by using liquid binders to selectively bond powdered food material layers.

Applications for 3D printing include plant-based meat, baked and fried snacks, cookies, meals for dysphagic people, and personalized products. Food inks that have been studied include proteins sources such as soy protein, gluten, and pea protein isolate, starch sources such as rice, wheat, oat, and buckwheat flours, meat paste, gums, and fruit powder. Further research is needed in 3D printing of foods for scale-up and sensory improvement. Objectives of the proposed thesis will be presented, which include: 1) understanding physico-chemical characteristics of starches and proteins-based food inks including gelation, thermal phase transition properties, and rheology; 2) development of extrusion-based 3D printed products in snack and plant-based meat applications; 3) studying effect of printing parameters such as speed, in-fill pattern, and density on product quality; and 4) relating food ink properties to printability and end-product texture and other aspects. Brief details of methodology and characterization techniques for food ink and final products will also be described, along with expected outcomes.

Graduate Posters

1. The effects of pellet quality on growth performance of pigs during varying weight ranges. **Patrick Badger. Advisor: Chad Paulk, PhD.**

   Pelleting swine diets is widely accepted for the positive influence it has on growth performance, predominantly attributed to G:F improvements. However, the quality of pellets must meet a certain standard to maximize this improvement in performance. Limited research has been conducted to determine if the response to pellet quality depends on the weight range of the pigs. Therefore, the objective of these experiments was to determine the growth performance effects on pigs fed pellets with increasing amounts of fines during varying weight ranges. A total of 350 pigs (600 × 241, DNA), initially 36 kg, were randomly placed in 35 pens with 10 pigs per pen (balanced by gender). Pigs were weighed prior to the onset of each of 3 experiments and placed in 1 of 7 blocks based on average pen weight. Pigs were fed 1 of 5 treatments consisting of a mash diet or pellet diet with different levels of pellet fines. Data were analyzed using the PROC-GLIMMIX procedure of SAS (SAS Institute, INC., Cary, NC) with contrasts created from the percent fines at the feeder for unequally spaced treatments using the PROC ILM function. Experimental diets were fed for 20, 21, and 20 days for experiments 1, 2, and 3, respectively. For Exp. 1, pigs fed pellets with 12.5% fines had improved ($P < 0.05$) G:F when compared to pigs fed the mash diet. Pig ADFI increased and G:F decreased (linear, $P < 0.05$) as percent fines increased at the feeder. For Exp. 2, pigs fed pellets with 15.5% fines had improved ($P < 0.05$) G:F when compared to those fed the mash diet. Pig ADFI increased while G:F decreased (linear, $P < 0.05$) as percent fines increased at the feeder. In Exp. 3, pigs fed pellets with 9.6 and 41.8% fines had improved ($P < 0.05$) G:F when compared to those fed the mash diet. Pigs fed pellets with minimal fines had improved G:F compared to those fed the mash diet. Pigs in Exp. 3 had the greatest pelleting response with an improvement of 9% for G:F when fed pellets with minimal fines.

2. Impact of fatty acid composition on markers of exocrine pancreatic stimulation. **Yunyi Zhang. Advisor: Greg Aldrich, PhD.**

   Chronic pancreatitis in dogs is typically managed with a low-fat diet. Human research suggests consuming medium-chain triglycerides (MCT) may lower pancreatic enzyme release compared to consuming long chain fatty acids (LCFA). Twelve healthy adult colony dogs were fed a meal of cod and rice with either 3% metabolizable energy (ME) fat (control), high MCT (25% ME MCT oil, 25% ME butter), high saturated LCFA (50% ME butter), or high unsaturated LCFA (50% ME canola oil) in a 4-period by 4-treatment crossover design. Serum concentrations of canine pancreatic lipase immunoreactivity, gastrin, amylase, cholecystokinin (CCK), cholesterol, triglycerides and serum activities of DGGR lipase were measured at times 0 (fasted), 30, 120 and 180 minutes post-prandial. Following a 3-or 4-day wash-out period, each dog was assigned a new diet and the process was repeated for all treatments.
   Data was analyzed as a repeated-measures mixed model ANOVA. Post-hoc pairwise comparisons were run using Tukey-Kramer adjusted p-values. Shapiro-Wilk tests were used to evaluate residual normality. All statistical assumptions were sufficiently met. Statistical significance was defined as $P<0.05$. Of the markers tested, only serum triglyceride concentrations were affected by treatment, with consumption of high MCT resulting in lower triglycerides than both LCFA groups at times 120 and 180 minutes ($P<0.0001$). As expected, the high MCT group also had

higher triglycerides compared to the control (P<0.0001). The type of dietary fat consumed had little acute impact on most markers of exocrine pancreatic stimulation in healthy dogs.

Key words: MCT, canine pancreatitis, triglycerides

3. The effects of antioxidants and storage time on measures of shelf-life in raw chicken-based pet foods. **Kallee Dunn. Advisor: Greg Aldrich, PhD.**

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The US pet food market has experienced a steady increase in sales over the past decade. Most of this growth has been attributed to the emergence of new food categories such as raw-frozen products. This is a high fat pet food product that is known to be at risk for oxidation. The objective of this study was to determine the effects of antioxidant addition during the production of raw pet foods on measures of oxidation. Raw-frozen samples of chicken based petfood patties were placed in plastic bags and stored at -20°C for 0, 4, 8, and 16 weeks. The meat mix in which patties were formed contained no antioxidant (CONT), mixed tocopherols (MT), mixed tocopherols + green tea (MGT), or butylated hydroxyanisole (BHA). Two bags of each treatment were removed from the freezer and thawed at each time point. The treatments were analyzed for free fatty acids (FFA), peroxide value (PV), propanal, thiobarburic reactive substances (TBARS), and hexanal. The greatest peroxide value (P < 0.05; 23.82 meq/kg) was found in the control samples, while the lowest PV was found in the MT treatment with MT+GT and BHA. The propanal content in each treatment increased from 0-4 weeks then decreased from 4-16 weeks. The highest (P<0.05) propanal concentration was found in the control, while the lowest was found in MT and MT+GT treatments. The control and BHA treatments had high hexanal concentrations, while the lower (P<0.05) hexanal concentrations were found in the MT and MT + GT treatments. The FFA and TBARS content of the samples held in frozen storage did not change over the 16 weeks of the study, while 2,4-decadienal was not detected in any samples. In conclusion, the treatment with MT was able to control of the increase in the PV and stabilized the AV in chicken, while it also had lower hexanal content.

4. Effect of sorghum accessions and small grains on pet food extrusion. **Katelyn Bailey. Advisor: Greg Aldrich, PhD.**

Pet owners are more concerned today about the ingredients used in pet food. Ingredients like sorghum, may provide health benefits in extruded pet food. Extrusion relies on high temperature and pressure to produce expanded kibbles. The objectives of this study were to determine the effect of three sorghum accessions varying in pericarp color and four small grains on processing conditions and product characteristics for extruded dog foods. All diets were produced using a single screw extruder (model X20; Wenger Manufacturing, Inc. Sabetha, Kansas). The control diet contained rice (50%) as the primary starch, which was replaced by white sorghums A and B, burgundy sorghum, sumac sorghum, barley, millet, or oats. Kibbles were collected for analysis at three different time points during the extrusion of each treatment with dimensions and bulk density measured. Differences in each parameter were analyzed by statistical software for a completely randomized design experiment (SAS, v.9.4). Rice-based kibbles had the largest diameters while millet, sumac, and oats were thinnest (11.46mm, vs average 9.19mm, respectively). Thickness was greatest in burgundy sorghum, millet and sumac while barley and oats were thinnest (average 6.72 mm vs average 4.86mm, respectively). Oats had the greatest

bulk density (489 g/L) while rice had the least (305 g/L) and the other grains were intermediate. Barley had the greatest hardness and toughness (6.68 kg and 57.72 kg mm, respectively) while millet and sumac were the least (2.04 kg and 15.97 kg mm, respectively). In conclusion, rice expanded better than all seven of the treatment diets.

5. Evaluation of fermentability of whole soybeans and soybean oligosaccharides by a canine in vitro fermentation model. **Hee Seong Kim. Advisor: Greg Aldrich, PhD.**

Whole soybeans (WSB) can be a nutritious ingredient for dogs for both protein and fat. However, WSB have been limited in use due to their significant contents of total dietary fiber and oligosaccharides (OS). The soy OS have been recently recognized as a prebiotic that can be fermented by microflora in the colon resulting in short-chain fatty acid (SCFA) production. These SCFA can be used as an energy source for enterocytes, colonocytes, and immune cells, supporting cell differentiation and gut health. Thus, WSB may behave as beneficial fermentable substrates in dogs. The objective of this study was to determine the effect of WSB oligosaccharides on *in vitro* fermentation using dog feces as inoculum. Treatments included total dietary fiber residues from WSB, soy hulls (SH), pea fiber (PF), beet pulp (BP), soybean oligosaccharides (WSBOS), and raffinose, stachyose, and verbascose (WSBRSV). The fecal samples were collected from three Beagle dogs and maintained in anaerobic conditions until dilution and substrate inoculation. Test tubes containing enzymatic pretreated fiber sources and inoculum were incubated for 1, 2, 4, 8, and 12hours at 39°C. Organic matter disappearance (OMD), pH, and SCFA were determined for each fiber source and time point. The data were subjected to ANOVA using the general linear model procedure (SAS, v 9.4). Least square mean differences were assessed using Tukey's post hoc test. The WSBOS and WSBRSV had higher OMD and butyrate than BP ($P < 0.05$; 43.59 and 60.18% vs 40.96% OMD; 293.33 and 266.67 vs 130umol/g butyrate, respectively). The BP and WSBRSV had the lowest pH (6.66 and 6.74, respectively) at 12 h ($P < 0.05$). The WSB had similar butyrate compared to BP (average 118umol/g). The PF and SH were poorly fermented with the lowest OMD and butyrate. In conclusion, soybean oligosaccharides were highly fermentable and produced the greatest amount of butyrate and thus, WSB may be an alternative to the use of BP in dogs. Further animal feeding studies are needed to determine the appropriate dose of WSB in dogs. (331 words)

Key words: beet pulp, canine nutrition, dietary fiber, in vitro fermentation, soybean, oligosaccharides

6. Validation of a method to determine dogs' preference for flavors. **Paris Johnson. Advisor: Greg Aldrich, PhD.**

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There is little information regarding the dogs' preference for flavors. Water may be an ideal medium to evaluate single flavor elements. Therefore, the objective of this study was to validate a previously developed water consumption test to determine the dogs' ability to discriminate flavors in drinking water. The study was conducted in three phases: 1) an evaluation of dog position bias, 2) an evaluation of preference for specific elemental flavors, and 3) a determination

of the dogs' ability to detect dose. For phase 2, the treatments were salty (salt 0.5%), sweet (dextrose 4%), sour (citric acid 0.1%), and umami (MSG 0.035%) in water versus the control (tap water). These compounds were selected since they create colorless and odorless solutions. For phase 3, increasing amounts of salt were mixed with tap water to create solutions of increasing concentrations (0%, 0.25%, 0.5%, 1%, 2%). For each phase, twelve adult Beagle dogs (average age one year) were offered treatments in a randomized complete block design over a 5-day period. Ceramic bowls (labeled A-E) were placed along the back wall of each pen and filled with 400g of the control or test solutions. After the first eight hours, bowls were filled with additional 200-400g of control or test solution as needed. Bowl position was randomized daily, to account for any position bias; and water disappearance was measured. Data were analyzed using a mixed model (SAS version 9.4, SAS Institute, Inc., Cary, NC) with treatment as a fixed effect and the dog and day as random effects. No side bias was detected. Dogs preferred sweet (average 250g/day) with sour and salty (average 96g/day and 86g /day) least preferred ($p < 0.05$) of the elemental flavors. For phase 3, a linear decrease ($p<0.05$) in water disappearance was observed as salt concentration increased. These results suggest that dogs do have the ability to discriminate between flavors and concentration in a water system. With the validation of this method, future studies can be conducted using continuous variables and individual elements to identify dogs' taste preferences.

7. Accelerating the acidification of sourdough through changes in substrate, strain, and process. **Andrew Dorsch. Advisor: Hulya Dogan, 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 the home baking sector. This drastically changed the consumer expectation and demand when it came to biologically leavened baked goods. It also drastically changed the way people digested bread. There is beginning to be a push back towards a more traditional push to incorporate more fermentation time into the baking process to achieve the flavors and 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 anywhere from 24-48 hours to achieve a pH 4.1 on average is desired. There are three classifications of sourdough that are commonly depicted within literature and 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 of these processes utilize 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. Research has been done using different processes and numerous strains of LAB to achieve a more efficient acidification than allowing the sour to naturally ferment. There has been very little research into the use of different flour substrates and their impact on the acidification of sourdough. In one research article, it is stated that bran improves the nutritional profile of the protein fraction (Zalan, 2015). With this idea, the possibility of decreasing the acidification time through controls of bacterial strain, processing parameters, and substrate fractions should be explored.

8. Evaluation of Wheat Kernel and Flour Quality as influenced by Chlorine Dioxide Gas Treatment. **Rania Buenavista. Advisor: Kaliramesh Siliveru, PhD.**

Increasing resistance among major stored-product insect species to widely used fumigant phosphine (PH_3) across the globe pose an inherent risk of massive grain storage losses. Chlorine dioxide (ClO_2) gas, known for its high oxidation and penetration capacity, is a potential alternative fumigant to control stored-product insect pest population. Further evaluation of this potential fumigant is critical in terms of grain and grain-based product quality. Limited research studies have evaluated the effect of chlorine dioxide (ClO_2) treatment on stored wheat and wheat-based product quality. In the present study, hard red spring wheat (*Triticum aestivum* L.) kernels were exposed to varying levels of gaseous ClO_2 concentrations (200, 300, 400, and 500 ppm) and held in a gas-tight bucket assembly for 24 h after achieving desired concentration. Three vials containing 20 unsexed adults of lesser grain borer (*Rhyzopertha dominica*) were placed at top, middle, and bottom layers of wheat mass during fumigation for insect mortality assessment. ClO_2 treatment achieved complete insect mortality at 500 ppm across all vial locations. Increased mortality was observed with increasing ClO_2 concentration. ClO_2-treated and untreated wheat kernels were milled into straight-grade flour using Chopin mill for flour quality analysis. On average, straight-grade flour production of ClO_2-treated wheat kernels was about 65.3-68.5%. Significant reduction (37.8-51.1%) in germination rate resulted after exposure to 300-500 ppm. In terms of flour color, lightness value significantly increased ($p < 0.05$) after treatment of 200-500 ppm. The pH value of wheat flour had significant reduction ($p < 0.05$) from 6.2 to 6.1 after 500 ppm treatment. In terms of pasting characteristics, peak and final viscosities of ClO_2-treated wheat flour at 200-500 ppm significantly decreased ($p < 0.05$) from 3303.7 to 3073.3 cP and from 3515.0 to 3208.3 cP, respectively. No significant difference ($p > 0.05$) was observed in other investigated flour quality and functionality parameters, including falling number, trough viscosity, breakdown viscosity, starch damage, and mixolab dough behavior properties. Overall, ClO_2 treatment at 500 ppm is effective in killing adult lesser grain borers without negatively affecting wheat flour quality parameters but affects wheat kernel viability.

9. Reduction in Salmonella load of wheat by tempering with organic and inorganic acid solution alone and in combination of heat. **Shivaprasad DP. Advisor: Kaliramesh Siliveru, PhD.**

Over the last decade, the number of foodborne illness outbreaks and recalls associated with wheat flour and wheat-based products contaminated with enteric pathogens such as *Salmonella* has increased. This demonstrates the importance of incorporating effective antimicrobial interventions into the milling industry. This research sought to determine survival of four different *Salmonella enterica* serovars on wheat during tempering (hydration). Hard red spring wheat kernels were inoculated with *Salmonella* (cocktail) and was dried for 24 h at ambient temperature. Following which, wheat kernels were tempered to 17% moisture with sodium bi sulfite (SBS), lactic acid (LA) and/or citric acid (CA) solution (5, 10 and 15% w/v concentration) and were held at 25^{o}C and/or 55^{o}C. Wheat kernels tempered with sterile water was taken as a control. The study's findings demonstrated that, after 24 h of treatment, tempering wheat with acidic water (15% w/v) reduced the *Salmonella* load by at least 3 log CFU/g for all the tested acids. Heat treatment (55^{o}C) alone significantly reduced the *Salmonella* load while acidic water tempering coupled with heat treatment (55^{o}C) resulted in greater reduction with complete inhibition achieved at 12h for LA and 18h for both SBS and CA. Furthermore, the study also demonstrated the production of reactive oxygen species (ROS) by virtue of which, protein and

sugar leaked from the bacterial cell leading to their lysis. Finally, the study showed that, tempering wheat with acidic water solutions, as opposed to the traditional water tempering method, may result in milled products with improved microbiological quality. The findings of this study could aid in the development of pathogen mitigation strategies for wheat flour products during milling.

10. Steam parboiling of durham wheat to produce bulgar. **Manoj Kumar Pulivarthi. Advisor: Kaliramesh Siliveru, PhD.**

Manoj Kumar Pulivarthi, Madhava Mondru, Anu Suprabha Raj, Kaliramesh Siliveru

Bulgur, which is produced from durum wheat (*Triticum durum*), is an important ingredient in traditional Middle Eastern cuisines. The conventional method of hydrothermal processing (70º - 90ºC for 2 h) of wheat to produce bulgur is time consuming and requires huge amount of water and energy. This study evaluated the efficacy of steam parboiling as a process step for bulgur production. Durum wheat was first soaked in hot water to increase its moisture (40-45%). Soaked grains were then pressure cooked under different pressure (15, 20, or 25 psi) and time (15, 20, and 25 min) combinations in a custom built steam processing chamber. Following steam treatment, treated grains (9 samples) were oven dried at 60ºC for 18 h (10-12% w.b). The dried samples were de-branned and roller milled to obtain three bulgur types with varying particle sizes: fine (500-1000µm), medium (1000-2000µm), coarse (>2000 µm). The milling yields (%) varied from 84.88 to 88.24% with the 15psi/25min combination producing the highest yield. The yield decreased with increasing pressure at all treatment times used. Steam parboiling reduced the bulk density of durum wheat compared to the untreated wheat (828 kg/m^3) wherein density values for treated grains ranged from 770.4 to 793.5 kg/m^3. The highest bulk density (793.5 kg/m^3) was recorded for the 15psi/15min treatment. Grain color was also affected ($P < 0.05$) with ΔE values among treated and untreated samples ranging from 4.85 to 8.43. The color, density, and water activity of the bulgur fractions varied significantly ($P < 0.05$) with respect to processing conditions and particle size. The L* values were highest for the fine bulgur fractions from all the treatment combinations varying from 67.42 to 69.68. The water activity (a_w) of the bulgur fractions produced from all process conditions used varied from 0.3 to 0.6 suggesting good storage stability ($a_w < 0.6$). Based on the milling yield and physicochemical properties of parboiled wheat and bulgur, the 15 psi/15 min steam treatment produced the best quality among the treatment conditions used. Overall, steam parboiling of durum wheat shows good potential as an alternative to the traditional method used for bulgur production.

11. Impact of tempering conditions on generation of damaged starch during roller milling of hard wheat. **Anu Suprabha Raj. Advisor: Kaliramesh Siliveru, PhD.**

Anu Suprabha Raj, Kaliramesh Siliveru, M. Hikmet Boyacioglu

Tempering, the preconditioning process for wheat milling, is reported to impact the milling characteristics and the particle size distribution of the wheat flour. This study focuses on the impact of tempering conditions on generation of damaged starch during roller milling of hard wheat. Hard red spring (HRS) and hard red winter (HRW) wheat tempered to 14, 16and 18% moisture content (wet basis) for 16, 20 and 24 h were milled using Buhler laboratory mill (AACC26-21.02). The milling streams (3 break and 3 reduction) and straight grade flour were

analyzed separately for protein content (AACC 46-30.01), damaged starch (SDmatic; AACC 76-33.01), particle size (Malvern Morphology G3), pasting characteristics (Rapid Visco Analyzer; AACC 76-21.01) and dough rheology (Mixolab; AACC 54-60.01). Protein content and damaged starch content varied significantly ($p < 0.05$) among the milling streams for both wheat classes. At all tempering conditions, flour from 3rd break roll had relatively higher protein content. Damaged starch content of HRW (14 % -16 h) flour increased from 5.63 % in the 1st break roll to 11.8 % in the 3rd reduction roll whereas for HRS (14 % -16 h) the corresponding variation was from 5.32 % to 11. 45%. Tempering the samples to 18 % moisture content for 24 h significantly ($p < 0.05$) increased the damaged starch content of the reduction flour streams. Damaged starch content of HRW samples were higher when compared to HRS samples for the studied conditions. The circle equivalent (CE) diameter, i.e., diameter of a circle of area equivalent to that of measured flour particle, varied significantly ($p < 0.05$) among different milling streams. Tempering at 18%for 24 h, the CE diameter of HRW flour decreased from 19.05-13.25 μm, whereas, for HRS it was from21.82 – 11.76 μm. The peak viscosity, break down viscosity and final viscosity values decreased with the successive milling streams. Dough characteristics from Mixolab analysis (thermal weakening, and mechanical weakening characteristics) were depended on tempering moisture content. From the analysis, increase in tempering time and moisture increased the damaged starch content of the samples.

Keywords: tempering, damaged starch, particle size, pasting, dough rheology

Undergraduate Posters

12. Effect of sourdough fermentation on the gas production and acidity of mill stream outputs.
Jayden McNerny. Advisor: Elisa Karkle, PhD.

Sourdough used to be the main leavening agent used in making breads. Once baker's yeast became widely available in the late 1800s, bakers reduced the use of active sourdough cultures in exchange of the ease and greater process control of baker's yeast, causing a change in the style and flavor of bread. Nevertheless, recent trends in the baking industry have made cause of the use of sourdough. The use of a sourdough culture is a long and lengthy process that requires more specialized equipment than bakeries currently have. The goal of this study was to determine the relationship between millstream product and acid/gas production during sourdough fermentation. Eleven mill stream samples were pulled from the Hal Ross Flour Mill and were analyzed using Near-Infrared Spectroscopy for ash and protein content. A sourdough starter was started using spontaneous fermentation of white wheat flour at 100% absorption. The individual mill streams were mixed with 40% (f.b.) mature starter using a pin mixer. The samples were immediately tested for pH and total titratable acidity (TTA). The samples were then loaded into risograph cannisters and allowed to ferment for 180 minutes. The CO_2 production was measured during and after fermentation. Samples were tested again for pH and TTA. The pH and TTA tested before and after fermentation showed an average increase in TTA of 2.5 ml and an average decrease in the pH of 0.50 from t=0 to t=180. The average CO_2 output of the millstreams varied from 75.8 ml to 86.1 ml. After running the variance on the data gathered, there was a significant correlation between ash and protein content and final TTA (0.77 and 0.94, respectively). There was no correlation with the total gas production.

13. The effect of feed retention time in the conditioner and conditioning temperature on pellet mill throughput and pellet durability index (PDI). **Carter Minson. Advisor: Chad Paulk, PhD.**

Carter D. Minson, Haley K. Otott, Charles R. Stark, and Chad B. Paulk

Summary
This experiment evaluated the effects of feed retention time in the conditioner and conditioning temperature on pellet mill throughput and pellet durability index. Treatments were arranged as a 3 × 2 factorial of retention time (30 seconds, 60 seconds, and 90 seconds) and conditioning temperature (165 and 185°F). The basal diet consisted of a corn-soybean meal-based diet. All treatments were pelleted at 3 different time points to provide 3 replications per treatment. Diets were steam conditioned (10 × 55 in. Wenger twin staff pre-conditioner, Model 150) and pelleted (CPM Model 1012-2) with an 11/64 x 7/8 in. (8 length:diameter [L:D]) pellet die at approximately 2,298 lb/hr. Pellet samples were collected at 3 time points throughout each run and immediately placed in an experimental counter-flow cooler for 10 min. Samples were analyzed for pellet durability index (PDI) using the modified tumble box (M-PDI) and Holmen 60 second (H-PDI) methods. Conditioning temperature, hot pellet temperature (HPT), and production rate were recorded throughout each pelleting run. Data were analyzed using PROC GLIMMIX in SAS (v. 9.4), with pelleting run as the experimental unit and time period as the block. There was no evidence ($P > 0.20$) for a conditioning retention time × conditioning temperature interaction for H-PDI. There was no evidence of difference ($P = 0.600$) in H-PDI when increasing conditioning temperature from 165°F to 185°F. Increasing condition retention time from 30 to 90 sec increased (linear, $P < 0.001$) PDI (59.6, 61.7 and 67.9%, respectively). For M-PDI, there was a marginally significant ($P = 0.093$) conditioning retention time × conditioning temperature interaction. When conditioning diets at 165°F, increasing conditioning time from 30 to 90 sec increased M-PDI (59.4, 65.3, and 67.4% respectively). However, when conditioning diets at 185°F, there was no evidence of difference in M-PDI when increasing the conditioning retention time (65.8, 69.0, and 69.0%, respectively). When pelleting diets using the settings reported herein, conditioning retention from 30 to 90 sec improved pellet quality. However, when analyzing PDI using the modified tumble box method, conditioning retention time only improved pellet quality when conditioning at 165°F.
Key words: conditioner retention time, conditioning temperature, pelleting, pellet quality

14. Utilizing Kernza in poultry diets: How does it influence the manufacturing process? **Garrett Friesen. Advisor: Chad Paulk, PhD.**

Walter G. Friesen, Haley K. Otott, Charles R. Stark, and Chad B. Paulk

Kernza® grain is a perennial grain that is harvested from intermediate wheatgrass (Thinopyrum Intermedium). The objective of this experiment was to evaluate the effects of grinding Kernza® grain with different hammermill screen sizes on subsequent particle size and flowability. Three separate lots (25-lb each) of Kernza® were ground with a laboratory-scale 1.5 HP Bliss Hammermill (Model 6K630B) using a #5 (2.0 mm), #7 (2.8 mm), and #9 (3.6 mm) screen. Each screen size treatment was ground at three separate time points to provide three replications per treatment. For each replication, three samples were collected and analyzed for particle size geometric mean diameter (dgw) and standard deviation (Sgw), and angle of repose (AoR). Increasing screen size from #5 to #9 resulted in increased (linear, $P < 0.001$) dgw of Kernza®

(323, 478, and 672 µm, respectively). However, increasing screen size from #5 to #9 resulted in decreased (linear, $P < 0.021$) Sgw of Kernza (3.15, 3.10, and 2.78 respectively). Reducing the particle size of Kernza® by reducing the screen size from #9 to #5 resulted in an increase (linear, $P < 0.001$) in AoR (43.0, 46.7, and 50.1, respectively). Therefore, grinding Kernza® with a #5 (2.0 mm), #7 (2.8 mm), and #9 (3.6 mm) screen resulted in dgw of 323, 478, and 672 µm and flowability characterized as poor (46-55), poor, and passable (41-45). Further research is needed to determine how Kernza® influences growth performance of livestock and poultry when included in diets. However, based on the AoR data collected herein, grinding Kernza® using #9 screen results in improved flowability compared to using a #5 and #7 screen.