

ABSTRACTS

Cereals & Grains Events and News Report

Cereal Foods World, Vol. 64, No. 6





2019 Cereals & Grains Meeting Abstracts

Abstracts submitted for presentation at the Cereals & Grains 19 Annual Meeting in Denver, CO, U.S.A., November 3–5. Abstracts are published as submitted for citation purposes. They have not been edited by editorial staff. Please send questions or comments to info@cerealsgrains.org.

The recommended format for citing annual meeting abstracts, using the first abstract below as an example, is as follows: Ringling, K. M. Seeds for sustainable health. (Abstr.) Cereal Foods World 64(6):A1. DOI: <https://doi.org/10.1094/CFW-64-6-0078>. 2019.

Seeds for sustainable health

K. M. RINGLING (1)

(1) Department of Food Science & Nutrition College of Food, Agriculture, & Natural Sciences, Minneapolis, MN, U.S.A.

Agronomists, nutritionists, and other food system professionals increasingly strive to deliver healthful foods that preserve the integrity of the environment while feeding the growing population. New approaches to developing sustainable food systems are required to preserve both human and environmental health. Recent efforts aim to establish an evidence base that supports the sustainable production of cereal grains, pulses, and novel crops that mitigate negative environmental impacts while delivering healthful foods. This presentation reviews examples of efforts to improve the sustainability of established cereal grains and pulses, describes current endeavors to develop new food crops that supplement established cropping systems, and discusses future opportunities and directions to develop sustainable grain and seed food systems.

Enzymatic modification of pulse starches to enhance the functional properties and resistant starch content

J. LI (1), Y. Ai (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada

This research aimed to improve the functional properties and increase the resistant starch (RS) contents of pulse starches through enzymatic modification. Lentil (LS), faba bean (FBS), commercial pea (CPS) and normal maize starches (NMS) were incubated with 1% (v/w) maltogenic α -amylase at pH 5.5 and 50°C for 4, 8 and 24 h. After the 24-h incubation, the degrees of starch hydrolysis ranged from 34.4% (FBS) to 38.4% (CPS), and the enzyme treatment reduced the amylose contents of LS, FBS, CPS and NMS by 6.4%, 4.9%, 2.8% and 2.0%, respectively. The modification decreased the pasting viscosities of all the used starches drastically, which could be attributed to the enzymatic breakdown of starch molecules. The enzyme treatment effectively elevated the gelatinization temperatures, but lowered the enthalpy changes and retarded the retrogradation of all the starches, resulting from shorter amylopectin branch chains of the modified starches. The 24-h enzymatic modification increased the RS contents of cooked LS, FBS, CPS from 2.7%, 3.4% and 4.2% to 8.2%, 9.9% and 11.4%, respectively, while a considerably smaller extent of increase was observed for NMS (from 1.6% to 3.6%). Modification with maltogenic α -amylase has been demonstrated to be a promising approach to diversifying the functional properties and reducing the *in vitro* digestibility of pulse starches in the current study.

Rice global market trends and demands for grain quality

T. L. HARRIS (1)

(1) Riceland Foods, Stuttgart, AR, U.S.A.

This presentation will focus on the marketability of U.S. rice grown in the mid-south. It will review the quality needs of importing countries, especially those in the Western Hemisphere, as well as the U.S. food service and food ingredient markets. We will analyze the criteria used in evaluating rice for the markets listed above including both the most preferred physical appearance attributes as well as the most desired cooking characteristics. We will also investigate the agronomic needs of rice farmers to both keep them competitive in the world market and their operations economically viable. Any research must also be made with the goal of the most sustainable production model for use of land, chemicals and water. The goal of this presentation is to help

establish quality parameters that will be useful in assisting rice breeders in making decisions that will move their research efforts in a direction to best serve the U.S. rice industry.

Effects of environmental temperature during maturation on spring wheat starch characteristics

S. AONO (1), S. Iwaki (1), K. Hayakawa (1)

(1) Nisshin Flour Milling Inc., Tsukuba-city, Ibaraki, Japan

Several factors affect wheat crop quality, and many reports have discussed the effects of climate (especially growing temperature) on wheat components. However, most of these studies were conducted under largely varying conditions using test intervals of as much as 5°C or more, or under harsh conditions causing heat stress. The objective of this study was to estimate variation in starch characteristics of wheat grown under realistic temperatures. Therefore, we used growing temperature conditions with intervals of 2°C. Using wheat grown under these conditions, we investigated the effects of growing temperature on wheat flour quality by analyzing the structure of the starch component and the expression of starch synthesis-related genes during the ripening stage. Wheat plants (*Triticum aestivum* cv. Haruyokoi) were grown in growth chambers. Growing temperatures in the light period were 12-20°C, 14-22°C, 16-24°C, 18-26°C, and 20-28°C by gradation for 14 hours, and in the dark period were 12°C, 14°C, 16°C, 18°C, and 20°C, respectively, for 10 hours. Using the isolated starch from the mature seeds, gelatinization was analyzed by differential scanning calorimetry (DSC) and the chain length of amylopectin was analyzed by high-performance anion-exchange chromatography with pulsed amperometric detection (HPAE-PAD). The immature seeds were collected every 5 days from 5 to 55 days post anthesis, and their complementary DNAs (cDNAs) were prepared for gene expression analysis. Lower growing temperature caused the gelatinization peak temperature of starch to decrease significantly (55.3°C at growing temperatures of 12-20°C vs. 60.8°C at growing temperatures of 20-28°C), the ratio of short chain (degree of polymerization (DP) ≤ 12) to increase, and the ratio of long chain (DP ≥ 13) to decrease. Our results indicated that growing temperature affected the amylopectin molecule structure. Lower growing temperature also caused the expression peak of starch synthesis-related genes in immature seeds to be delayed and the amount of their accumulated expression to increase. The increase in the amount of branching enzymes by the prolongation of the expression time caused the number of side chains of amylopectin to increase, the ratio of short side chain (DP ≤ 12) to increase, and gelatinization peak temperature to decrease.

Impact of mixer geometry on gluten network structure and dough aeration

A. M. LE BAIL (1,2), J. Fontaine (1,3), D. Dellavalle (1), J. Grua (1), J. Cheio (3)

(1) GEPEA-UMR CNRS, Nantes, France; (2) ONIRIS-UMR CNRS GEPEA, Nantes, France; (3) VMI, St. Hilaire de Loulay, France

Dough mixing, the first step of bread making, has a strong impact on the final structure of the bread. It aims at (1) distribution and homogenization of dough ingredients, (2) hydration of flour particles and (3) development of an isotropic gluten network and embedment of gas cells in the dough. The gluten-network plays a major role in the gas holding capacity and final bread volume. This study aims at exploring the impact of the mixing conditions and mixer geometry on dough aeration and rheology. A 10 liters Spiral-dough-mixer (SPI11-VMI/France) was used with power counter which was used to follow the evolution of the gluten-network during mixing. A maximum of consumed power was observed for a “ t_{PEAK} ” time, over which overmixing occurs with negative impact. An experimental design was used considering a sandwich-bread dough and three parameters; spiral-tool rpm, bowl-tool nip and bowl-tool speed (rpm) ratio. Dough aeration was the response. It was found that t_{PEAK} was strongly correlated with the number of tool revolutions, the temperature increase and the specific energy, indicating that these parameters can be used to follow dough development. Tool speed, bowl speed and the bowl-tool nip control the shear rate of the mixer that have a strong effect on dough aeration, mixing time, structure and rheology, showing the importance of mixer geometry on dough properties. Imaging of the gluten network (CLSM+ rhodamine/B) was done to monitor the gluten-network structure and connectivity of the gluten strips. The time to reach maximum consistency during mixing is matching with the maximum dough aeration. During overmixing (after time to peak), dough aeration declines. The dough porosity at time to peak declines with decreasing nip and rises back for highest nip levels. The nip was found to be very impacting on the connectivity between the gluten strips and on the size of the gluten strips. This was monitored by CLSM microscopy. The protein strips length, the branching rate and the end point rate increased with increasing nip whereas the protein width was declining with increasing nip. As a conclusion, the control of the structure and geometry of a mixer plays a major role in the formation and quality of the dough obtained during mixing; impact on bread structure will be pointed out. Acknowledgements: This project was funded by VMI, ONIRIS and ANR-LABCOM “MIXI-LAB” project (contract ANR- 15-LCV3-0006-01).

Investigating and comparing arabinoxylan structures in ruminant-relevant cool-season pasture grasses

G. JOYCE (1), R. Schendel (1)

(1) University of Kentucky, Lexington, KY, U.S.A.

Arabinoxylan (AX) is a polysaccharide that constitutes a major structural component in secondary cell walls of monocots such as cereal grains and pasture grasses. The AX backbone consists of β -D-xylopyranoses linked via β -(1 \rightarrow 4) linkages, with α -L-arabinofuranose substituents attached to the backbone via α -(1 \rightarrow 3) and/or α -(1 \rightarrow 2) linkages. In addition, AX contains complex heteroxylan sidechains and hydroxycinnamic acids, such as ferulic and *p*-coumaric acid, which are esterified to α -L-arabinofuranose at the O-5 position. These structural elements combine in a random pattern, making AX particularly difficult to rapidly characterize. AX structures differ between grass species, and these differences impact gut microbial fermentation and production of short chain fatty acids (SCFA) in livestock. With a better structural understanding of the AX, the impact of structure on microbial fermentation and other metabolic consequences in the host can be elucidated. In this project, AX structures in the foliage of different cool-season pasture grasses are being investigated and compared. The monosaccharide composition of the cell wall carbohydrates and the esterified phenolic acid profile are being characterized. In addition, the AX structure is being digested using xylanases, creating AX oligosaccharides. These AX oligosaccharides will be separated, detected, and quantified using High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection (HPAEC-PAD). HPAEC-PAD is an excellent analytical tool that can separate mono- and oligosaccharides effectively without sample derivation. Although some AX oligosaccharide standards are commercially available, there is a need to expand the standard library in order to easily quantify specific AX structural elements. Mass spectrometry and 2D NMR are being used to characterize the structure of these AX oligosaccharides.

Edith Christensen Award Presentation – Analytical support of a pet food business

K. S. PHILLIPS (1)

(1) retired, NP Analytical Laboratories, retired, St. Louis, MO, U.S.A.

Analytical support of pet food manufacturing is much more than testing for moisture, protein, fat, and fiber. Pet foods must be shown to meet both the nutrition and sensory needs of the pet while satisfying the pet's human companion. They also need to comply with appropriate regulatory requirements. Manufacturers need to demonstrate that diets provide the 30–40 key nutrients as identified by AAFCO and are free from microbial and chemical contaminants such as salmonella and aflatoxin. In addition, the diets must appeal to the pet of which kibble quality is an important component. To meet these needs, testing of ingredients, intermediate products, and finished diets is conducted. Laboratories providing this support should demonstrate competence in testing both the analytes of interest and matrices used in the diets. In addition, sample preparation is a key requirement in providing a representative sample to the analytical laboratory. This presentation will explore the testing needed and the challenges of providing valid results to the business.

Compositional characterization of hairless canary seed oil and starch associated lipids

E. ABDELAAL (1), M. Hernandez (2), I. Rabalski (1), L. L'Hocine (3), C. A. Patterson (4), P. J. Hucl (5)

(1) Agriculture and Agri-Food Canada, Guelph, ON, Canada; (2) Guelph Research and Development Centre, AAFC, Guelph, ON, Canada; (3) Saint-Hyacinthe Research and Development Centre, AAFC, Saint-Hyacinthe, QC, Canada; (4) The Pathfinders Research & Mgmt. Ltd., Saskatoon, SK, Canada; (5) Crop Development Centre, Saskatoon, SK, Canada

Hairless (glabrous) canary seed is a true cereal grain relative to oat, wheat and other cereal grains. Recently the hairless canary seed received novel food approval from Health Canada and GRAS status from US-FDA. The dehulled canary seed grains (also called groats) can be used as whole grain flour or as an alternative source of protein, starch and oil for use in both food and non-food applications. The current study is intended to investigate compositional characteristics of the whole grain oil and starch associated lipids including granules surface and internal lipids from two hairless canary seed varieties. Oil was recovered from the groats using extraction with ethanol, followed by sequential extractions with alkaline and water to separate protein, coarse fiber, fine fiber and lastly starch. The oil obtained from the wet milling fractionation process yielded on average 4.9 g/100 g groats. The crude oil extracted by Soxtec Auto Extraction unit with hexane had an average 7.3%. Starch surface lipids were extracted with isopropanol at ambient temperature while internal lipids were obtained from starch granules in a mixture of n-propanol and water (3:1, v/v) at $92 \pm 2^\circ\text{C}$. Oil obtained from the whole grain and starch lipids were characterized using gas chromatography (GC) and thin layer chromatography (TLC). The total fatty acids % in the oil from the fractionation process was higher than that in the crude oil being slightly higher in poly-unsaturated fatty acids (PUFAs) and mono-unsaturated fatty acids (MUFAs) but they are close in the % of saturated fatty acids (SFAs). The canary seed oil had more mon-unsaturated fat (e.g. MUFAs) and less saturated fat when it was compared with wheat oil. Starch lipids from canary seed also contained more levels of MUFAs and PUFAs and lower levels of SFAs than wheat starch lipids. Starch internal lipids varied from the external lipids in terms of content and composition. TLC analysis revealed that the internal lipids contained

primarily monacyl lipids and free fatty acids (FAs), while the surface lipids comprised mainly from triacylglycerols. The results indicate that hairless canary seed oil has exceptional FA composition compared with wheat oil, and its starch also contains distinct lipid composition (e.g. more polar lipids) which could contribute to the uniqueness of canary seed starch properties.

Phenolic interactions in whole grains: Implications for starch functionality, digestion and glycemic properties

M. FERRUZZI (1)

(1) Plants for Human Health Institute, N.C. State University, Kannapolis, NC, U.S.A.

Whole grains are rich in phenolic compounds that have been associated with many of health benefits of whole grain consumption including cardiovascular health and modulation of carbohydrate digestion and glycemic response. In the case of carbohydrate digestion, proposed mechanisms include the ability of individual phenolics to inhibit starch digestive enzymes and suppress intestinal glucose transport. However, these interactions, often measured in vitro or preclinically, have not fully translated in clinical settings. More recently, physical interactions between phenolics and starch have been reported to alter pasting properties of starch and subsequent digestibility. To determine the extent to which such interactions may contribute to whole grain functionality, the physical complexation between phenolic acid (caffeic acid and ferulic acid) with maize amylopectin and potato starch was studied to determine the nature of these interactions and their ability to pasting properties, digestibility and subsequent intestinal glucose transport. Phenolic complexes were generated by steeping native starch with phenolic acids (50 mg/g starch) in an aqueous HCl (pH = 2.0) for 24h prior to freeze drying. Non-covalent interactions between starch and phenolics were explored by GC-MS, DSC and NMR. While phenolic treatment had minimal impact on monosaccharide compositions or glycosidic linkages, supporting the lack of covalent/chemical modification, of resulting complexes, DSC experiments indicated a significant reduction in glass transition temperatures with phenolic complexation ($> 1^{\circ}\text{C}$, $p < 0.05$). NMR characterization further suggests that phenolics remained complexed with gelatinized starch molecules through weak CH- π bonds, leading to reduction in both hydrodynamic radius and digestibility of model systems. Simulated gastrointestinal digestion found a modest reduction in the digestibility for starch-phenolic complex relative to controls. Glucose transport assessed using highly differentiated Caco-2 human intestinal cell monolayers, was also reduced for maize amylopectin-phenolic complex (58.7-119%) than native amylopectin (100%) and the matching amylopectin-phenolic mixture (104-128%), but increased in potato starch-phenolic complex (73.7-156%). Combined these data suggest that functionality provided by physical phenolic-starch complexation might be a contributing factor modulating digestibility and intestinal absorption of starch and phenolics.

Impact of the composition of selected fat blends on the texture and staling rate of brioche

A. M. LE BAIL (1), G. Diler (2)

(1) GEPEA-UMR CNRS, Nantes, France; (2) ONIRIS-GEPEA CNRS, Nantes, France

The reference fat for French brioche is butter, which contains a high levels of saturated and trans fatty acids. In this study, five shortening composed of fat from vegetal and/or animal origin including in some of them an emulsifier were developed to replace butter with the objective of improving their nutritional profile. The impact of these shortening on mixing and fermentation time, brioche properties (specific volume, crumb texture, alveolation, water content and fatty acid composition) and staling rate were studied. Rapeseed oil gave brioche with the better nutritional profile. Properties the most affected by the shortening substitution were mixing time and firming rate; it was assumed that the observed changes may be attributed to the presence of emulsifiers and/or to the composition (saturated fat) of the shortening. Shortening containing lipids from vegetable sourcing and emulsifiers gave soft dough with long mixing time, and brioche with slow firming rate during storage. The Young modulus was measured during staling on 5 brioche in duplicate; the values after 31 days of storage at 10°C was $4.1 \text{ kPa} \pm 0.5$ (butter), $7.0 \text{ kPa} \pm 0.8$ (Duck Fat), $9.1 \text{ kPa} \pm 1.3$ (milk fat/duck fat), $2.2 \text{ kPa} \pm 0.7$ (milk fat/rapeseed/sunflower/texturing agent), $4.9 \text{ kPa} \pm 1.1$ (rapeseed/texturing agents) and $7.4 \text{ kPa} \pm 1.0$ (anhydrous milk fat/sunflower/texturing agents). For each brioche, the Avrami model parameters, k (rate constant in d^{-1}) was determined; kinetics was faster for increasing level of fat saturation. Time constant as ranging between 0.07 days for milk fat/rapeseed/sunflower/texturing agent), up to 0.31 days for butter and 0.28 days for duck fat. Duck fat resulted in dough and brioche with properties close to that of the control (butter brioche) with half less saturated fat, and almost no trans fatty acids. Then, duck fat appeared as an interesting alternative to butter, combining a better nutritional profile, without affecting production characteristics and brioche properties. Acknowledgments: This research was funded by the Region Pays de la Loire, Région "Basse Normandie" and Région "Bretagne" within the Project "MGBVP". ITERG, technical center specialized in lipids (Bordeaux – France) is acknowledged for the preparation and characterization of the different fat mixes used for the baking tests.

The nexus between polyphenols and dietary carbohydrate quality: Towards healthier high “carb” foods

J. M. AWIKA (1)

(1) Texas A&M University, College Station, TX, U.S.A.

Carbohydrates are a major component of most food products due to their versatile functionality and broad sensory appeal. Unfortunately, the growing prevalence of excess calorie intake and undesirable consequences like obesity and type II diabetes has brought considerable public scrutiny on the contribution of carbohydrates to these nutrition-linked problems. Meanwhile evidence indicates that dietary polyphenols can mitigate some of the undesirable consequences of excess available carbohydrate intake by modifying carbohydrate digestion, absorption, and metabolism. Dietary polyphenols can regulate glucose homeostasis and insulin sensitivity via various mechanisms, including formation of non-digestible complexes with starch, direct inhibition of intestinal amylase and glucosidase enzymes, inhibition of intestinal glucose transporters, and stimulation of insulin secretion. The mode of action of the polyphenols depends on their structure and molecular weight, dietary carbohydrate composition, as well as the food matrix. For example, only high molecular weight polyphenols (tannins) are capable of forming organized, non-digestible complexes with starch; these complexes reach the colon and are likely to influence gut microbiota in important ways that are yet to be fully explored. On the other hand, a wide variety of polyphenols are known to inhibit digestive enzymes and intestinal sodium-dependent glucose transporters. Thus, polyphenols can be effectively harnessed through raw material selection and processing technologies to improve carbohydrate quality of foods and enhance their positive impact on human health. This introductory presentation aims to broadly highlight the current body of evidence on mechanisms and consequences of dietary carbohydrate-polyphenol interactions, and how to exploit the interactions to benefit human health.

Prediction of bioactive composition in soybeans using NIR

M. SINGH (1), M. Berhow (1), S. X. Liu (1)

(1) USDA-ARS-NCAUR, Peoria, IL, U.S.A.

Isoflavones and saponins are major classes of bioactives in soybeans that have been linked to cancer prevention and control. Rapid analytical techniques are needed to estimate their levels in soybeans as they arrive at the grain elevators and processing plants. We are evaluating NIRS as a suitable, rapid, nondestructive method to determine isoflavone composition in ground soybeans. Soybean samples (N >3000) were obtained from the Agricultural Research Service soybean germplasm collection, and from several locations in United States over a five year period. The soybean samples were ground and scanned on near infrared spectrometers (NIRS) and analyzed by wet chemical methods for total isoflavone composition (genistein, daidzein and glycitein), and total saponin composition (A group-, B group- and DMPP-group). A subset selection of these samples was used to prepare NIRS calibrations. Selected preprocessing algorithms were applied to spectral data to minimize/eradicate noise or disturbance in the spectra. Partial Least Squares (PLS) regression analysis of preprocessed spectral data and wet chemistry data were used to develop models to predict individual sugars. The selection of a suitable calibration model was based on a high regression coefficient (R²) and lower standard error of calibration (SEC) values. Optimized PLS regression models were then used to predict validation sets. Reasonable predictions were obtained for isoflavones, however less than robust calibrations were obtained for the total saponins.

Development of emulsifiers from pea and corn starches using octenyl succinic anhydride modification

F. CHENG (1), S. Ghosh (1), Y. Ai (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada

Pulses are dried, edible seeds of *Leguminous* plants, which are processed into various ingredients to improve their commercial value. However, pulse starch, as a major co-product of the pulse processing industry, shows limited industrial applications. The objective of the study was to expand the utilization of pulse starch as an emulsifier by using octenyl succinic anhydride (OSA) modification. Isolated pea starch (IPS), along with commercial normal corn starch (NCS) and waxy corn starch (WCS), was modified with 1, 3 or 5% (w/w, dry basis, db) OSA. Structure, functional and emulsifying properties of OS-starches were characterized. All the OSA-modified starches showed lower pasting temperatures and higher peak viscosities compared with their corresponding controls, and more noticeable changes were observed with a higher degree of OS substitution. Canola oil (5 wt%)-in-water emulsions were prepared with OS-starches (2 wt%) by high pressure homogenization. The OS-IPS decreased the oil-water interfacial tension from 21.1 to 6.9-9.5 mN/m, and a similar decreasing effect was found with OS-NCS and OS-WCS. The droplet size of fresh emulsion stabilized by OS (3%)-IPS was 0.160 μm, which increased considerably to 0.295 μm after storing at 4°C for 28 days. By contrast, emulsion stabilized by OS (3%)-WCS exhibited better stability as the droplet size (0.154 μm) remained unchanged after 28-day storage at 4°C. The emulsion formed by OS (3%)-IPS showed good stability under mild pH condition (7.0 to 5.0) and heating at 90°C for 30 min; however, the emulsion destabilized when the pH further dropped to the range of 4.0 to 2.0 or when 0.1 M sodium chloride was present in the system. Overall, OS-IPS showed the ability to create emulsion with a relative small droplet size, but the emulsion was less stable against

environmental change and long-term storage compared to emulsion formed by OS-WCS modified with the same concentration of OSA.

Have refined, enriched grain staples been unfairly demonized?

J. M. JONES (1)

(1) emerita, St. Catherine University, Minneapolis, MN, U.S.A.

Ingestion of whole grain foods (WGFs) has, in epidemiological studies, been consistently associated with nutritional and health benefits. These are observed with approximately 48 g of whole grains (WGs) [three 1 oz servings results (90 g) of WGFs]. However, intervention trials substituting WGFs for refined-grain foods (RGFs), at the same or higher levels, fail to show the same consistent results. Despite this, health professionals eagerly endorse WGFs, but may fail to support the evidence-based recommendation to make 'half your grains whole' and denigrate RGFs as dietary pariahs. This talk reviews literature supporting recommendations balancing WGFs and RGFs and identifies various factors that potentially both inflate benefits of WGFs and risks of RGFs. These are: 1) Unintended bias due to binary categorization. WGFs categories are comprised of recommended staple foods, such as pasta, bread; RGFs categories are half staple and half indulgent grain-based foods (GBFs), recommended in dietary guidance as foods to limit due to detractor nutrients and poor nutrient profiles. 2) Inadequate adjustment for multiple sources of confounding and their interactions in epidemiological studies. 3) Impacts of skewed GBFs intakes are also not considered. Under 10% of consumers eat the recommended 3 servings of WGFs, but many eat more GBFs than recommended, often indulgent GBFs. This is not considered in communications about RGFs that often damn them rather than the poor choices and imbalance. 4) There is unequal consideration and communication of conclusions about all GBFs from meta-analyses, based on varying definitions of WGFs which mean they may contain between 49% and 74% RGs. While studies identify decreased health risks with WGFs, no change in risk with ingestion of RGF is neither promulgated nor considered when making recommendations about GBFs. 5) Those who advocate all GBFs be WGFs, do not consider results showing the best nutritional and health outcomes with the right mix and quantity of GBFs. 6) Recommendations to avoid enriched/fortified, staple RGFs may impair folate and B vitamin status and mineral bioavailability and decrease WGFs acceptability. Thus, calls to eliminate all RGFs is neither backed by existing data nor reflected in current dietary guidance and fail to recognize the importance of the RGFs/WGFs balance. Public health professionals should craft messages that reflect the scientific literature and promote choice of the right type, quantity and mix of WGFs and RGFs.

New infrared treatment approaches to combat contamination of shelled corn with harmful molds

Z. MOHAMMADI SHAD (1), G. G. Atungulu (1)

(1) Department of Food Science, University of Arkansas, Fayetteville, AR, U.S.A.

Harmful molds such as *Aspergillus flavus* have the potential to generate mycotoxins on corn thereby jeopardizing consumer health and posing significant economic losses to growers. This study investigated the efficiency of IR with subsequent tempering step at 50-60°C for 24 h to dry corn to the safe storage moisture content (MC); the study also investigated the resulting microbial decontamination and fungal diversity on treated corn using metagenomics techniques. Infrared treatments were performed with corn samples at bed thicknesses of 1.5, 2.7 and 4.5 cm. A pilot-scale, continuous-flow, radiant heating system equipped with catalytic IR emitters was designed and built to conduct the corn drying and decontamination. Drying was done at 5.55 kW/m² for IR heating intensity, fixed product-to-emitter-gap size of 450 mm, belt drive speed of 0.11 m/s, and intermittent heating duration of 30 s. Result showed that duration required to reduce the corn MC from 21 to 13.5 percent depended on the corn bed thickness. The efficiency of IR drying was also improved with addition of tempering step. Results indicated that when corn bed thickness increased from 1.5 to 4.5 cm, the percentage of moisture reduction significantly reduced. This research also revealed that the drying was feasible with simultaneous decontamination of microbes on the corn. *Aspergillus* and *Oidiodendron* were the most susceptible fungal genera affected by the IR drying. There was significant reduction in these fungi. In conclusion, this work showed that IR drying of corn holds promise as a rapid drying method with potential benefits of microbial decontamination of corn; this may help producers combat mold related problems such as mycotoxin contamination.

Controlled sprouting in wheat increases quality and consumer acceptability of whole wheat bread

R. Johnston (1), C. Byker-Shanks (1), J. M. Martin (1), M. J. GIROUX (1), S. M. Finnie (2)

(1) Montana State University, Bozeman, MT, U.S.A.; (2) Bay State Milling, Quincy, MA, U.S.A.

Intentional sprouting of grain to modify grain products nutritional composition and flavor has been in practice for thousands of years. However, few studies have tested the impact of controlled sprouting on wheat flour functionality and flavor. In this study, grain of nine hard red spring (HRS) wheat (*Triticum aestivum* L) cultivars was sprouted with the goal of attaining a falling number (FN) value of 200 from a starting FN of 350 seconds. Paired samples of sprouted and sound HRS grain were then assayed for nutritional composition, functionality in bread baking, and in bread taste tests. Sprouting reduced grain hardness and test weight while increasing grain

color brightness, yellowness, and redness. Whole sprouted grain flour had twice the alpha amylase activity and a large decrease in flour swelling power relative to sound grain flour. Sprouted flour also contained increased free amino acids and monosaccharides while having decreased sugar alcohol content. Total dietary fiber trended down in the sprouted grain flour while starch content remained unchanged. Whole grain flour color parameters were relatively unaltered by sprouting. Sprouting reduced dough mix times while increasing loaf volume. Sensory panel evaluations demonstrated that testers preferred bread prepared from sprouted grain flour to bread prepared from sound grain while also finding that sprouted grain bread tasted less bitter and grainy while also being perceived as sweeter and moister. The results demonstrate that controlled sprouting of wheat grain could be used to increase whole grain flour functionality in bread baking and consumer acceptability of whole grain foods.

Preparation of porous starches by combining acid hydrolysis or surface gelatinization with alpha-amylase digestion

A. I. GONZALEZ (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

Porous starches are attracting much attention because their great adsorption ability finds applications in both food and pharmaceutical industries, such as carriers of bioactives that are sensitive to processing conditions. Porous starches are commercially prepared by digestion of cereal starches (A-type starches) with amylases, but not from the B-type starches such as potato starch. The limited amylolytic digestion of potato starch is attributed to its absence of surface pores, large and smooth granules, and crystalline structure. We hypothesized that modifying starch granule surface could facilitate the access and subsequent hydrolysis of enzymes, thus enhancing the formation of a porous structure. This study compared the effect of surface gelatinization or acid hydrolysis on the digestion of potato starch versus common corn starch by α -amylase. Starch was subjected to surface gelatinization with 13 M lithium chloride to yield 8.0-9.0% surface gelatinized starches or treated with 3.16 M sulfuric acid to yield approximately 10% hydrolysis. Native and treated starches were then subjected to α -amylase digestion for 1, 5, 10, and 24 hours. The resultant starches were characterized for hydrolysis degree by quantifying soluble sugars, morphology by scanning electron microscopy, and crystallinity by X-ray diffractometry. The crystalline type of the starches was not affected by acid hydrolysis or surface gelatinization. The extent of α -amylase digestion after 24 hours increased by 30.6 and 70.2% for potato and common corn, respectively, after acid hydrolysis, and increased by 12.3 and 11.3% for potato and common corn starches, respectively, after surface gelatinization. The morphology of the corn starches displayed a greater and uniform distribution of enlarged pores even after only one hour of enzymatic treatment. Despite a more defined porous structure after the combination of acid hydrolysis or surface gelatinization with α -amylase digestion, the pores in potato starch tended to be smaller and their distribution was not as homogeneous as those in corn starch. The results indicate that acid hydrolysis and surface gelatinization enhanced the hydrolysis of starch by α -amylase, thus promoting the formation of porous structure in both potato and corn starches.

Solving CBD formulation and taste challenges

C. CASTLEJOHN (1)

(1) FONA International, Geneva, IL, U.S.A.

Cannabidiol-infused (CBD) products continue to skyrocket, exciting consumers with the promise of future functional food innovation. As competition continues to raise the stakes, companies must not only possess a broader understanding of the marketplace, but they must also overcome a major taste challenge often found in CBD-infused grain products: undesirable off-notes like bitterness. In this presentation, we will explore these taste and formulation challenges within a variety of grain-based applications, including bars, bakery and cereal. Additionally, we will provide an overview of how to overcome these challenges using a data-driven approach with analytical tools, such as e-tongue. Finally, we will look at how these tools are used to safely validate these taste solutions with consumers.

Comparison of molecular structures and physicochemical properties of high amylose rice starches with different crystalline types

J. NO (1), M. Shin (2)

(1) Songwon University, Gwangju, South Korea; (2) Division of Food and Nutrition, Chonnam National University, Gwangju, Korea

The crystallinity of rice starch shows generally A type, but B type crystallinity is shown in newly developed rice varieties in Korea. The molecular structure and resistant starch of high amylose rice starches, Goami, Singil, Goami2, and Dodamssal were compared. Goami2, Singil and Dodamssal are developed by mutation breeding with MNU (N-methyl-N-nitrosourea). Amylose contents of Goami, Singil, Goami2, and Dodamssal starches were 25.56, 30.34, 36.33, and 45.78%, respectively. The crystalline structures of Goami and Singil starches was A type, but those of Goami2 and Dodamssal starches was B type. Dodamssal starch showed the highest in initial

pasting temperature, but the lowest in setback viscosity. The peak, trough, final and breakdown viscosities of Goami2 were the highest among them. The molecular weights of amylose of B type starches (1.64 and 1.88×10^5) was lower than those of A type starches (3.88 and 3.00×10^5). The branched chain length proportions of amylopectin in DP25-36, and DP \geq 37 of B type starches were higher than those of A type starches. Resistant starch and total dietary fiber contents of B type starches were higher than those of A type starches. It is suggested that molecular structure of high amylose rice starches should be different from crystalline types and B type starches should have higher resistant starch and dietary fiber contents than A type starches.

Heat-moisture treated starch as an alternative to cross-linked starch

Y. H. CHANG (1), J. H. Lin (2), C. L. Lin (1), C. L. Pan (1)

(1) Providence University, Taichung, Taiwan; (2) MingDao University, Changhua, Taiwan

Through heat-moisture treatment (HMT), the rigidity of starch granules is strengthened, gelatinization peak viscosity decreased and viscosity stability improved. This further makes HMT starch more oriented to cross-linked starch. In this study, tapioca starch with 15-30% moisture content was treated at 80-120°C for 3-12 h, its physical properties were analyzed, and the pasting properties were compared with those of commercial cross-linked tapioca starch (CLTS) to evaluate the feasibility of using HMT to prepare starch with characteristics comparable to CLTS. Results showed the alterations in birefringence, thermal and pasting properties of HMT tapioca starch depended on HMT parameters, including moisture content (MC), temperature (T) and duration (D). Additionally, the effects of HMT parameters on gelatinization onset temperature, peak temperature and enthalpy change were in the order of MC > T > D, and the effects on pasting viscosities were T > D > MC. Besides, after HMT with 30% moisture content at 100°C for 6 h or 120°C for 3 h, HMT starch was characterized with comparable final viscosity to CLTS. Moreover, shear resistance of both HMT starch pastes (5.5%, w/w; similar viscosity to drinking yogurt) was comparable to that of CLTS under neutral (pH 6.7-6.8) and mild-acidic (pH 4.4-4.5) conditions, but was decreased when further lowering the pH to 2.4-2.5. The findings of this study suggest the pasting characteristics of HMT tapioca starch can be tailored by varying the T, D, and MC of the treatment. Moreover, with appropriate HMT conditions, the obtained starch exhibits adequate granular characteristics and shear resistance after gelatinization, and could be an alternative to CLTS when the pH of food system is in the range of 4.4-6.8.

Late maturity alpha-amylase, falling number, baking quality: What do we know?

J. P. F. RAL (1)

(1) CSIRO Agriculture and Food, Canberra, Australia

Late maturity α -amylase (LMA) is a recently identified quality issue that is now receiving increasing attention and whose prevalence is now seen as impeding the development of superior quality wheat varieties worldwide. LMA is a genetic defect present in specific wheat genotypes and is characterized by abnormally elevated levels of the high pI TaAMY1 α -amylase, triggered by environmental stress at precise grain developmental stage throughout grain maturity and harvest. Elevated level of α -amylase lowers Falling Number (FN) test (a test used to detect sprouted grain) at receipt, causing a down-grading of the grain, often to feed grade, thus reducing the farmers' income. To date only a portion of the new elite varieties are released for commercialisation due to breeding lines failing the LMA screening process. Elimination of high yielding varieties represents a huge economic loss to both the seed companies and wheat growers. Breeders need the introduction of new high yielding varieties in order to maintain competitiveness in the International export market. As a consequence growers might not have access to potentially high yielding lines that are not released due to LMA risk. Reputation can be damaged if selling grains affected by LMA. This severely impacts grower profitability through increasing risk of a reduced grain value. There seems to be a knowledge gap in describing and cataloguing the wheat α -amylase isoforms, despite compelling information on the involvement of two α -amylases on economically important issues for the international cereal community, namely Preharvest sprouting (PHS) and Late maturity α -amylase (LMA). Consequently any wheat line possessing low FN or high α -amylase levels is automatically considered a poor bread wheat despite there being no published evidence to date, to show that LMA is detrimental to end product quality. To evaluate the validity of this assumption we performed a comprehensive evaluation of the impact of elevated level of α -amylase on grain composition, starch structure and baking properties combining a set of engineered wheat lines overexpressing the different α -amylase isoforms and over 200 RILs from Multi-parent Advanced Generation Inter-Cross (MAGIC) wheat population. Alpha-amylase levels were assessed along with quality parameters including end product functionality using AACC Approved Methods 10-09.01 and 10-10.03. No consistent or significant genetic or phenotypic correlation was found between elevated level of α -amylase related Falling Number and any of the quality traits. Overview of these studies provide the first direct evaluation as to whether elevated levels of α -amylase impact baking quality.

Gamma-aminobutyric acid (GABA), amino acid, polyamines and their correlation analysis of mung bean under mild heat and relative humidity treatment

Y. Ma (1,2), S. ZHOU (1), C. Blecker (2), L. Tong (1), L. Liu (1), L. Wang (1), X. Zhou (1), B. Zhao (1), S. Wang (1,3), T. Liu (1)

(1) IFST, Chinese Academy of Agricultural Sciences, Beijing, China; (2) Department of Food Science and Formulation, Gembloux Agro-Bio Tech-ULg, Gembloux, Belgium; (3) Tibet Academy of Agricultural and Animal Husbandry Sciences, Lhasa, China

Gamma-aminobutyric acid (GABA) has been reported to have many functional activities and the GABA enrichment in cereals is important for people's health. In this article, a novel and safe GABA enrichment approach based on mild heat (°C) and relative humidity (RH) treatment for hours (h) (Step1: 70°C, 95% RH, 4 h; Step2: 40°C, 70% RH, 4 h; Step3: 30°C, 70% RH, 4 h.) was examined. 34 Chinese mung bean varieties were processed by the method. Results showed that the average GABA content increased from 4.90 mg/100 g, dry weight (DW) at native mung bean to 31.54 mg/100 g, DW after mild heat and relative humidity treatment. The No. 8 mung bean variety exhibited the highest GABA content (82.47 mg/100 g, DW) after processing, which was equivalent to 33 times concentration of original mung bean (2.48 mg/100g, DW). The changes of amino acid, free amino acid and polyamines of mung bean under treatment were different. GABA, serine (Ser), free alanine (F-Ala) and citrulline (Cit) significantly increased. However, valine (Val), free glutamic (F-Glu), free aspartic (F-Asp), spermine (Spm) and free valine (F-Val) significantly decreased. Correlation analysis showed that the content of F-Glu, free amino iso-butyric (F-b-AiBA), free arginine (F-Arg), b* and L* in the native mung bean had a significantly correlation ($r = 0.483, p < 0.01$; $r = 0.412, p < 0.05$; $r = 0.381, p < 0.05$; $r = -0.514, p < 0.01$; $r = -0.347, p < 0.05$, respectively) with the GABA content in processed mung bean. Besides, the correlation analysis indicated the enrichment of GABA also caused other amino acids and polyamines (especially free amino acid) increase or decrease to jointly resist heat and humidity stress. These results were anticipated to provide useful information on the development of GABA-rich functional products and heat stress plant metabolism mechanism.

Sprouting as a bio-technological process to enhance the use of quinoa (*Chenopodium quinoa* Willd.) in cereal-based products

A. MARTI (1), M. A. Pagani (1), D. P. Suárez Estrella (1)

(1) Department of Food, Environmental and Nutritional Sciences, University of Milan, Milan, Italy

Awareness of the several agronomic, environmental, and health benefits of quinoa has led to a constant increase in its consumption. However, producing quinoa-enriched products alters some quality characteristics, including dough development and sensory acceptance, due to the lack of gluten and the presence of saponins, bitter compounds mainly located in the pericarp. Developing processes to decrease or modify the bitterness of quinoa can enhance its palatability and consumption. The aim of the study was to investigate the effect of sprouting on the molecular, functional and sensory properties of quinoa, in order to enhance the use of sprouted seeds as a new ingredient in food formulation. Whole quinoa was sprouted for 12, 24, 48 and 72 h at 22°C and 90% of relative humidity and dried at 55°C for 6 h. The development of amylases and proteases promoted changes in both starch and protein features, reaching the maximum extent after 48 h of sprouting. The molecular changes affected flour functionality, by: (1) decreasing the ability of absorbing and retaining water; (2) lowering syneresis during freeze-thawing; (3) decreasing foaming capacity and improving the stability of the foam. The 20% enrichment level was able to assure a good gluten aggregation suitable for the formation of dough able to maintain its structure during leavening and retain a high percentage of gas. The behavior of sprouted quinoa enriched-bread was compared with that of pearled quinoa-enriched bread at the same percentage (20%). Sprouted quinoa-enriched bread showed the best results in terms of volume and crumb softness up to three days of storage, suggesting that sprouting can be preferred to pearling, which is the most common pre-treatment for allowing the use of quinoa in bread-making. The increase in total titratable acidity and the decrease in pH upon sprouting time affect quinoa sourness. On the other hand, the decrease in foaming capacity observed in quinoa after 48-72 h sprouting could be associated with a decrease in saponin content, as measured by the afrosimetric method. In conclusion, sprouting can be proposed as an alternative method to washing or pearling to decrease the amount of saponins starting from 24-48 h of process. Thus, sprouted quinoa can be used as a new ingredient in cereal-based products thanks to its capacity of enhancing bread performance, without using additives. Diego Suárez-Estrella is supported by a Doctoral Fellowship from the Secretaría de Educación Superior, Ciencia, Tecnología e Innovación, Ecuador.

Physicochemical properties of alkaline noodles enriched with clarified beetroot juice

W. C. Pan (1), G. H. Li (2), Y. H. CHANG (3), S. Y. Shiau (1)

(1) Tajen University, Pingtung, Taiwan; (2) Jiangsu Agri-animal Husbandry Vocational College, Taizhou, China; (3) Providence University, Taichung, Taiwan

Beetroot juice is rich in bioactive compounds, such as betalains, phenolics, flavonoids, etc., and is described to have antioxidation, anti-inflammation and antitumor effects. The addition of beetroot juice in food product may improve consumer preference and fulfill the demand for clean label food products. In this study, 10% clarified beetroot juice was added in alkaline yellow noodle, which is an important popular staple food in Asia. The objective of this study was to investigate the effect of various kansui concentrations (0 - 0.4%) on physicochemical properties of enriched noodles. Results showed that with increase of kansui concentration, the pH, thickness, tensile strength and extensibility of raw noodle increased, along with the breaking force of dried noodle. Addition of kansui level was proportional to tensile strength of cooked noodle and inversely proportional to its extensibility. Cooking loss and moisture content of cooked noodle were not significantly affected. Both L^* and b^* (yellowness) values as well as white index of dried noodle increased with the concentration of kansui, while redness (a^* value) was significantly decreased. Similarly, dried noodle with high kansui concentration had lower betacyanin and betaxanthin contents and DPPH-scavenging activity. Cooked noodle had lower redness and higher yellowness than dried one. Accordingly, to maintain red color and good antioxidative activity, noodle enriched with the beetroot juice should be prepared with low kansui concentration (0.1%).

Molecular structures, amylopectin chain profile and physicochemical properties of pea starches

Y. ZHOU (1), G. A. Annor (1), E. Bertoft (2)

(1) University of Minnesota, St. Paul, MN, U.S.A.; (2) Bertoft Solutions, Turku, Finland

It is important to evaluate the structure and functionality of pea starches with a view to providing suggestions for further research to improve their utilization in food and non-food industry. Little research has been done on unit and internal chain profiles of pea starches so far. This study was to investigate molecular structure, amylopectin chain profiles and physicochemical properties of pea starches. Two commercially available pea starches were purchased and the experiments were conducted to figure out any differences between two samples. Unit and internal chain profiles were analyzed by HPAEC after amylopectin fractionation. The content of amylose and the purity of isolated amylopectin were measured using Gel Permeation Chromatography (Sephacrose CL-6B). Gelatinization characteristics and pasting properties of the starches were determined using Differential Scanning Calorimetry and the Micro-Visco-Amylo-Graph respectively. The characteristic C type pattern of both samples was revealed by using Bruker D8 Discover X-ray diffractometer. The average diameter of starch granules measured with a laser particle sizer was 25.44 μm , 26.51 μm and the amylose contents were 33.27%, 29.14% for sample 1 and 2, respectively. Peak value of sample 1 with higher amylose content was higher than sample 2 since amylose bound much more iodine than amylopectin. After isolation, the purity of amylopectin in both samples were up to 93%. There was no significant difference in unit chain profiles between two samples. The major difference in the amylopectin chain profiles was in the internal part. Sample 1 had clearly shorter internal chains than sample 2, although their external chains were similar. The pasting temperature of sample 1 was higher than sample 2, which agreed with the results of DSC. Sample 1 showed higher T_o , T_c , T_p than sample 2, but the enthalpy of sample 2 was much higher than sample 1. This study showed the differences in structures and functional properties between these two samples, providing a basis for detailed structural analysis.

Asparagine content of breadmaking wheat: A potential issue for market access

M. G. SCANLON (1)

(1) University of Manitoba, Winnipeg, Canada

2018 legislation in the EU requires the baking industry to demonstrate that it is taking measures to mitigate acrylamide formation in bread, due to its reported health risks. One possible solution for reducing acrylamide formation in bread is the reduction of the main precursor of acrylamide, the amino acid asparagine. For wheat, select agronomic practices, along with the development of new varieties with lower propensity to form free asparagine are demonstrable mitigation steps. Hence, levels of free asparagine in breadmaking wheats destined for export needs to be determined, and the effects of agronomic practices on these levels quantified in order to maintain access to key export markets. To address this concern, a comprehensive study of the effect of genotype, fertilizer treatments, and location on the free asparagine content of eight commercially grown Canadian wheat varieties was undertaken. Wholemeal flours from the varieties grown at two locations in Manitoba under various sulfur and nitrogen fertilizer treatments were assessed for free asparagine content. For this purpose, an ultrahigh pressure liquid chromatograph (UPLC) equipped with a photodiode array detector was used. The results showed a significant effect ($P < 0.05$) of genotype (G) on asparagine levels in wheat, indicating that breeding strategies can be an effective means of developing varieties with intrinsically lower levels of asparagine. A significant effect of location was also observed, with significantly higher free asparagine levels present in wheat samples grown in Carberry compared to those grown in Lilyfield. At higher rates of nitrogen fertilizer treatment, free asparagine

content increased. Further investigations on the relationships between fertilizer treatments, free asparagine levels in breadmaking wheat varieties, dough strength and acrylamide levels in bread are underway. Such studies will benefit wheat breeders, producers, exporters, and policy makers by providing sound quantitative data on the safety-related quality of breadmaking wheat.

Egg yolk lipoprotein functionality in pound cake making

L. J. DELEU (1), K. Brijs (1), J. A. Delcour (1)

(1) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium

Egg yolk lipoproteins play an important role in the stabilization of interfaces before and during baking. Lipoproteins contain a protein and a lipid part (with both triacylglycerol and phospholipids). Low and high density lipoproteins (LDL and HDL) occur in yolk, having different (i) protein/lipid ratios, (ii) protein and lipid profiles and (iii) structural organizations. This study focusses on the role of the yolk lipids, proteins and their organization as lipoproteins for pound cake making. Yolk fractions rich in LDL (plasma) and HDL (granules) were used in the cake recipe, as well as a combination of the granules combined with the lipids from plasma. The changes during baking (protein and lipid extractability, oven rise and collapse) were monitored and linked to the cake quality (volume and texture). Overall, plasma has better cake making functionality than granules. This is mainly ascribed to LDL, which is believed to play a major role in egg yolk functionality. Lipid-protein interactions play an important role in pound cake batter preparation and baking. These interactions are maintained during interface stabilization (oil-water and gas-water) in the batter and during oven rise. At the maximal oven rise, both protein-protein and lipid-protein interactions change, such that proteins form a network and more lipids appear as 'free' lipids. These changes impact pound cake quality. It becomes also clear that adding 'free' yolk lipids in the recipe has a negative impact. This shows that the integrity of lipoprotein is key for cake quality. These generated insights may contribute to the reduction and/or replacement of yolk in cake recipes without compromising on quality.

Selection and evaluation of rice flours for gluten-free cookies

S. BRYAN (1), G. Vericel (2), G. Tawil (2), P. T. Fleury (3)

(1) Unity Scientific, Lenexa, KS, U.S.A.; (2) CHOPIN Technologies, Villeneuve la Garenne, France;

(3) LEMPA, Laboratoire National de la Boulangerie Patisserie, Rouen, France

More and more people are now choosing a gluten-free diet. Over the past decade, various products have been utilized to replace wheat, which is high in gluten. **Rice** is often chosen for its neutral flavor, its whiteness, it is easy to digest, low in sodium, and has hypoallergenic properties. The rice flours available on the market vary widely in the terms of suitability to replace wheat flour. This complicates their use in gluten-free preparations, since it has a direct impact on the quality of the finished products. The Mixolab, has the capabilities to measure physical dough properties like dough strength and stability, and also to measure the pasting properties of starch on actual dough. It measures in real time the torque (Nm) produced by mixing of the dough between the two kneading arms. It is used to characterize the rheological behavior of dough subjected to a dual mixing and temperature constraint. The goals of this study were to determine the ability of the Mixolab to differentiate between different rice flours, evaluate the impact of the rice origin on cookie quality and draw correlations between Mixolab's parameters and cookie characteristics. As depicted from the Mixolab patterns, significant variations during mixing, pasting and gelling were noticed among the rice flours depending on their botanical origin. C_{max}, C_s, C₂, C₃, C₄ and C₅ varied from 0.59 to 3.33 Nm, 0.26 to 1.20 Nm, 0.31 to 1.44 Nm, 0.93 to 2.54 Nm, 0.74 to 1.93 Nm and 1.42 to 3.29 Nm, respectively. Looking at the results of the cookie tests baking, one can notice that all rice flours were able to produce cookies with correct shape and color. However, significant variations in cookie weight and thickness were noticed, in agreement with the Mixolab findings. Cookie weight and thickness varied, respectively, from 9.5 to 11.60 g and 48 to 64 mm. Our results also revealed high correlations between technological tests results and Mixolab characteristics. Correlation coefficients (R²) were 0.88 and 0.64 between cookie weight and C₅ and cookie thickness and C₄, respectively. This study confirmed the strong variability in the quality of rice flours depending on their botanical origin. Mixolab was shown successful in evaluating their rheological performances. Cookie baking tests revealed significant differences between cookies in terms of weight and thickness.

A breadbasket checkoff: An overview

C. COCHRAN (1)

(1) Grain Foods Foundation, Washington, DC, U.S.A.

Why a checkoff? Sales of grain-based foods are on the decline, and have been for years. Fad diets, bad research, and negative media are all to blame. How do we, as an industry address these challenges? The goal of a breadbasket checkoff is to change the perception of bread, tackling a challenge that cannot be addressed by individual companies alone. In addition to increasing sales, the program aims to enhance the industry's reputation and give consumers permission to eat the products they know and love. This presentation will

discuss what a checkoff is, define the breadbasket, give an overview of the structure of the program and the steps taken so far.

Rapid analysis of sorghum grain composition using ATR-FTIR spectroscopy

H. LIN (1), S. Bean (2), M. Tilley (1)

(1) USDA ARS Center for Grain and Animal Health Research, Manhattan, KS, U.S.A.; (2) USDA ARS, Manhattan, KS, U.S.A.

As an important cereal crop, grain sorghum (*Sorghum bicolor*) is widely grown in the Great Plains area and is used in food, animal feed, and biofuel industries. Chemical composition and grain quality are important for the end-use application of sorghum. Thus, a rapid and non-destructive analytical method will benefit both farmers and manufactures. In the present study, a method based on infrared (IR) spectroscopy was developed to characterize the major chemical components in sorghum flour. Enzyme hydrolyzed total starch and nitrogen combustion analysis were used as reference methods for starch and protein content. Sorghum flour has three major IR active regions in the range from 1,800 to 800 cm^{-1} . According to peak position, shape and intensity, IR spectra revealed that starch was the primary compound in sorghum flour, following by protein. Lipids and phenolic acids only accounted for a small percentage of sorghum flour. Phenolic acids were characterized by a peak at 1,709 cm^{-1} , which were varied in intensity depending on different sorghum samples. It was also found that flour from the outer part of kernel had higher protein and lipid absorbance while the inner kernel had higher starch absorbance. Pearson's correlation analyses between IR peak intensities and protein and starch content were calculated using statistic software. Starch content did not have significant correlation with infrared peaks, whereas the amide I peak at 1,652 cm^{-1} (C=O stretching group), highly correlated with protein content ($P \leq 0.05$). A calibration curve ($Y = 127.79X - 14.345$, $R^2 = 0.9454$) was built using peak height at 1,652 cm^{-1} to predict protein content. The ATR-FTIR based predication curve not only provides a fast way to measure protein content but also can be applied to protein digestion prediction.

Leveraging partnerships to amplify whole grain messaging

C. G. SLUYTER (1)

(1) Oldways Whole Grains Council, Boston, MA, U.S.A.

Switching to whole grains is a simple way to support health and longevity, but intake continues to fall well below recommended levels making clear the importance of whole grain promotion and consumer education. This presentation will outline the work of the Partnerships and Communications working groups, detailing their efforts to organize an International Whole Grains Day and to compile a toolkit of best practices for creating a Public-Private Partnership.

Effects of sugars and sugar alcohols on the gelatinization temperatures of different starches (wheat, potato, and corn (dent, waxy, high amylose varieties))

M. C. ALLAN (1), M. N. Chamberlain (1), L. J. Mauer (1)

(1) Purdue University, West Lafayette, IN, U.S.A.

Sugars increase the gelatinization temperatures (T_{gelS}) of starches, and the effect is dependent on the sugar type and concentration. Although a variety of starches are used in sweetened food products, and T_{gel} is related to starch functionality and food texture, a direct comparison of the effects of different sweeteners and concentrations on the T_{gelS} of different starches is lacking. Therefore, the objective of this study was to determine the effects of sweetener type and concentration on the T_{gelS} of starches commonly used in foods (wheat, potato, waxy corn, dent corn, and both 55% and 70% high amylose corn). These starches encompass varying amylose: amylopectin ratios, native amylopectin architecture, polymorphic structures, granule sizes, etc. The sweeteners studied were glucose, fructose, mannose, galactose, sorbitol, sucrose, maltose, trehalose, isomaltulose, maltitol, and isomalt at concentrations ranging from 0.5-4M depending on sweetener type. Starch slurries (1:2 w/w starch to sweetener solution) were prepared and equilibrated overnight prior to analysis by differential scanning calorimetry (DSC). The onset and peak temperatures of gelatinization, and enthalpy, were measured by DSC scanning from 30°C to 130°C at 10°C/min. Differences between the T_{gel} of a starch in a sweetener solution and the same starch in water ($\Delta T_{\text{gel}} - T_{\text{gel0}}$) were calculated. All starch T_{gelS} increased with increasing sweetener concentrations, but the difference of $\Delta T_{\text{gel}} - T_{\text{gel0}}$ varied between sweeteners and starches. Potato starch in a 4M sorbitol solution had the greatest $\Delta T_{\text{gel}} - T_{\text{gel0}}$ (28.91), while the smallest $\Delta T_{\text{gel}} - T_{\text{gel0}}$ in a 4M 6-carbon sweetener solution was waxy corn in a 4M fructose solution ($\Delta T_{\text{gel}} - T_{\text{gel0}} = 20.28$). Potato starch T_{gelS} were the most affected by 6-carbon sweeteners at all sweetener concentrations. However, potato starch T_{gelS} were the least affected by 12-carbon sweeteners at all sweetener concentrations, suggesting a sweetener size limiting phenomenon. In general, the $\Delta T_{\text{gel}} - T_{\text{gel0}}$ of dent corn was the most affected by 12-carbon sweeteners. Sugar alcohols increased the T_{gel} of starches more than the sugar counterparts, potentially because sugar alcohols form stronger hydrogen bonds with starch due to the open ring structure and extra hydroxyl group. The data generated in this study provide a comparison of the effects of different sweeteners at different concentrations on the gelatinization

temperatures of a variety of starches, which should be useful for developing reformulation strategies when replacing the sweetener and/or starch in food products for which starch gelatinization is an important quality parameter.

Sensorial attributes and preference of extruded pearl millet (*Pennisetum glaucum*) flours

P. C. TORRES AGUILAR (1), B. R. Hamaker (1), R. de Kock (2), M. Kinnear (2)

(1) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.; (2) University of Pretoria, Pretoria, South Africa

Increased consumer purchase power in developing economies has opened economic opportunities for food processors offering high quality and nutritious products. Traditionally in the developing economies, high quality products are imported due to the lack of technical knowhow and post-harvest infrastructure, however the paradigm is changing by emergence of small and middle size entrepreneurial companies taking a share of local markets. In this study, we evaluated the use of a low-cost, single screw extruder (35 kg/hr) as a potential technology in the development of ready to eat, instant extruded flours. The objective of this study was to evaluate the effect of hot-extrusion on consumer preference as well as their impact on specific sensorial attributes of pearl millet flour (*Pennisetum glaucum*) var Tifleaf 3. During the hot-extrusion process, grains are subjected to high temperature and shear, which melts and fragments the starch in order to adapt its rheological and hydration properties to the emerging food trends. Moreover, protein denaturation, microbial reduction, and enzyme inactivation occur which increases shelf life stability. In our experiment, we evaluated the influence of extrusion on porridge from fresh whole pearl millet flours and after six months of storage on liking of appearance, aroma, color, taste, and texture. Seventy-five subjects were recruited at random. The consumer test was carried out using a 9-point hedonic scale, anchored at the extremes by “dislike very much” and “like very much”. Principal Components Analysis (PCA) was performed to characterize the liking of the samples attributes. The internal preference maps (IPM) were generated from the consumer acceptability test, based on the overall impression results. The first two dimensions explain 81% of the data variance for the liking responses for appearance, 85% for color, 86% for aroma, 81% for flavor, and 83% for texture. The samples showed distinct locations around the components axis. Overall, across samples there were differences in participants preference between extruded and native samples, with extruded and native samples clustering on opposite sides of the second component axis. Moreover, samples stored for six months showed decreased preference due to the build up of oxidation compounds. This work shows that extrusion is a feasible technology for adding value to millet grains by extending its shelf life, nevertheless further strategies are necessary to improve sensorial attributes.

Farinograph application in whole-wheat flour: Explore the influence of circulating water temperature and mixing speed on dough mixing properties in farinograph

L. DENG (1,2), and G. G. Hou (2)

(1) Wheat Marketing Center, Portland, OR, U.S.A.; (2) SPC Group, Seoul, Korea

The Farinograph is one of the most widely used instruments in the flour and baking industries to assess flour quality. Its associated constant flour weight method, AACC Approved Method 54-21.02, was established to evaluate the absorption of refined wheat flour and determine the stability and other rheological characteristics of dough during mixing. However, whole-wheat (WW) flours exhibit abnormal dough mixing properties with this method because dietary fiber and other WW flour components alter dough rheological properties. Two of the biggest issues are the excessive mixing times required to reach and depart maximum torque at 500 BU for WW flours, which significantly increases test time and rarely reflects actual dough mixing requirements, and the lack of repeatability due to the presence of dietary fiber. The overall objective of this study was to identify a modified protocol for WW flours to reduce test time and minimize the influence of dietary fiber on the test results. The first stage focused on varying mixing speed (43-103 rpm) and circulating water temperature (20-35°C) to decrease test time and improve repeatability. Farinograph testing was conducted on six WW flours with coarse and fine particles made from different hard and soft wheat classes. The results showed that as circulating water temperature was raised from 20 to 35°C and mixing speed from 23 to 103 rpm, the dough development time and stability were significantly reduced regardless of the wheat class or particle size. The combination of increased circulating water temperature (35°C) and mixing speed (103 rpm) significantly reduced dough development time (6.2-2.1 min vs. 9.8-2.3 min) and stability (7.7-2.9 min vs. 25.3-5.3 min) compared to the current method of 30°C and 63 rpm. Repeatability, as measured by standard deviation, showed the largest improvement from 13.7% to 0.2% for stability when mixing speed was increased from 63 to 103 rpm and circulating water temperature was increased from 30 to 35°C. The next stage of the study will be to conduct baking trials to see if the modified Farinograph protocol results correlate with baking performance.

Effect of the supplementation of wheat flour with coconut flours on dough rheology and physical properties of tortillas

N. G. G. HEREDIA-SANDOVAL (1), M. C. Granados (1), F. Vasquez (1), A. R. Islas-Rubio (1)
(1) Research Center in Food & Development, AC, Hermosillo, Sonora, Mexico

Wheat flour tortillas are a popular food in the Mexican population, whose consumption has spread in the American diet. However, they usually have a high caloric content and low nutritional quality. Wheat tortillas are a good candidate for dietary supplementation with different ingredients as a strategy to promote healthy eating. The aim of the study was to evaluate the effect of the addition of two commercial coconut flours on dough rheology and physical properties of tortillas. One of the coconut flours (CF1) was high in fat, and the other (CF2) had a medium fat content. Commercial wheat flour (WF) was used as control. Chemical composition, water retention capacity (WRC), color and viscosity behavior of flours and their blends were evaluated. Mixograms from WF and its blends with CF1 or CF2 (10%, 20%, 30% or 40%) were obtained. The total fat content in the tortilla formulations was kept constant (10%). Thickness, diameter, rollability, firmness and water activity of tortillas were evaluated. Fat, ash and protein content of CF1 and CF2 were significantly higher than WF. Significant differences in fat and protein content of CF1 and CF2 were observed. CF1 and CF2 showed higher WRC than WF, as the substitution level increase a significant increment in WRC was observed in the blends. The CF2 substitution showed higher L^* values of flour blends than those of CF1, the opposite behavior was observed for the a^* and b^* values. Peak and final viscosity, breakdown and setback were higher in WF than those of CF1 or CF2. A significantly decrease in these parameters was observed as the level of substitution increased, as well as longer optimum mixing time were observed. Tortillas thickness varied between 1.7-2.0 mm. The WF-CF1 (60-40) showed tortilla diameter significantly lower than the rest of the tortillas (115.9 vs 124.8-130.5 mm). The tortillas substituted up to 20% of CF2 showed the best rollability scores (1) and were different to the rest of the tortillas, whose rollability ranged 2.7-3.7. The effect of the interaction between type of CF and substitution level on tortilla firmness was significant. The level of substitution, the type of CF nor their interaction had an effect on water activity of control and blends tortillas. Substitution levels of 10 or 20% of CF gave bigger and less firm tortillas.

Practical application of cereal and grains and co-product streams across species

J. R. SEWELL (1)

(1) Land-o-Lakes, Inc., Purina Animal Nutrition, Arden Hills, MN, U.S.A.

Feed cost is one of the largest input costs of livestock production; therefore, utilizing ingredients that provide economical, consistent performance is paramount. The practical application of cereal and grains and co-product streams are a key component of diet formulation for many species and contribute to these criteria. Feed manufacturers are challenged with limited storage space for raw materials and the influence of least cost formulation, which causes rapid changes in use of raw materials in formulation. This can occur weekly if not daily. Although the nutrients appear to be similar within the formulation program, there are often hidden nutritional attributes that will not provide consistent performance. It is the role of Research and Development individuals to discover means of utilizing these ingredients across species while minimizing diet costs and providing exceptional performance. The application of corn, rice, soy, wheat and their respective co-products in multi-specie formulation is outlined and defined in this review. The use of these ingredients by specie, the purpose of the ingredient in formulation and precautions are evaluated, providing insight on the practical use of these ingredients. Advances in feed additive technology allows us to push the limits of these macro raw materials and offers greater performance and economic advantage.

Debranching of pea starch using pullulanase and ultrasonication synergistically to enhance slowly digestible and resistant starch

Z. H. Lu (1), E. A. Donner (2), Q. LIU (3)

(1) Guelph Research and Development Centre, Guelph, ON, Canada; (2) Agric and Agri-Food Canada, Guelph, ON, Canada; (3) Guelph Research and Development Centre, Agric and Agri-Food Canada, Guelph, ON, Canada

Pulse starch has a lower rate of starch digestion compared to starch from cereal grains. A further increase in slowly digestible starch (SDS) and resistant starch (RS) in pulse starches could yield a novel ingredient. Pullulanase (P) debranching of amylopectin is an effective strategy for increasing the quantity of linear fragments in starch and thus increases levels of RS upon autoclaving and retrogradation. The process is time-consuming (over 24 h) and the high viscosity of substrate hinders the debranching efficiency. Ultrasonication (U) can quickly decrease substrate viscosity and also shows molecular scission and debranching effects on amylopectin. Therefore, the objectives of this study are to debranch pea starch by simultaneous pullulanase treatment and ultrasonication (PU), and to investigate the accelerated enzymatic reaction and synergistic debranching effect on the production of pea linear glucans, and thus the enhancement of SDS and RS content in debranched pea starch (DPS). DPS-PU was prepared from pre-cooked starch slurry (5% w/v, 80°C for 10 min,) with an ultrasonic processor (20 kHz, 600 W) at varied amplitude (0%, 40%, 70%, or 100%) and pullulanase concentration (40, 200,

or 1,000 npun/g) for 0, 1, 3, 6, and 24 h. Total starch and free glucose content were determined. Amylose or linear glucan content was determined by the concanavalin A precipitation method. Thermal properties and molecular weight distribution were also characterized. *In vitro* starch digestibility was analyzed based on the method described by Englyst et al. (1992). The results showed that a synergistic debranching effect was obtained under optimal conditions of pullulanase (40 npun/g) and ultrasonication (100% amplitude in pulse mode, 1 min on followed by 9 min off), which produced 73.5% linear glucans, 18% SDS and 26% RS in the resulting DPS-PU after 6 h of treatment. DPS-PU contained no substantial amounts of low molecular weight sugars. Even when autoclaving the DPS-PU at 118°C for 30 min, following cooldown, 11% SDS and 25% RS were retained in the DPS-PU, compared with 0% SDS and 12% RS in autoclaved native pea starch. The SDS fraction in autoclaved DPS-PU further increased to 16% while the RS content remained constant during 14 days of cold storage. In summary, DPS-PU is high in large molecular weight linear glucans, low in starch digestibility, and has a thermally stable RS fraction. These advantages make DPS-PU an ideal material for developing food products and/or food ingredients with slow starch digestion.

When more becomes less: A tale of soluble dietary fibers and phenolics interactions

N. BORDENAVE (1)

(1) University of Ottawa, Ottawa, Canada

Health benefits of cereals and other plant products depend largely on the biochemical and physico-chemical properties of phenolic compounds and dietary fibers. These two classes of bioactive compounds are often co-formulated or co-consumed and are known to form non-covalent complexes. Whereas the impact of this complexation on the phenolics' properties has been explored, its impact on the fibers' properties has received little attention. We will recent advances in the characterization of phenolics-fibers complexes, their impact on the rheological properties of the fibers and their potential impact on the nutritional properties of formulated cereal products.

Matrix cereal based dietary fibers support distinct gut bacteria, compared to soluble fibers

B. R. HAMAKER (1)

(1) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.

Soluble fibers are generally considered best to support the gut bacteria and produce high levels of beneficial short chain fatty acid (SCFA) metabolites, however there is good evidence that insoluble fermentable fibers are equally important in supporting important bacteria for health. This is because the mucosal-associated Clostridia bacteria, which have among its members most of the major butyrate producers, seems to have particular abilities to utilize insoluble fiber matrices for energy. In 3 studies from our group, we have shown that fabricated or modified insoluble fiber matrices can be designed to support and promote bacteria within the *Clostridium* clusters IV and XIVa that increase butyrate in *in vitro* human fecal fermentation or animal studies. Starch-entrapped microspheres in a porous alginate matrix were made that favored butyrate-producing Firmicutes bacteria in mice, resulting in high mol% butyrate in the distal colon. Modifying cereal bran fibers to increase fermentability, while retaining the insoluble character, targeted fibers to Clostridia butyrate-producers *in vitro*. Lastly, solubilized cereal arabinoxylan re-crosslinked into small soluble matrices both favored butyrate-producers and increased butyrate level *in vitro*. Physical form of fibers, thus, is an important consideration in the support of different gut bacterial groups, and needs to be part of designed fiber mixtures for gut health.

Changes in the metabolome during in vitro fermentation of non-digestible carbohydrates from whole wheat by human gut microbiota

T. H. NGUYEN (1), D. Rose (2)

(1) Food for Health Center, University of Nebraska–Lincoln, Lincoln, NE, U.S.A.; (2) University of Nebraska–Lincoln, Lincoln, NE, U.S.A.

Many of the health benefits of non-digestible carbohydrates in whole grains rely on fermentation by the human gut microbiota. Microbiota accessible carbohydrates (MAC), dietary fibers fermented by gut bacteria, enrich for beneficial members of the microbiome that can produce beneficial metabolites. The objectives of this study were 1) to determine MAC from whole wheat among a diverse set of microbiomes using an *in vitro* fermentation approach; 2) to determine metabolite changes after 12 hours of *in vitro* fermentation, and 3) to determine the associations between MAC and microbial metabolite concentrations during the fermentation. Stool samples from 22 two individuals were used in an *in vitro* fecal fermentation system with digested whole wheat flour as a substrate. Metabolites of fermented samples and MAC were measured using proton nuclear magnetic resonance spectroscopy and high performance anion exchange chromatography-pulsed amperometric detection (HPAEC-PAD), respectively. A wide range of MAC presented among 22 individual microbiomes (22% to 70%) with an average of about one-third of non-digestible carbohydrates being available for gut bacteria. Twenty-five microbial metabolites were detected in fermented samples. The concentration of arabinose in digested whole wheat was highly correlated to the concentration of propionate ($p < 0.05$) during the

fermentation. These results may have a number of implications regarding the influence of non-digestible carbohydrates on human metabolic health.

Improving understanding of pearl millet-based foods for satiety

A. M. R. HAYES (1)

(1) Purdue University, West Lafayette, IN, U.S.A.

Pearl millet-based foods are anecdotally found to promote satiety among populations in the West African Sahel. This satiety attribute, coupled with the purported slow starch digestion property of pearl millet and its ability to grow in dry, arid regions, exemplify how value is manifested in multiple ways. By enhancing understanding of these value-added factors, we can expand and refine efforts to improve the value chain. Here, we will focus on recent basic and applied research investigations that offer insights to the satiety property of pearl millet-based foods. Physicochemical characterization, in vitro digestion experiments, and human clinical trials reveal that pearl millet-based foods exhibit a slow starch digestion property that appears to trigger ileal brake signaling among certain populations to enhance satiety, yet there is variation in human responses among different populations. Future efforts are required to further understand the mechanisms that give rise to satiety, as well as other properties that impart added nutritional value in grain-based products.

Preparation and textural properties of white salted noodles produced with partial substitution of cross-linked phosphorylated RS4 wheat starch for hard winter wheat flour

C. F. HSIEH (1), L. Wang (2), B. Xu (2), P. A. Seib (1), Y. C. Shi (1)

(1) Kansas State University, Manhattan, KS, U.S.A.; (2) Jiangsu University, Zhenjiang, China

Asian salt noodles were produced by partial substitution of cross-linked phosphorylated RS4 wheat starch for a hard winter wheat flour (~70% extraction from wheat). When more than 40 parts of cross-linked RS4 wheat starch was substituted for wheat flour, a dough sheet did not form unless vital wheat gluten or wheat protein isolate was added. The substitution of 10-40 parts of RS4 for flour did not change hardness in cooked noodles, but reduced their extensibility, cohesiveness, and springiness. At 40 parts replacement, supplementation of 2-8 parts of vital wheat gluten or wheat protein isolate in the composite flour notably enhanced hardness and extensibility of cooked noodles, whereas cohesiveness and springiness were minimally affected. The low-swelling cross-linked RS4 maintained granular structure upon cooking, which appears to have sustained hardness. Also during cooking, the RS4 in the noodles did not release amylose, which likely explains the reduction in cohesiveness and springiness. The extensibility of cooked noodles was primarily controlled by protein content and quality. According to confocal laser scanning microscopy, supplemental vital wheat gluten produced a thicker protein network compared to endogenous protein or added wheat protein isolate. A thick protein network was associated with an increased extensive force and breaking length in the cooked noodles.

In-depth understanding of ingredient functionality in cake as a basis for clean label products: Bleached flour replacement in layer cake

B. PAREYT (1)

(1) Puratos NV, Groot-Bijgaarden, Belgium

This presentation demonstrates how innovation can be driven by research thereby focusing on the case of bleached (chlorinated) flour replacement in layer cakes. Such cakes, as the name implies, are composed of different layers (of cake and decoration) and pose very specific requirements for the cake part. The high ratio cake recipes typically used, result in cake with a very fine and homogeneous crumb structure, a firm and moist texture which is sufficiently resilient, that is it shows no collapse during the cake preparation procedure (baking/cooling). Because of the above requirements, typically bleached (that is, chlorinated or chlorine-treated) flour is used for the production of this type of cakes. The objective of the work was to develop a layer cake free from bleached flour with similar or improved properties than those of standard layer cakes made with bleached flour. The research approach focused on studying the major impacts of bleaching flour, its constituents and how this relates to very specific functionalities. To that end, specific attention went to physico-chemical transformations occurring in the cake batter, both in the bulk phase (e.g. starch gelatinization and pasting, flour water holding capacity, ¹H NMR based water distribution, microscopy during heating of cake batter) and at the gas cell interface (gas cell stability), based on a combination of different research tools new in this context. The solution developed based on the research insights obtained, allows using non-bleached flour and less emulsifiers in layer cakes while maintaining cake layer quality in terms of volume, texture and structural aspects and a clean(er) label.

Validation of the Reveal® Q+ for DON method for quantitative determination of deoxynivalenol in grains and grain products

C. KRONEMEYER (1), R. L. Gray (1), A. Kostin (1), G. Anderson (1), B. Roman (1), F. Klein (1), R. Donofrio (1)
(1) Neogen Corporation, Lansing, MI, U.S.A.

A Performance Tested MethodSM validation was conducted on Neogen's Reveal® Q+ for DON quantitative immunochromatographic test for determining deoxynivalenol contamination in grains. The results showed the test to be accurate and consistent, and the test has been accepted for PTM status and assigned PTM number 071901. The test's performance was validated on naturally contaminated corn and wheat samples. Across a reference level range of 0.5 to 34.5 ppm, mean recovery ranged from 90% to 104%. The limit of detection was calculated as 0.014 ppm in wheat and 0.037 ppm in corn, and the limit of quantitation was calculated as 0.042 ppm in corn and 0.11 ppm in wheat. Both commodities had a linearity R^2 value of 0.999. Spiked samples of eight additional grains were analyzed from 0.5 to 30 ppm, with mean recovery ranging from 90% to 109%. Cross-reactivity tests showed no detection of or interference by other mycotoxins. All primary validation results were supported by independent laboratory testing, and consistency and stability studies showed consistent lot-to-lot performance across the test's 18-month expiry period.

An advanced kilning system for the processing of oat flakes

C. SCHLOSSER (1)

(1) Revtech Process Systems, Chicago, IL, U.S.A.

Kilning is an important step in the processing of oat flakes. The main aim of kilning, using steam and heat, is to both stabilize the product by eliminating enzymatic activity leading to rancidity, and tempering, allowing the creation of mechanically resistant flakes. Additional effects of the heat treatment can be development of flavor and some degree of microbial reduction. The Revtech kilning system ensures accurate control of residence time, perfect homogeneity, high heat and mass transfer and a wide range of precisely controlled operating parameters. The total absence of dead zones and perfect plug-flow inside the stainless-steel tube ensure that every particle going through the system receives exactly the same treatment, vastly improving the overall quality of the final product.

Modification of wheat bran properties through thermomechanical and acid treatment

C. ROYE (1), H. Chanvrier (2), M. Colin-Henrion (2), C. M. Courtin (1)

(1) KU Leuven – Laboratory of Food Chemistry and Biochemistry, Leuven, Belgium; (2) Nestle PTC Orbe, Orbe, Switzerland

In line with the growing interest in healthy food, there is an increasing interest in food products with a high dietary fiber content. In this context, cereal bran is an interesting raw material, as it is one of the most concentrated natural sources of dietary fiber. However, it can be questioned whether native millers bran exerts its optimal physiological and nutritional impact due to the recalcitrance of the structure. Techniques that open up the bran structure by applying high temperature, pressure and shear can therefore be expected to lead to a more accessible bran with improved nutritional properties. To that end, the objective of this study was to evaluate the effect of different thermomechanical treatments on the physicochemical characteristics and structure of wheat bran. Three different types of thermomechanical treatments (treatment applied once and twice, addition of acid) were tested. The thermomechanical treatment applied once and twice resulted in an increased strong water binding capacity (1.1 and 1.4 g/g dm, respectively) compared to that of untreated wheat bran (0.9 g/g dm). This may be attributed to the bran destructureation happening during the treatment. Upon replacement of water with a diluted acid solution, the strong water binding capacity was decreased to 0.7 g/g dm due to acid hydrolysis. Extractability increased from 12% to 18% for the treatments applied once and twice, respectively, and to 21% for the acidic treatment, leading to increased extract viscosities. Increased extractabilities and extract viscosities can be explained by disruption and fragmentation of the wheat bran by shear. During the acid treatment, also acid hydrolysis contributes to the solubilisation of the bran structure. Wheat bran fragmentation was shown by the increase of the water-extractable arabinoxylan content to respectively 1.1%, 1.8% and 2.4% dm by applying the treatment once and twice, and with acid, respectively, compared to an untreated wheat bran sample (0.6% dm). The free phosphate levels in treated wheat bran also increased compared to native bran, indicating notable phytate breakdown. Although treatments induced fragmentation, cryo-SEM and light- and fluorescence microscopy showed (partially) intact wheat bran microstructures after the treatments. Overall, it can be concluded that the different thermomechanical treatments alter the physicochemical characteristics of wheat bran. Consequently, applying a thermomechanical treatment seems as an interesting way to modify wheat bran before incorporation into food products. Nevertheless, further research should be performed to understand whether these treatments enhance the physiological and nutritional properties of bran as well.

Regulatory aspects of protein claims

R. L. VAN LAACK (1)

(1) Hyman, Phelps, & McNamara, P.C., Washington, DC, U.S.A.

Dietary protein has received substantial attention over the last decade. This increased attention has highlighted the hurdles to making protein claims in the United States. Under the regulations, a nutrient content claim on a food about the amount of protein, such as “good source of protein” requires determination of protein quality. The amount of protein itself is not sufficient. Specifically, for more than two decades, the U.S. Food and Drug Administration has required the determination (or calculation) of protein digestibility the protein digestibility-corrected amino acid score (PDCAAS) as a measure to characterize the protein quality of a given food. In 1993, FDA elected to use PDCAAS for evaluating protein quality based on the endorsement of the PDCAAS by the Codex Alimentarius Commission’s Committee on Vegetable Proteins and the Joint Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) Expert Consultation on Protein Quality Evaluation. Although the FAO/WHO has long continued to endorse PDCAAS, following a 2012 meeting of an FAO Expert Consultation on Protein Evaluation in Human Nutrition, a report was published that advocates for a new method, called the digestible indispensable amino acid score (DIAAS), to be used as the standard for determining protein quality. Although some segments of the industry have suggested that FDA replace PDCAAS with DIAAS, both the determination of PDCAAS and DIAAS have disadvantages: they require an animal-based bioassay, are time consuming and are costly. Despite the critique of PDCAAS, FDA has rejected requests to revise its regulations to provide for alternatives to the PDCAAS method. What are the chances that FDA will amend the regulation? These and other aspects related to regulatory aspects of protein claims will be discussed.

Artificial wheat dough – Opportunities for a better understanding of structure–function relationships of gluten and starch surface interactions

S. BRANDNER (1), T. Becker (1), M. Jekle (1)

(1) Technical University of Munich, Freising, Germany

The interactions within and between main structural wheat dough elements (gluten and starch) present the fundamental basis of microstructure and determine the characteristic functional properties of dough. However, structure-function relationships are still not understood in detail. Their dependence from processing time, raw material fluctuations, process conditions and enzyme/yeast activity poses a major challenge in clarifying the mechanistic relations of structure and function. To overcome these difficulties a standardization and simplification of dough is necessary. A promising approach is the imitation of functional wheat dough properties by artificial systems. To imitate wheat dough on a functional level, natural and synthetic hydrocolloids were used in combination with inert filler particles. These systems were investigated by fundamental rheological tests and analysed by mechanical models (Power Law/Burger Model) to enable an assessment of network properties. In particular, a mixture of natural hydroxypropylcellulose (HPC) and synthetic polyvinylpyrrolidone (PVP), reinforced with glass particles, showed consistent viscoelastic properties to wheat dough. Within the linear viscoelastic region, the slope of storage ($n' = 0.21 \pm 0.01$) and loss ($n'' = 0.24 \pm 0.01$) modulus were in agreement with wheat dough analysed ($n' = 0.20 \pm 0.01$, $n'' = 0.21 \pm 0.02$) and cited in literature. But even exposed to larger deformations (creep test) the stress response (instantaneous compliance and retardation time) was in accordance with wheat dough. Based on this artificial system the effect of polymer (HPC/PVP or gluten) particle interactions on viscoelastic dough properties can be identified in more detail by a targeted manipulation of surface functionality of filler particles. For this, surface functionality of glass particles was specifically altered by coating with silanes, offering different functional groups. Depending on silane type none, weak (hydrophobic, hydrogen) or strong (covalent) interactions between particle and polymer matrix were enabled. The results show that network formation (Farinograph curve) as well as network strength A_t , ranging from $15,250 \pm 2,316$ to $22,591 \pm 3,481$ Pa s^{1/2}, and the extent of interactions z , ranging from 4.55 ± 0.07 to 5.36 ± 0.01 , were influenced by the different surface functionalities. In contrast to commonly used methods for altering surface properties (e.g. heat or acid treatment) no further modifications of dough systems take place. Thus, a new approach for clarifying the impact of type and strength of particle-matrix (starch-gluten) interactions on the mechanical behaviour is available.

Storage stability of acetylated tapioca starch: A viscometric study

J. H. LIN (1), C. L. Pan (2), C. L. Lin (2), Y. H. Chang (2)

(1) MingDao University, Changhua, Taiwan; (2) Providence University, Taichung, Taiwan

Pasting properties of starch can be tailored via chemical modifications to suit the food processing requirements, while the properties may be influenced by the residual chemicals. However, research in this regard is limited. In this study, commercial acetylated tapioca starch (CATS) before (UW) and after fully washed (FW) with deionized water were stored at 25 and 55°C for 84 days, and the pasting properties of both CATSs were analyzed to investigate the changes in pasting characteristics of CATSs during storage in the presence of residual

chemicals. Result showed that the degree of substitution (DS) and gelatinization peak viscosity (PV) of FW-CATS were comparable to those of UW-CATS, while FW-CATS was characterized with reduced pH (4.46 vs 5.28) and conductivity (22 $\mu\text{s}/\text{cm}$ vs 451 $\mu\text{s}/\text{cm}$). During the subsequent storage, CATSs exhibited marginal changes in DS and pH, plus gradual increases in conductivity with increasing storage time. In contrast, the PV of UW-CATS remained comparable during storage, while that of FW-CATS decreased significantly and the extent depended on the storage condition. After storing at 25°C for more than 30 days, the PV of FW-CATS gradually decreased with increasing storage time. Moreover, when the storage temperature was elevated to 55°C, the decrease in PV was even more drastic with increasing storage time; more than 50% decrement in PV was observed for FW-CATS after storing at 55°C for 50 days. The findings of this study reveal that the residual chemicals from the modification resulted in limited effect on pasting viscosity, especially PV, of CATS. Moreover, eliminating the residual chemicals by repetitive washing significantly reduced the pasting viscosity of the starch, suggesting the trace of chemicals (such as sodium acetate) can play an important role in stabilizing the pasting properties of CATS.

The change of starch and alpha-amylase in wheat with low falling number

A. H. M. LIN (1)

(1) Bi-state School of Food Science, University of Idaho, Moscow, ID, U.S.A.

The reduction of falling number in wheat is quick liquefaction of wheat flour paste during the falling number measurement. In the recent outbreak of the low falling number issues in the Northwest of the United States, they were all associated with unexpected weather, such as pre-harvest rain or temperature change. We hypothesize the impact of the weather on wheat flour quality is not only the elevation of wheat alpha-amylase quantity and activity but the starch structure, which, consequently, leads to the change of starch paste property and susceptibility of starch to alpha-amylase. We examined the starch structure and alpha-amylase hydrolytic activity of low falling number affected soft white wheat. Our research showed there was a developmental change of starch in the low falling number wheat, which more B-type small wheat granules were observed than they were in the normal wheat. We also found the alpha-amylases in the wheat with the expected falling number and low falling number differ in their capacity to hydrolyze wheat starch granules. Our research findings suggest that the cause of low falling number in wheat is involved in the change of starch, starch degrading enzymes, non-starch macromolecules, and their interactions, which lead to various impacts on the end-use quality.

Effects of red rice or buckwheat addition on nutritional and technological quality of potato-based pasta

C. CAPPA (1), C. Alamprese (1), R. Invernizzi (2), M. Lucisano (1), M. C. Casiraghi (1)

(1) DeFENS, Università degli Studi di Milano, Milan, Italy; (2) Zini Prodotti Alimentari S.p.A, Cesano Boscone, Milan, Italy

The main objective of the present study was to investigate the effects of red rice (R) or buckwheat (B) flour addition on nutritional and technological quality of frozen potato-based pasta tailored to celiac consumers. Since pasta behavior during cooking is related to protein network, effects of R and B addition in traditional (containing gluten) products were explored for comparison. One gluten-free (GF) and one traditional (T) sample without R or B addition and four samples containing 20% R (GFR and TR) or B (GFB and TB) were investigated. All samples were produced in an industrial line by a turbo-cooking technology and individual quick-freezing at -35°C. Pasta samples were evaluated in terms of proximate composition, starch digestibility, and cooking behavior. The addition of R and B increased the amount of fats and reduced starch content in both traditional and gluten-free products. The enrichment with B promoted a significant increase in dietary fiber in both the product types (4.8 \pm 0.5 versus 1.7 \pm 0.1 g/100 g, respectively for TB and T; 6.0 \pm 0.5 g/100 g versus 0.8 \pm 0.3 g/100 g, respectively for GFB and GF), mainly represented by the insoluble fraction. However, compared to T and GF products, samples added with R or B showed an increase in the ready digestible starch fraction, thus suggesting a potential increase of the glycemic impact. The addition of R flour worsened the structure of GFR sample with respect to GF, increasing significantly ($p < 0.05$) matter loss in cooking water (5.4 \pm 1.2 versus 4.1 \pm 0.5 g/100 g pasta) and reducing significantly ($p < 0.05$) the product resistance to shearing/extrusion (from 408 \pm 13 to 108 \pm 2 N) as evaluated using a Kramer cell. While the presence of B flour resulted in intermediate shear force values (243 \pm 8 N), despite the highest weight increase of this sample during cooking. Similar trends were found also for R and B addition in the traditional samples, indicating a better texturizing capacity of buckwheat in comparison to red rice flour. Outcomes of this research can be useful in developing new potato-based pasta for consumers focused on healthier foods and industries willing to better valorize their products. This work was supported by Lombardy Region (Linea R&S per Aggregazioni; project number 145075).

Effect of nitrogen and sulfur fertilizations on phenolic antioxidants of hard red winter wheat varieties

W. TIAN (1), Y. Li (1), G. Smith (1), A. Fritz (1), N. Nelson (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

The objective of this study was to investigate the effect of nitrogen (N) and sulfur (S) fertilizations and wheat variety (V) on phenolic content, antioxidant activity and phenolic acid composition of wheat grains. The experiment was set up in a 3×2×4 factorial design. Four genotypes (2137, Everest, Fuller and Jagger) were chosen based on nitrogen use efficiency and nitrogen uptake. For each genotype, there were 3 nitrogen levels (50, 90 and 130 lb/ac applied as urea) and 2 sulfur levels (0 and 20 lb/ac as ammonium sulfate) with four replicates. Results showed that total phenolic content (TPC), total flavonoid content (TFC), and radical scavenging activities (RSA) were affected by N, S, V and their interactions. Increased N application generally increased wheat TPC, TFC and RSA. However, effect of increased S on these measurements was more variety-dependent. Metal chelating activity was predominantly determined by the variety. Amounts of syringic acid, vanillic acid, ferulic acid and sinapic acid were affected by N, S, V and their interactions. However, the amount of 4-hydroxybenzoic acid and p-coumaric acid were only significantly influenced by the variety. Our study indicated that potential health benefits of whole wheat flour are dependent on the cross interactions of nitrogen application, sulfur application and wheat variety. As potential health benefit of wheat is becoming an additional quality criteria, these agronomic factors need to be further investigated to produce wheat grains with good balance of agronomic performance, grain quality, and health benefits.

Antioxidative and structural characteristics of corn coproduct protein hydrolysates and their applications

R. HU (1), Y. Li (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

Antioxidants are widely used in food, feed, and pet food industries to delay lipid oxidation and prevent quality deterioration. There has been a rising demand for the gradual replacement of synthetic antioxidants with naturally derived antioxidants. Corn coproducts, such as distiller's dried grains with solubles (DDGS) and corn gluten meal (CGM), are cheap source of proteins containing abundant antioxidative peptide sequences and structural domains. The objectives of this study were to develop antioxidative peptides from corn DDGS and CGM proteins through enzymatic hydrolysis, to evaluate the antioxidant performances using chemical assays and model systems, to isolate fractions with superior antioxidant properties, and to identify their peptide compositions. Hydrolysates prepared with Neutrase and Alcalase displayed promising yield and antioxidant capacity among the eleven commercial proteases evaluated. The effect of critical variables including protein substrate content, enzyme-to-substrate ratio, and reaction time on the production were studied. Selected hydrolysates were further fractionated through ultrafiltration using an Amicon® Stirred Cell device. Medium-sized fraction revealed relatively stronger antioxidative activities with regards to free radical scavenging activity, metal ion chelating activity, reducing power, and oxygen radical absorbance capacity. Selected antioxidants were further formulated into fish oil, poultry fat, pork fat, model emulsion, ground pork, dry dog food, and dry nursery pig feed at different levels, which were incubated under accelerated conditions in an oven, and POV_s and TBARS were measured. The inclusion of corn antioxidants significantly improved the oxidation stability of these systems and effectively inhibited lipid oxidation. Both POV and TBARS decreased with increased amount of the antioxidants. In addition, the corn antioxidants also effectively reduced HepG2 cell growth via non-toxic mechanisms, indicating its anticancer potential. Peptide compositions of the most promising fraction from ultrafiltration and RP-HPLC were identified using MALDI-TOF/TOF MS. Our study demonstrated that corn coproduct proteins are feasible sources for peptide antioxidant production, and these antioxidants could be potentially used as alternatives to synthetic antioxidants in improving the oxidative stability of various lipid-rich products.

Leveraging novel chickpea protein technology to drive market-based bakery and snacking product innovation

M. SPINELLI (1)

(1) Nutriati, Henrico, VA, U.S.A.

Background: The plant-based food, beverage and sports nutrition categories have witnessed dramatic growth across every sector of the consumer product market. This growth has outpaced most other food and beverage categories and will continue to expand as a global norm. Ongoing market demand for diverse and sustainable plant-based ingredients will create stress points and opportunities in the areas of global agriculture, socioeconomic and ecological impact, public health and economic benefits. Those researchers and businesses who choose to consider the entire value chain from the aspects of procurement and breeding, manufacturing, applied culinary food science principals to end-user product applications will become the most impactful and prosperous in industry. Nutriati® was formed to address each step of the plant-based value chain while focusing on ingredient manufacturing technology coupled with culinary food science applications. Plant-based ingredients, including proteins, will continue to play a pivotal role in the future of our food systems with Cereal

Chemists and Food Engineers best suited to lead necessary innovations. **Objectives:** Our goal is to showcase the broad application versatility and technical functionality of Artesa® chickpea proteins and flours in their various forms within the ingredient toolbox for R&D and Manufacturing purposes. The aspects of functionality, nutrition, cost and sensory quality will be presented and discussed. Emphasis will be placed on the considerations product developers must face when formulating composite products with plant-based proteins while assuring manufacturing scalability. **Methods:** Specific application functionality will be discussed including: gelation properties, foaming and emulsification properties, water and oil binding capacities as well as the transformation of native proteins, fibers and starches to their differentiated forms during various mechanical food processing interventions such as heat, shear, pressure and hydration. The following R&D and manufacturing methods will be highlighted: Co-rotating, twin screw extrusion for expanded high-protein snacks and textured proteins; Plant-based meat formulation, forming and extrusion; Plant-based cheese and yogurt (gelation and culturing); Plant-based egg gelation and protein cross linking; Plant-based milk. **Results:** Prototypical formulations which utilize Nutriati's branded chickpea ingredients, Artesa® chickpea protein and Artesa® chickpea flours, will be presented including targeted nutrition panels, ingredient listings, methods of development and preparation.

A dynamic module to optimize bread quality of einkorn and emmer hulled wheats

A. A. JARADAT (1), L. Dykes (2,3)

(1) USDA-ARS and University of Minnesota, Morris, MN, U.S.A.; (2) USDA-ARS-ETSARC, Cereal Crops Research Unit, Fargo, ND, U.S.A.; (3) USDA-ARS-RRVARC, Cereal Crops Research Unit, Fargo, ND, U.S.A.

Renewed research and development efforts are underway to introduce hulled wheat [e.g., einkorn; *Triticum monococcum* L. subsp. *monococcum*, and emmer; *Triticum turgidum* subsp. *dicoccon* (Schrank) Thell.] products into American food systems due to a growing consumer demand for organically-produced and healthy products. A diverse germplasm collection composed of landraces, old cultivars and improved genotypes (i.e., groups) of einkorn (35 accessions) and emmer (60 accessions) from 40 regions in 17 countries within four agroecological zones, were evaluated for 3 years under typical wheat growing conditions in the Upper Midwest, U.S.A. Plant and grain attributes were documented in a relational database composed of 158 variables and 95 accessions. The database was mined for intra- and inter-specific multi-trait variation, association and functional relationships among the ionome (macro- and micro-nutrients, especially iron and zinc contents); protein composition; rheological qualitative and quantitative dough properties; bread physico-chemical composition; and color space coordinates of grains, flour and whole bread loaves and slices. The local spring wheat cultivar 'Glenn' was used as a reference. Classification and regression algorithms in a support vector machine-learning module were used in model building and validation to respectively discriminate between and within species (i.e., groups), and to predict loaf/slice characteristics. Whereas, deep machine learning, and dynamic profiling were used to identify common or species-specific traits with significant role in quantitatively and objectively defining and predicting bread quality index as a 'latent variable.' Accuracy of cross-validation of species classification using a minimum set of grain, flour and bread variables was 100.0%; whereas, it was 74.1 and 70.5% for groups within einkorn and groups within emmer germplasm, respectively. Loaf volumes of einkorn and emmer were predicted with validation R^2 of 0.98 and 0.93, respectively. A latent 'quality index' was validated using a small, but different set of grain, flour and dough traits for einkorn ($R^2 = 0.82$; $p < 0.01$), emmer ($R^2 = 0.75$; $p < 0.01$), and for both species ($R^2 = 0.64$; $p < 0.05$). An optimized bread quality index was based on traits' complementarity between species (e.g., micronutrients, carotenoids and kernel color from Turkish einkorn; and large kernel weight and loaf volume from Ethiopian emmer). A module based on field evaluation, laboratory analysis, and statistical data mining, machine learning and modeling is presented as a prototype for the development of hulled wheats as sources of locally-adapted cultivars and for the production of nutritionally-balanced bread. The module can be dynamically adapted to fit emerging research and development of new products.

Characterisation and stability of short chain fatty acids in modified starch Pickering emulsions

N. B. ABDUL HADI (1), B. Wiege (2), M. Matos (3), A. Marefati (3), M. Rayner (3)

(1) Department of Food Technology, Engineering, and Nutrition, Lund University, Lund, Sweden; (2) Max Rubner-Institute, Detmold, Germany; (3) Department of Environmental and Chemical Engineering, University of Oviedo, Oviedo, Spain

Rice and quinoa starch modified with short chain fatty acids (SCFA) (acetate, propionate, and butyrate) at different levels of modification and starch concentration, were used in the preparation of oil-in-water starch Pickering emulsions (SPEs) at 10% oil fraction. This work aimed to study feasibility of the utilization of SCFA-starches to produce Pickering emulsions. In order to investigate the stability phenomenon SCFA-starch Pickering emulsions, and how the droplet size and chain length affect resulting emulsion stability over time. Initially, and after 50 days of storage of short chain fatty acid starch Pickering emulsions (SCFA-SPEs) were characterised to identify the particle size distribution of emulsion droplets and starch particles, microstructure, emulsion index (EI), and stability by using Static Multiple Light Scattering. Increased starch concentrations led to decrease of emulsions droplet size. Apart from that, the emulsifying capacity of SCFA-SPEs were improved by increasing the chain length of SCFA, where pronounced results were observed in SCFA-rice-SPEs as less amount non-adsorbed

starch was observed. Quinoa-SPEs were showed to have a good capability in stabilising the Pickering emulsions in the native or modified state. High stability of emulsions was observed in butyrylated and propionylated quinoa starch at a higher level of modifications which had small droplet size with high EI over the entire 50 days storage. Thus, at optimised formulation, SCFA-SPEs are potential in stabilising emulsions in functional foods, pharmaceutical, or food industrial application.

Field experience with two new rapid falling number tests

M. L. BASON (1)

(1) Perten Instruments of Australia Pty Ltd, Macquarie Park, Australia

The standard Falling Number (FN) test (AACC Approved method 56-81.03) requires 250-300 s to ensure sound grain is correctly classified and segregated, which can put pressure on elevator throughput during harvest, so a faster test is desirable. Perten Instruments has developed two new rapid test protocols for FN testing, a 60 s test intended for markets using a grading threshold of 250 s, and a 90 s test where a FN of 300 s or higher is required. Both methods measure the force on the stirrers during mixing and predict the sample's FN value based on this information. The goal of this study was to assess the ability of these methods to satisfactorily predict actual FN values under field conditions. Wheat samples were collected during the 2018 Australian east coast harvest and tested by our commercial partner on a modified Falling Number 1,000. For the 60 s method, the subset of samples with actual FN values up to 300 s (n = 133) were used to develop a cross-validated partial least squares (PLS) regression model fitting the force data to the corresponding FN values. The fit yielded a calibration RMSEC of 22.3 s and r^2 value of 0.92, with a cross-validation RMSECV of 22.9 s and r^2 value also of 0.92. Including samples with actual FNs above 300 s in the model resulted in a plateau in the corresponding predicted values, limiting the use of the 60 s method to FN grading threshold values of 250 s or below. For the 90 s method, the subset of samples with actual FN values up to 350 s (n = 398) were similarly used to develop a cross-validated PLS model. The fit yielded a calibration RMSEC of 21.5 s and r^2 value of 0.96, with a cross-validation RMSECV of 21.8 s and r^2 value also of 0.96. A similar plateau was evident with the 90 s sample set but at approximately 350 s predicted value, allowing the 90 s method to predict FN values up to the 300 s grading cut-off. The lower sample viscosity and longer mixing time employed evidently allowed for a more sensitive detection of the underlying liquefying action of alpha-amylase than the 60 s method, increasing this method's detection threshold. The methods show promise as rapid tests to classify wheat by FN where the time requirement of the standard method poses logistical issues during harvest.

Effect of semolina replacement with whole unripe plantain flour or commercial resistant starch on the chemical, cooking quality and starch digestibility of pasta

L. A. BELLO-PEREZ (1), D. E. Garcia-Valle (1), F. Gutierrez-Meraz (1)

(1) CEPROBI-IPN, Yautepec, Mexico

There is interest in produce foods with high dietary fiber (DF) content due to that their consumption is related to decrease health problems as overweight and obesity. The aim of this study was to prepare spaghetti with different level of whole unripe plantain flour (WUPF) and evaluate the chemical, cooking quality and starch digestibility compared with a commercial source of DF (Hi-Maize[®] 260 (HM)). Spaghetti was prepared with semolina and WUPF or HM at three different fractions (0.15, 0.25 and 0.35 w/w). The spaghettis were analyzed in their chemical composition, cooking quality (AACC Approved Methods) and *in vitro* starch digestibility. The total starch for spaghetti substituted with WUPF and HM ranged between 78-82% and was similar to control sample (76.6%). The pasta substituted with HM at the different levels showed higher optimum cooking time (OCT) than the semolina spaghetti (control) and those substituted with WUPF, but the spaghetti substituted with WUPF presented the highest cooking loss values, pattern related to the network produced by the macromolecules present in the ingredients. The digestibility of the cooked pasta was largely affected by the presence of dietary fiber, with similar results for WUPF and HM. The slowly digestible starch fraction was increased from about 15% for pasta made with semolina, to about 75-85% for pasta incorporating dietary fiber, either WUPF or HM. The resistant starch fraction was only marginally affected by dietary fiber. Overall, the results showed that WUPF is a viable alternative to commercial dietary fiber sources (like HM) for decrease the starch digestibility of semolina-based pasta.

The role of starch structure in the eating quality of oat-fortified wheat noodles

T. NGUYEN (1), S. Mitra (2), R. G. Gilbert (1), M. Gidley (3), G. Fox (1)

(1) University of Queensland, Brisbane, Australia; (2) Australian Export Grains Innovation Centre, Perth, Australia; (3) University of Queensland, St. Lucia, Australia

Noodles are of significant importance in the Asian diets and around of 20-50% of the total wheat flour consumption in many Asian countries is used for noodle making. Wheat flour noodles have been fortified with various ingredients to meet consumer demand in terms of improved eating quality and nutritional value. However, due to the health benefits of beta-glucan found in oat grain, the enrichment of wheat noodles with oat

flour will give nutritional benefit but may reduce the eating quality. This study examined correlations between the starch molecular fine structure, the physicochemical properties of wholemeal oat flour and the texture of oat-fortified white-salted noodle. White-salted noodles were prepared using white-salted noodle wheat flour in combination with 50% of flour replacement of wholemeal oat flour. The experiment included different oat genotypes grown in four locations in Australia. Starch molecular fine structure, specifically the chain-length distribution (CLD) of debranched starch was determined by size-exclusion chromatography. Biosynthetic models were used to fit the CLDs of amylopectin and amylose. The pasting properties of wholemeal oat flour were measured by rapid visco-analysis (RVA). The texture properties of noodles were determined by texture profile analysis (TPA). The amount of medium length amylopectin chains with degree of polymerization (DP) 26-61 positively correlated ($p < 0.001$) with RVA peak viscosity, final viscosity and swelling power of wholemeal oat flour while the opposite trend was found for amounts of short amylopectin chain with DP less than 25 ($p < 0.001$). The long amylose chains showed negative correlation ($p < 0.001$) with RVA peak viscosity but positive correlation ($p < 0.05$) with RVA final viscosity. Texture profile analysis on cooked noodles showed oat-fortified white-salted noodles are softer and more adhesive than control (only wheat flour) noodles. RVA peak viscosity and swelling power of wholemeal oat flour positively correlated with the hardness and adhesiveness of oat-fortified noodles. The results suggested that the amount of short and medium amylopectin chains, amylose content and amount of longer amylose chains all control the RVA pasting viscosities and the swelling power of oat flour which then in turn affect the hardness and adhesiveness of noodles. This study provided new insights about the molecular structure mechanism of starch for controlling noodle quality. This in-depth understanding will be very useful for the scientific community as well as for industry to choose oats with optimal starch structure for targeted oat-fortified noodle quality.

Measuring the protein quality of ingredients and foods with a new and more ethical method of analysis

D. W. PLANK (1,2)

(1) WRSS Food & Nutrition Insights, Taylors Falls, MN, U.S.A.; (2) Department of Food Science & Nutrition, University of Minnesota, St. Paul, MN, U.S.A.

High-protein foods continue to be in high demand by consumers. High-protein foods have been demonstrated to help satisfy an individual's feeling of hunger for a longer period than when consuming comparatively low-protein foods. The feeling of fullness that high-protein foods can provide helps limit overconsumption of food and can help promote a healthier lifestyle. Further, a high-protein diet can support lean muscle mass growth and maintenance for active individuals. Given the nutritional and lifestyle benefits of a high-protein diet, manufacturers are providing increasing numbers of high-protein products to the consuming public. It is required by Federal regulation that manufacturers who make claims for protein content on these types of products must first assure that their product meets a minimum of 10% DV (daily value) of quality protein on both a per serving basis and a per reference amount customarily consumed basis. The methodology required in the U.S., and in many jurisdictions around the world, for determining protein quality is the PDCAAS (Protein Digestibility Corrected Amino Acid Score). Unfortunately, beyond being an expensive and time-consuming test, the standard PDCAAS method also requires the use and sacrifice of animals (rats) for determining digestibility which is conflict with animal testing bans that many food manufacturers have adopted as policy. We have developed an *in vitro* digestion methodology that addresses many of the shortcomings of previous attempts at simulating rat digestion. This presentation will review the new animal-free digestion technology method development and validation. Current uses of the method by the food industry for product development cost savings and future uses for regulatory compliance will also be discussed.

Physicochemical and nutritional evaluation of wrinkled pea and round pea flours of different particle sizes

Y. REN (1), R. Setia (1), T. Warkentin (1), Y. Ai (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada

Pea (*Pisum sativum* L.) is a pulse crop widely grown for human consumption worldwide. Different from the common varieties of round pea cultivated in Canada, wrinkled pea is a *rugosus* (*rr*) mutant, which has an elevated level of amylose in the starch. We hypothesized that the increased amylose content could impart unique functional properties and enhance the nutritional value of wrinkled pea flour (WPF). In this study, wrinkled pea (B99/108 and TMP15159 varieties) and round pea (CDC Meadow and CDC Golden varieties) seeds were provided by the Crop Development Centre at the University of Saskatchewan, both of which were grown in two locations in Saskatchewan, Canada. The harvested whole seeds were milled to pass through a 0.4-mm or 1.0-mm screen to prepare WPF and round pea flour (RPF). Total starch contents of WPF (25.4-29.4%, dry basis, db) were significantly lower than those of RPF (46.0-51.2%, db), while the starches in WPF consisted of more amylose (69.9-73.6%) than those in RPF (34.7-39.0%). The increased amylose contents of starches in WPF elevated their gelatinization temperatures. Under normal pasting conditions (holding temperature = 95°C), WPF exhibited negligible viscosities; however, obvious viscosity development was observed when WPF was pasted under high temperature conditions (holding temperature = 110°C-140°C). WPF showed the highest final viscosity at the heating temperature of 130°C compared with 120°C of RPF, which could be attributed to the

differences in gelatinization temperature and starch content between WPF and RPF. Coarse WPF and RPF (particle size ≤ 1.0 mm) displayed lower peak viscosities compared with their fine counterparts (particle size ≤ 0.4 mm), which could be explained by the fact that the larger particle size restricted the swelling of starch granules. In addition, WPF showed significantly lower contents of rapidly digestible starch (17.5-21.9%), larger dietary fiber contents (21.8-28.3%), and greater protein contents (25.4-29.6%) in comparison with RPF (39.0-44.2%, 14.3-18.7%, and 21.3-24.7%, respectively), indicating more desirable nutritional quality of WPF. However, particle size did not show clear trends on the nutritional profiles of WPF and RPF. This research demonstrated that wrinkled pea could be a promising crop to generate new pea flours with distinct functional characteristics and enhanced nutritional value.

Cereal starch structures that appear to be slowly digestible

B. R. HAMAKER (1)

(1) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.

Starch digestion rate kinetics affect postprandial glycemia and can also activate the gut-brain axis and ileal brake system for satiation. A number of factors influence how fast starch is digested in the small intestine, and an important one is amylopectin and amylose fine structural features. For instance, amylopectin with longer average linear chain length tends to retrograde more rapidly and this slows digestion rate, as does amylopectin that is highly branched as branches themselves are digested at a comparably slow rate. Further, it seems that some highly branched internal structures of amylopectin may be even slower digesting and may be digested more distally in the small intestine or even be resistant. These starch structural aspects and their relation to rate of digestion, and to postprandial glycemia and potential stimulation of physiological feedback controls related to health will be discussed.

Impact of dextran produced in situ on the textural and nutritional properties of whole grain millet bread

Y. WANG (1), D. Compaore-Sereme (2), H. Sawadogo (2), R. Coda (1), K. K. Katina (3), H. N. Maina (3)
(1) University of Helsinki, Department of Food and Nutrition Sciences, Helsinki, Finland; (2) Département Technologie Alimentaire (DTA)/IRSAT/CNRST, Ouagadougou, Burkina Faso; (3) University of Helsinki, Helsinki, Finland

The effect of dextran produced *in situ* by *Weissella confusa* on the structure and nutrition quality of whole grain pearl millet bread containing 50% of wheat flour was investigated. NMR spectroscopy analysis indicated that the dextran formed by the strain consisted of a α -(1 \rightarrow 6)-linked linear backbone and 3% α -(1 \rightarrow 3) branches, and had a molar mass of 3.3×10^6 g/mol. *In situ* production resulted in 3.5% dextran (DW) which significantly enhanced the dough extensional properties, increased the bread specific volume (\sim 13%) and decreased crumb firmness (\sim 43%), moisture loss (\sim 15%) and staling rate (\sim 10%), compared to the control millet bread. DSC analysis showed that amylopectin recrystallization was significantly reduced in the bread containing dextran. *In situ* dextran production altered the nutritional value of millet, leading to increased free phenolic content (\sim 30%) and antioxidant activity. It also markedly lowered the bread predicted glycemic index and improved *in vitro* protein digestibility.

The role of amylose and amylopectin during baking and cooling of bread containing unusual starch: A temperature-controlled 1H NMR study

M. A. NIVELLE (1), G. M. Bosmans (1,2), P. Vrinten (3), T. Nakamura (4), J. A. Delcour (1)

(1) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium; (2) Puratos NV, Groot-Bijgaarden, Belgium; (3) Bioriginal Food and Science Corp., Saskatoon, SK, Canada; (4) Tohoku National Agriculture Research Center, Morioka, Japan

Starch transformations during bread making strongly influence bread crumb structure. Native wheat starch appears as semi-crystalline granules and primarily consists of two biopolymers, *i.e.* amylopectin (AP) and amylose (AM). The functionality of these starch biopolymers during bread baking and cooling was studied *in situ* using a recently optimized temperature-controlled time domain proton nuclear magnetic resonance (TD ^1H NMR) toolbox. Dough samples were prepared with flour from unique near-isogenic lines (NILs) of which the AM content and the AP chain length distributions differed while their genetic background was uniform. NIL 5-5 flour contained less AM and a higher portion of short AP branch chains than NIL 1-1 (wild type) flour. During baking of NIL 5-5 dough AP crystals melted at lower temperatures than those in dough prepared from NIL 1-1 flour. This was attributed to the higher portion of short AP branch chains and, thus, a decreased stability of starch double helices in NIL 5-5 than in NIL 1-1 dough. At the end of baking, all AP crystals had melted in both types. During cooling, a semi-crystalline AM network was formed. Since the AM concentration was lower in NIL 5-5 than in NIL 1-1 bread making, crystallization started later during the cooling process and eventually occurred to a lesser extent in the former case. This resulted in a lower level of rigid protons and a higher mobility of the gel network in fresh NIL 5-5 than in NIL 1-1 bread. The higher mobility of mobile, exchanging protons at the end of baking and during cooling when bread crumb had a lower AM content

points to the key structural role of AM in bread crumb. In conclusion, the timing of gelatinization during baking and the timing and extent of AM crystallization during cooling were determined by respectively AP crystal stability and AM concentration. That proton distributions were altered in a way in line with starch AM contents and AP chain length distributions, adds support to the suggested interpretation of NMR profiles during bread baking and cooling.

Development of an improved method to measure maltose value of wheat flour

T. SUYAMA (1), M. Miyazaki (1)

(1) Yamazaki Baking Co., Ltd., Ichikawa, Chiba, Japan

Maltose value (MV) is reduced sugar content produced by amylase in a wheat flour under conditions of pH 4.6-4.8, and converted to maltose. The value is used as the ability to supply reduced sugars from wheat flour during dough fermentation, especially for sponge-dough method. The conventional method defined by AACC Approved Method 22-15 is a complicated procedure and uses several poisonous reagents during quantitation by titration. So we aimed to develop a new quantitative method to improve efficiency and safety. In the improved method, 100 mg of wheat flour was suspended in 1 mL of acetate buffer (pH 4.6-4.8) and stood at 30°C for one hour. After centrifugation (2,000 g, 5 min, 5°C), alpha-glucosidase (from Yeast) was added to the supernatant, and reduced sugars were degraded to glucose. The degraded glucose was quantified by a colorimetric method using glucose oxidase/peroxidase (GOPOD) reagent, and converted to maltose. In several wheat flours with a wide range of MV (about 50 to 300 mg/10 g), the relationship between measured values of each method showed a good correlation ($n = 73$, $R^2 = 0.986$), and the improved method gave same values as the AACC method; the average of differences between each method was 1.2 mg/10 g. Moreover, each repeatability precision was equivalent; the AACC method was 1.3% (Relative Standard Deviation, RSD%), while the improved method was 1.4% in the five pair measurements of hard wheat flour (MV about 250 mg/10 g). Since the improved method shows same value and precision as the AACC method, could have the possibility of saving time and labor, and reduce the use of poisonous reagents, this study will contribute to efficient and safe work of analyzing MV for wheat flour quality control.

Ancient grains – What's old is new again: Emphasis on companion animal nutrition

G. DAVENPORT (1), J. Hoke (2)

(1) ADM Nutrition, Englewood, OH, U.S.A.; (2) ADM Research, Decatur, IL, U.S.A.

The use of ancient grains in the pet food industry is growing as more pet owners are avoiding foods and treats containing traditional grains, pulses, gluten, and genetically modified ingredients. Despite this rising popularity and their historical use as a human food staple, there is little published research-based information on the nutritional composition, processing properties or animal utilization of ancient grains used in pet foods and treats. Therefore, selected ancient grains were evaluated to understand their similarities and differences for guiding their use in formulating pet foods and treats. Results demonstrate ancient grains are unique in nutritional composition and processing functionality which must be considered in pet food and treat formulations. Buckwheat, barley and oat groats are low fat and high fiber making them appropriate for weight management and senior pet foods. Quinoa, white millet, sorghum and amaranth can be used interchangeably due to similar nutrient profiles. In contrast, chia and flaxseed are pseudo-cereals containing no starch but higher levels of protein and fat making them appropriate for puppy, kitten and performance foods. However, they have unique functional properties and processing requirements due to the absence of starch. The water-holding capacity of chia (88.6%) is significantly higher than starch-containing ancient grains that range from 6.0% (sorghum) to 8.8% (quinoa). Viscosity measurements show the pasting (gelatinization) temperature is lower for chia (50°C) than other sources that range from 76.8°C (buckwheat) to 94.8°C (amaranth). A standardized cookie recipe shows cookies baked with chia flour have more spread and less rise while cookies baked with ancient grain flours have less spread and more rise than pastry wheat flour (control). The nutritional value of quinoa, white millet, amaranth, oat groats, and rice (control) for adult dogs are similar based on nutrient digestibility and glycemic responses when included (40%) in nutritionally-complete, extruded foods. Ancient grains provide substantial formulation flexibility for manufacturers developing new consumer-desired pet foods and treats. Their starch content provides important processing functionality and structural integrity of finished products while supplying required glucose and energy for the pet. Understanding these similarities and differences are important when using them to replace traditional grains and other ingredients in pet foods and treats. While ancient grains have existed for centuries, these evaluations demonstrate more knowledge and experiences will be forthcoming as their use increases in foods and treats formulated for today's companion animals.

The use of nitrogen gas injection during extrusion cooking to manipulate the microstructure of expanded foods

E. K. CHAN (1), S. Luo (1), C. Erkinbaev (2), J. Paliwal (2), T. M. Masatcioglu (3), F. Koksel (1)

(1) Food and Human Nutritional Sciences, University of Manitoba, Winnipeg, Canada; (2) University of Manitoba, Winnipeg, Canada; (3) Mustafa Kemal University, Alahan, Hatay, Turkey

Nutritional quality of pulses (i.e., high concentrations of proteins, insoluble and soluble fibers) makes them appealing ingredients for the healthy snack foods industry, e.g., puffed snacks. However, the higher the protein and fiber content in a puffed food formula, the lower the overall acceptability (e.g., expansion, structure, texture) becomes. Physical blowing agent-assisted extrusion is a novel technology used to control the structure of expanded foods. The objective of this study was to determine the impact of screw speed (150 and 200 rpm), feed moisture content (18, 20, 22%), and nitrogen (i.e., the physical blowing agent) injection pressure (0, 300, 400, and 500 kPa) on red lentil extrudate structure. The three dimensional structure of extrudates was studied using X-ray microtomography imaging. An increase in screw speed and a decrease in feed moisture content resulted in higher extrudate void fraction and expansion index. The use of nitrogen injection provided additional bubble nuclei during extrusion, which resulted in extrudates with an increased number of cells. However, the relationship between number of cells in the extrudate and nitrogen injection pressure was non-linear, indicating an optimal injection pressure in order to achieve the highest expansion. This optimal injection pressure was also a function of screw speed. Even at relatively higher moisture contents where expansion is negatively affected, nitrogen gas assisted extrusion cooking has shown great potential to create desirable physical properties for expanded snacks with higher protein and fiber content.

The unexpected nutritional benefits of high shear extruded ingredients in the baking industry

M. M. MARTINEZ (1)

(1) University of Guelph, Guelph, ON, Canada

Growing mega-trends in the food market include natural and flexible diets that drive the expansion of plant-based food products, food sustainability and healthy foods. Handling plant-based materials through process-intensifying technologies, such as high shear extrusion, could result in sustainable and indulgent food systems. However, it also leads to starch gelatinization and, therefore, high shear extrusion is commonly associated with foods categorized as having high glycemic index. The formation of structurally-driven slowly digestible starch (SSDS) from fully gelatinized and fragmented starch has received little attention, nor has the effect of high shear extrusion on the bioaccessibility of phenolic compounds been understood. This presentation will cover recent progress on the development of ingredient prototypes through high shear extrusion for the baking industry and attain low/slow starch digestibility, more abundant and bioaccessible phenolic compounds, and attenuated trans-epithelial absorption of glucose from available carbohydrates.

How do gut microbiota ferment starch and arabinoxylan?

M. GIDLEY (1)

(1) University of Queensland, St. Lucia, Australia

Background and Objectives - The fermentation of dietary polysaccharides (primarily) in the large intestine is an important component of the health-promoting effect of a fibre-rich diet. However, the biochemical mechanisms by which the consortium of microbes in the large intestine degrade fibre polysaccharides is incompletely understood. Through the analysis of enzyme activities involved in polysaccharide breakdown and residual polysaccharide structure/size during fermentation *in vitro*, we have shed new light on the processes by which two of the most important cereal fibres—arabinoxylan (AX) and (resistant) starch (RS)—are fermented. **Methods** – AX (from wheat and rye) and RS from a range of sources were fermented *in vitro* using faecal inocula from either pigs fed a fibre-deficient diet or humans with no diet restrictions. Samples were taken throughout the fermentation process for characterisation of relevant enzyme activities, residual polysaccharide amounts and structure/size, as well as fermentation products such as short chain fatty acids (SCFA). **Results** – AX fermentation was driven primarily by enzyme activities (endo- β -1,4-D-xylanase, exo- α -L-arabinofuranosidase and exo- β -1,4-D-xylosidase) located on the surface of microbes. The steady reduction in molecular size and small changes in substitution pattern of residual unfermented AX shows that fermentation was not limited to competitive capture of AX molecules by single microbes. RS fermentation showed similar gradual changes in residual unfermented polysaccharides, and enzyme analysis showed the presence of endo- α -amylase, exo- α -glucosidase, (exo-) β -amylase and debranching enzyme activities. The rate of starch fermentation showed different relative kinetics to the standard *in vitro* enzyme digestion kinetics, consistent with roles for multiple enzyme activities. **Conclusions and Relevance** – These studies are helping to unravel the complex processes through which important nutritional benefits of cereal polysaccharides are exerted. The evidence suggests that both competitive and cooperative fermentation processes occur, leading to efficient production of SCFA and a diverse microflora respectively; both of which are considered important for health benefits.

The effect of boiling on the phenolic content in Canadian hulless barley varieties

P. C. DRAWBRIDGE (1), P. Silveira Hornung (1), T. Beta (1)

(1) University of Manitoba, Winnipeg, MB, Canada

Phenolic acids have received much attention due to the potential health benefits associated with their regular consumption. Phenolic acids in grains are present in both free and bound form. The objective of this study was to evaluate the effect of boiling on the amount of free, bound, and total phenolic acid content in four, hulless, food-grade whole-grain barleys grown in Canada: CI1248, Atahualpa, Peru-35, and Roseland. Each variety of barley was boiled, and freeze dried prior to analysis in triplicate. Free phenolic acids were extracted using acidified 80% methanol. Bound phenolic acids were obtained under alkaline conditions (4M NaOH). Total phenolic content on free and bound extracts was determined using the Folin-Ciocalteu method. Comparisons of means were done using Tukey's method, with a level of significance determined at $p < 0.05$. HPLC chromatograms were used to identify phenolic acids in the raw and boiled barley samples, by comparing to those of standards. The predominant phenolic acids in all barley samples, raw and boiled, were *trans*-ferulic acid and *m*-coumaric acid. Free phenolic acids were more abundant than bound phenolic acids in all four barley varieties. Free phenolic content varied among the raw barleys, ranging from 265.28 to 453.05 mg gallic acid equivalents (GAE) per 100 g barley, however; there were no statistically significant differences in terms of bound phenolic content. Boiling increased the level of bound phenolic acids, however; the observed increases were not statistically significant. The effect of boiling on the free and total phenolic content (TPC) depended on barley variety. In terms of TPC, lighter coloured barley varieties, Atahualpa and Roseland, had a greater TPC than the darker coloured varieties, containing 506.84 and 486.79 mg GAE per 100 g of barley, respectively. Despite differences in free phenolic content and TPC of the raw barleys, the free, bound, and TPC after boiling were not statistically different among all four barleys. This finding suggests that the hulless food-grade barleys investigated are all equal in terms of the level of health-promoting phenolic acids when boiled. Further studies are underway on the bioaccessibility of the barley phenolics following *in-vitro* digestion.

Using tannin-protein complexes to alter rheology and end-use properties

A. L. GIRARD (1)

(1) Texas A&M University, College Station, TX, U.S.A.

Tannins, especially condensed tannins (proanthocyanidins, PA), can strongly complex wheat gluten through hydrogen bonding and hydrophobic interactions, which alter gluten functionality. Barley and rye proteins are closely related to gluten, but do not have equivalent viscoelasticity. This study aimed to determine the effect of PA (mean DP = 19.5) on functionality of barley and rye flours. Flours were mixed with PA (0-25 mg PA/g flour) and assessed for dough extensibility (TA.XT2 Texture Analyzer) and starch pasting properties (Rapid ViscoAnalyser, RVA). Proanthocyanidin addition (2.5 mg PA/g flour) increased the force required to extend rye flour dough by 34% and increased extensibility by 19%. Similarly, previous work showed PA improved tensile strength of wheat flour doughs by complexing gluten proteins. PA had a negligible effect on barley dough extension properties. This suggests that, like wheat, rye storage proteins interact with PA, but at 2.5 mg PA/g flour, barley proteins were not significantly altered. Addition of 25 mg PA/g flour increased barley and rye flour RVA peak viscosity by 1.9 \times ; the increased viscosity during cooking suggests increased polymer size. Interestingly, rye flour, but not barley, had a viscosity increase beginning at $\sim 60^{\circ}\text{C}$ that plateaued (730 cP) before reaching the starch pasting peak viscosity (3,360 cP). This suggests rye prolamins are denaturing during the initial heating process, exposing hydrophobic amino acid residues for interaction with PA, similar to an observation we recently reported for wheat gliadins. The evidence suggests rye proteins interact with PA via mechanisms like those of wheat gluten proteins, but barley has different interaction mechanisms. PA may be a useful natural additive to improve dough strength and batter viscosity of rye products.

Behaviors of starches evaluated at high heating temperatures using a new model of Rapid Visco Analyzer – RVA 4800

S. Liu (1), T. Z. Yuan (1), M. C. Reimer (2), C. Isaak (2), Y. AI (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada; (2) Perten Instruments Inc., Winnipeg, MB, Canada

Rapid Visco Analyzer (RVA) is a reliable instrument that is commonly deployed to determine the pasting properties of starch. The conventional model of RVA can only measure starch pasting properties at heating temperatures up to 95°C , which thus cannot assess the performance of starch in high-temperature processing, such as retorting, jet-cooking and extrusion. In this study, RVA 4800—the latest model of the viscometer having high-temperature capability—was utilized to determine the pasting properties of representative waxy, normal and high-amylose starches containing 1.8-69.7% amylose at heating temperatures of 95 - 140°C . As the temperatures increased from 95 to 140°C , the pasting temperatures and peak viscosities of most waxy and normal starches were not altered, but their holding strengths and final viscosities decreased, which could be explained by thixotropic thinning and thermal degradation of starch molecules under the high pressure condition. Consequently, the paste adhesiveness or gel hardness of most waxy and normal starches was decreased by high-

temperature cooking. By contrast, heating at temperatures above 120°C fully gelatinized wrinkled pea and high-amylose maize starches, allowing the starch granules to swell for viscosity development and subsequent gel formation. Matrix structures of the freeze-dried starch gels/pastes were observed under scanning electron microscope to elucidate how the changes at granular and molecular levels at the tested heating temperatures affected the pasting and gelling properties of various starches. This research provided new insights into the relationships between the thermal properties, pasting properties and gelling ability of different starches at heating temperatures of 95-140°C.

The role of wheat, rye, and oat dough aqueous phase constituents in bread making

F. JANSSEN (1), A. G. B. Wouters (1), M. Paula (1), R. Derua (1), J. Vermant (2), J. A. Delcour (3)
(1) KU Leuven, Heverlee, Belgium; (2) ETH, Zürich, Switzerland; (3) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium

Proper gas cell stabilization during bread making is essential to obtain bread with high loaf volume and a homogeneous crumb structure. In wheat bread making, gluten proteins form a viscoelastic network that during fermentation provides structural support to expanding gas cells. However, it has been proposed that this expansion causes stretching of gluten proteins so that some gas cells are not completely surrounded by the gluten network. At this point, dough aqueous phase lipids, proteins, and non-starch polysaccharides supposedly take over gas cell stabilization. Non-wheat breads have lower loaf volume than wheat breads because they lack gluten proteins. This implies that the mechanism whereby dough aqueous phase constituents stabilize gas cells is arguably more important in non-wheat than in wheat doughs. However, no studies are available dealing with the composition or functionality of non-wheat dough aqueous phase. Dough aqueous phase constituents are typically studied by isolating dough liquor (DL), which is the supernatant obtained after ultracentrifugation of dough. DL was isolated from fermented wheat, rye and oat doughs. Wheat, rye, and oat bread loaf volume and crumb structure were related to the composition (protein, lipid, and non-starch polysaccharide levels as well as the lipid population) of the respective DLs as well as the air/water interface characteristics (foaming properties, thin film drainage dynamics, extent and rate of diffusion to and adsorption at the air/water interface, and/or shear and dilatational rheological characteristics) of the respective DL constituents. Three strategies were employed to investigate the role of and interplay between different DL constituents in stabilizing air/water interfaces: (i) removal of DL lipids by defatting, (ii) enzymatic hydrolysis of DL non-starch polysaccharides after DL isolation, and (iii) enzymatic hydrolysis of lipids during dough making and fermentation prior to DL isolation. It was concluded that rye and oat DL constituents have potential to provide air/water interfaces with a high degree of stability in model system tests. Nevertheless, the quality of rye and oat breads was still lower than that of wheat breads. Thus, under the assumption that the behavior of DL constituents is representative for that of those in the dough aqueous phase, it seems that rye and oat dough aqueous phase constituents cannot match the efficiency by which the gluten network stabilizes gas cells in wheat bread.

Impact of the wheat tempering procedure (moisture content and tempering time) on the grain behavior during milling and on the flour quality: Effect of tempering time

A. DUBAT (1), J. E. Bock (2)
(1) CHOPIN Technologies, Villeneuve la Garenne, France; (2) Wheat Marketing Center, Portland, OR, U.S.A.

Studies were conducted to analyze independently the impact of moisture content and tempering time on wheat behavior during laboratory milling and on the resulting flour quality. The Moisture content study was focused on determining the optimal final tempering moisture content (MC). Our results clearly indicate that the tempering MC directly impacts milling behavior. The extraction rate decreases with higher MC because of a diminution of the wheat resistance to grinding as measured by the resistance index and the apparent hardness. If flour production increased with final tempering MC at the 1st break, it stayed constant at B2 and decreased at the sizing stage. It appeared that, for higher tempering MC, part of the endosperm is removed with the coarse bran because a mellower endosperm tends to adhere more strongly to the external wheat kernel layers. During the tempering study we observed 2 primary groupings based on tempering time. The first grouping occurs between 0 and 12 h of tempering time and is characterized by major changes in wheat performance during milling. It appears that the tempering process has achieved a point of stability at 12 h and beyond, and it is therefore recommended to mill the grain during this period. Furthermore, our results did not show or showed only limited influence of the initial wheat hardness on the milling performance and flour quality, meaning that a different tempering time and/or protocol for hard vs. soft wheat is not necessary at the laboratory level. Looking at flour quality gave two important pieces of information. The first is that the milling of dry grain produces a flour with much higher ash content, higher starch damage, and lower Alveograph W and Ie values. The second is that wheat tempered between 15-17% final moisture content produced similar flour in terms of quality. From these observations we conclude that milling untempered wheat at the laboratory level is not recommended as it negatively affects the flour quality, and that any final tempering MC between 15% and 17% can be chosen without having to adapt to the wheat hardness. Our recommendation would be 16%, and a tempering of minimum 12 hours necessary to reach the stability zone in terms of milling behavior and flour quality.

Bioactive components and antioxidant capacities of Tibetan hulless barley cultivars

S. WANG (1,2), S. Zhou (1), Y. Zhang (2), L. Liu (1), L. Tong (1), L. Wang (1), Y. Ma (1,3), X. Zhou (1), B. Zhao (1) (1) IFST, Chinese Academy of Agricultural Sciences, Beijing, China; (2) Tibet Academy of Agricultural and Animal Husbandry Sciences, Lhasa, China; (3) Department of Food Science and Formulation, Gembloux Agro-Bio Tech-ULg, Gembloux, Belgium

In this study, the bioactive components (phenolics, flavonoids, beta-glucans and gamma-aminobutyric acid) and antioxidant capacities (DPPH radical scavenging capacity, ABTS radical scavenging capacity and Ferric ion reducing antioxidant power) of 25 Tibetan hulless barley cultivars were determined and compared, including 4 two-rowed white hulless barley (TWHB), 9 six-rowed white hulless barley (SWHB) and 12 six-rowed purple hulless barley (SPHB). The content of total phenolics, total flavonoids, beta-glucans and gamma-aminobutyric acid varied between 1.74-3.17 mg of gallic acid equivalents per gram of dry weight (mg, GAE/g, DW), 0.50-1.49 mg of rutin equivalents per gram of dry weight (mg, RE/g, DW), 4.31-8.15% of dry weight and 12.78-43.00 mg per 100 g of dry weight. The highest average contents of total phenolics (2.7 ± 0.52 mg GAE/g DW), total flavonoids (1.12 ± 0.39 mg RE/g DW), beta-glucans ($6.54 \pm 0.31\%$) and gamma-aminobutyric acid (29.79 ± 12.81 mg/100 g, DW), as well as the highest average level of antioxidant capacities were measured in two-rowed white hulless barley. The correlation analysis showed that the phenolics and flavonoids were the contributors to the ABTS radical scavenging capacity and FRAP antioxidant capacity, the flavonoids were the main contributors to the DPPH radical scavenging capacity. Results showed that Tibetan hulless barley, especially the two-rowed white hulless barley, was the potential sources of phenolics, flavonoids, beta-glucans and gamma-aminobutyric acid, which suggested Tibetan hulless barley could be used as food ingredients.

Effects of different physical blowing agents on physical and techno-functional properties of pulse-based expanded foods and food ingredients

F. KOKSEL (1), M. T. Masatcioglu (2)

(1) Food and Human Nutrition, Winnipeg, MB, Canada; (2) Mustafa Kemal University, Alahan, Hatay, Turkey

Extrusion is an effective method to aerate foods (by converting dense, hard materials into lighter and more appealing forms) and to create new food ingredients with superior functionality (by modifying techno-functional properties due to momentum and heat transfer during processing). Pulses, rich in proteins and dietary fibers, present great opportunities to be incorporated more frequently into our diets, either as expanded foods (e.g., snacks, breakfast cereals) or ingredients modified to fit a wide range of applications in the food industry (e.g., in soups, baby foods, etc.). The objective of this study was to examine the use of physical blowing agents (e.g., gases with different solubility values) during extrusion, as an alternative to conventional extrusion cooking, to manipulate physical properties (e.g., expansion, texture, microstructure) of expanded foods and techno-functional properties (e.g., water binding capacity, emulsion stability, pasting properties) of extruded ingredients. The effects of nitrogen and carbon dioxide gases (0-500 kPa injection pressure range) and feed moisture content (14-18%) on physical properties of expanded yellow pea and red lentil extrudates were investigated. Extrudate expansion was feed moisture content, physical blowing agent type and injection pressure dependent. High correlations were found between extrudate expansion and hardness ($r = -0.899$) and between injection pressure and crispiness ($r = 0.822$). Both physical blowing agents possibly increased bubble nucleation sites during extrusion, which is reflected as smaller but higher number of cells in three dimensional X-ray microtomography images. The effects of nitrogen gas at 300 kPa injection pressure, die temperature (in the range of 100-175°C) and feed moisture contents (20-24%) on techno-functional properties of yellow pea and red lentil extrudates were also investigated. Nitrogen injection assisted extrusion resulted in extrudates with a higher cold viscosity, higher water solubility, lower gelatinization enthalpy. These changes in extrudate physical and techno-functional properties as a result of the use of physical blowing agents demonstrate the potential of this novel technology to help generating a variety of nutritionally-dense expanded foods and food ingredients fit for a wide spectrum of products.

Formulating with whole food sources of plant based proteins

K. HARRIS (1)

(1) Bay State Milling Company, Quincy, MA, U.S.A.

Because consumers are looking to reduce their consumption of animal protein, there is a demand for high protein products formulated with plant-based protein ingredients. There is consumer acceptability for the two major plant-based protein ingredient categories: one of which is a whole food source (i.e. chickpea flour), and the other is an isolate/concentrate source (i.e. pea protein isolate). While product developers have been successful in incorporating plant protein isolates or concentrates into acceptable food products, there can be challenges and there is a gap in the market for high protein plant-based protein products that are based solely on whole food protein sources. Plant-based proteins in the form of isolates or concentrates deliver high protein quantity, moderate-to-high protein quality, and can be successfully incorporated into food products at low use levels to

achieve a protein claim. However, these isolated sources of plant-based protein may come with undesirable sensory characteristics and a lack of functionality. While whole food plant-based protein sources deliver other beneficial nutrients (fiber, vitamins, minerals, phytochemicals, etc.), their protein quantity and quality are often low, forcing product developers to compromise on finished product quality by using them at higher inclusion levels to get their desired protein claim. One solution is blending complementary whole food plant-based protein sources to attain optimal nutrition, sensory, and/or functionality. To help streamline the product development process, a proprietary database has been developed to help predict the PDCAAS score of blends made with various whole food plant-based protein sources. Optimal blending can produce whole food plant-based ingredient blends with >20% protein, a PDCAAS score >0.70, and a sensory profile that is mild compared to the individual components on their own. Despite this success in ingredient development, lower protein quantity in whole food plant-based protein sources and understanding the effects of processing remain limitations when formulating high protein plant-based protein products.

Flavor modification: A novel approach for enhanced organoleptic property of pea flour

S. VATANSEVER (1), C. A. Hall III (1)

(1) North Dakota State University, Fargo, ND, U.S.A.

Dry pea (*Pisum sativum* L.) is a notable pulse crop for fulfilling gluten-free requirements to fortify cereal-based foods. However, pea flavor restricts the utilization of pea flour in the food market. Therefore, a green technology, supercritical fluid extraction (SFE), was employed as a deodorization method to improve sensory attributes of pea flour. Optimum extraction conditions (ethanol at 22%, temperature at 86°C, and pressure at 6,195 psi) were significantly ($p < 0.05$) obtained using response surface methodology. The three-particle sizes (>250, >150, and >106 μm) of pea flour were separated using a sieving system and flavor intensity was differentiated by trained sensory panelists. The effects of particle size along with the extraction system on the flavor of pea flour were investigated using multiple approaches, which were a gas chromatographic (GC) system, a GC-olfactometry (GC-O) system, and sensory analysis. The total volatile contents of un-extracted and extracted whole, >250, >150, and >106 μm flours were 18.1, 7.7, 7.1, and 10.4 ppm and 0.6, 0.7, 0.9, and 1.0 ppm, respectively by the GC system. 1-Hexanol, 1-heptanol, 1-octen-3-ol, 1-octanol, 1-nonanol, nonanal, and an alkyl pyrazine were found as major off-aroma compounds in un-extracted pea flour. The SFE system significantly ($p < 0.05$) extracted those compounds from the pea flour at the optimum conditions and further reduced bitterness compounds. Increasing particle size for un-extracted and extracted pea flours resulted in less off-aroma compounds based on the GC analysis, but this result did not follow the same pattern as the sensory analysis. The trained sensory panelists stated that non-extracted and extracted larger particle size flour had significantly ($p < 0.05$) higher pea intensity and bitterness than smaller particle size flour. The trained panelists for the GC-O system mostly identified the off-aroma compounds in un-extracted pea flour compared to the extracted pea flour. This research showed that the SFE could be an acceptable method for removing off-flavor from pulse flour. Additionally, different particle sizes impacted the flavor attributes of pea flour; therefore, considering particle size would be useful for improving the sensory quality of pulse flour.

Study of the components influence on noodle dough loosening

K. NAKAMURA (1), K. Hayakawa (1), C. Abe (1)

(1) Nisshin Flour Milling Inc., Tsukuba-city, Ibaraki, Japan

The stickiness and looseness of the dough in resting are undesirable for noodle making in the line. The objective of this study was to clarify the mechanism of noodle dough loosening in resting. Japanese domestic wheat "Kitahonami (KH)" and Australian standard white (ASW) were used. Noodle doughs and strands were prepared by AACC Approved Method 66-60.01 with some modifications. Both ends of noodle strands were set between two boxes and stored for 3 hr in the dough conditioner at 17, 27, 35°C at 95% humidity. The distances of hanging down as an index of loosening were 12.3-23.5 cm for KH and 9.3-16.4 cm for ASW at 27°C (for 0.5-3.0 hr, respectively). These results showed the dough of KH (DKH) was significantly ($P < 0.05$) looser than the dough of ASW (DASW). Also, the higher the temperature in resting, the easier it was to loosen the dough ($P < 0.05$). Proteins in dough were extracted using 0.5% SDS phosphate buffer with homogenization and analyzed by SE-HPLC. The degrees of extractability of protein (DEP) were 87.2-88.4%, (17°C), 87.9-89.8%, (27°C), 87.3-90.0%, (35°C), for DKH, 83.4-87.4%, (27°C) for DASW, resting for 0-3.0 hr, respectively. DEP for DKH at 35°C reached 90% earlier than that at 27°C (resting for 0.5, 1.0 hr, respectively). The proportions of polymeric proteins (PPs) were 36.1-35.8-35.5-35.3%, (17°C), 36.4-36.4-36.4-35.8%, (27°C), 36.1-36.4-36.0-35.2%, (35°C), for DKH, 30.0-30.8-31.0-30.7%, (27°C), for DASW, resting for 0, 0.5, 1.0, 3.0 hr, respectively. These results indicated that the larger the looseness, the faster the solubilization of PPs. Fluorescence intensities of tryptophan (FIT) on dough surface were measured using spectrofluorometer. Decrease in FIT of DKH for 3 hr at 27°C was significantly ($P < 0.01$) more than that of DASW (274, 140 fluorescence intensity area, respectively). FIT of DKH at 35°C was more rapidly reducing than those at 17 and 27°C (27°C > 17°C). Sugars in dough were extracted using 80% ethanol and measured using HPAE-PAD. The amounts of sugars in DASW were significantly ($P < 0.01$) more than those in DKH (62.3-81.7, 30.3-42.6 mg/dry dough gram, 0-3 hr, for maltose, 14.0-15.0, 7.8-8.4 for sucrose,

respectively). In summary, it was suggested that protein composition in dough changed in resting, consequently might change the solubilization properties of protein, followed by loosening dough. Also the changes in hydrophobicity in dough affect to loosen noodle dough. The changes in hydrophobicity and protein composition might be linked each other. It appeared that the amount of sugars wasn't a main factor for loosening noodle dough.

Preharvest sprouting and baking quality

C. M. COURTIN (1)

(1) KU Leuven, Leuven, Belgium

Preharvest sprouting (PHS) results in the production of several hydrolytic enzymes in the kernel, which decreases the technological quality of wheat and causes problems during processing of the flour into cereal-based products. Therefore, wheat that is severely sprouted in the field is less suitable for products for human consumption, and is often discounted to animal feed. In this talk, I will give an overview of the recent findings on PHS of wheat in the field, as compared to knowledge generated using controlled sprouting. I will discuss the functional changes occurring in wheat during PHS and its impact on wheat and bread quality. Strategies to reduce the enzyme activity in flour from sprouted wheat to increase its potential to be used in the food industry are presented and the enhanced quality of the resulting flour will be demonstrated in bread making. The talk will provide a useful background for further research concerning the potential of field-sprouted wheat to be used as raw material in the food industry.

Fortifying wheat-based foods with high amylose wheat flour to achieve fiber benefits

K. HARRIS (1)

(1) Bay State Milling Company, Quincy, MA, U.S.A.

Refined wheat flour made from traditional wheat is a highly functional ingredient that is used in the production of numerous wheat-based foods. Products made from refined wheat flour are devoid in dietary fiber which has grave public health implications due to the high digestible starch content and low dietary fiber content in refined flour. High amylose grains have been developed to increase the amylose and resistant starch content within the endosperm of the wheat kernel, which when processed creates a refined wheat flour with both functionality and fiber benefits that can be used to make healthier processed foods. The health benefits of high amylose grains have been reported in a number of different clinical studies, with health benefits ranging from blood sugar management to fermentation and subsequent production of short chain fatty acids. Studies have been conducted to understand the amount of high amylose wheat flour required in food formulations to deliver measurable levels of dietary fiber in wheat-based products. Typical white bread delivers roughly 1 gram of dietary fiber per slice, whereas the inclusion of high amylose wheat flour can yield anywhere from 3 to 5 grams of dietary fiber per slice. Furthermore, a traditional flour tortilla delivers roughly 1 gram of dietary fiber in a single tortilla, whereas the inclusion of high amylose wheat flour can yield anywhere from 3 to 5 gram of dietary fiber per tortilla. The utilization of high amylose wheat flour in processed foods allows for consumers to significantly increase their dietary fiber intake while eating common staple foods.

High-amylose wheat: Starch structure and in vitro digestion and fermentation

H. LI (1), S. Dhital (1), R. G. Gilbert (1,2), M. J. Gidley (1)

(1) University of Queensland, Brisbane, Australia; (2) Yangzhou University, Yangzhou, China

Increasing fibre intake is an important public health target. Starches with elevated levels of amylose are rich in resistant starch (RS), and can be a convenient route for increased fibre intake. The recent development of high amylose wheat now allows formulation of major wheat-based products (e.g., breads and noodles) with higher fibre contents. This study focused on the nutritional profile of high-amylose wheat starch (HAWS) obtained through conventional breeding. Noodles made of HAW contain 8-times-higher RS compared to noodles made from normal (wild type) wheat flour. Similarly, isolated high amylose starch both in native and cooked forms are more resistant to *in vitro* digestion. The enhanced resistance of cooked/processed HAWS is proposed to be largely physical in nature, the ability of HAWS to retain granular structure (high-density packing of starch polymers) during cooking limiting the access of digestive enzymes to the glucans. Further, the evolution pattern of starch structure during digestion, from size exclusion chromatography (SEC) before and after debranching, was different between wild types and HAWS. In debranched SEC, wild-type starch residuals have similar debranched profiles, suggesting the branches are evenly digested. In HAWS, however, elongated amylopectin and amylose branches were digested relatively faster than shorter branches. The uneven digestion of HAWS suggests that native granules of HAWS could contain heterogeneous crystalline regions, including a previously unreported arrangement of branched glucans which is more resistant to enzymatic digestion. The starch molecular structural changes during *in vitro* colonic fermentation are different to those from digestion: α -limit dextrin was produced during digestion, but was further degraded during fermentation. This difference is attributed to starch-degrading enzymes other than α -amylase being produced by colonic microbiota.

Optimization of recovery of anthocyanins from colored wheat

D. Kumar (1), C. V. KURAMBHATTI (1), N. Kumar (2), S. Kumar (2), M. Garg (2), V. Singh (1)

(1) University of Illinois Urbana-Champaign, Urbana, IL, U.S.A.; (2) CCS Haryana Agricultural University, Hisar, India

In an era of natural ingredients and clean label, the food industry is increasingly looking for economic alternatives of synthetic colorants. Anthocyanin based extracts from colored fruits, such as red grapes, berries and other dark colored fruits/vegetables, entail potential health benefits and can be used as food additives as well as natural colorants in foods and beverages. However, higher extraction costs due to low anthocyanin concentrations and limited use of fruits/vegetables after anthocyanin extraction have largely prevented their use in the food industry till now. The objective of this study was to develop and optimize an efficient method of anthocyanins extraction from color wheat. Wheat is a major staple crop in several countries and many different colored wheat cultivars are available around the world. Colored wheat, even with its superior nutritional quality, is generally not preferred by farmers because it results in darker colored flour. The method developed in this study can address this challenge and also provide a high concentration anthocyanins source for the food industry. Preliminary studies have suggested that a large fraction of total anthocyanins are located in the pericarp tissue and can be easily extracted by soaking the pericarp in water. Removal of anthocyanins rich pericarp would result in white flour when ground. Four colored wheat cultivars, available in the United States, were investigated in this study. A laboratory scale dry milling procedure was developed and optimized to recover a high amount of wheat pericarp from these wheat cultivars. Various soaking conditions—temperature, pH, and incubation time—were investigated to determine the optimum conditions required for maximum anthocyanins recovery from pericarp. The analysis for total monomeric anthocyanins concentration was performed by the pH differential method using a microplate reader method in three independent replicates. The total monomeric anthocyanin concentration was calculated as mg of cyanidin-3-O-glucoside (C3G) equivalents per liter, and converted to mass percentage based on the pericarp yields from wheat grains.

Camelina and pennycress as emerging oilseed proteins: Extraction, modification, and structural/functional characterization

B. ISMAIL (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.

The demonstration of equivalent or superior/new functionality of novel plant proteins compared to existing alternatives is essential to both the food industry and the consumer. However, there is limited consumer and producer knowledge of plant proteins other than soy. Food producers are seeking information on the nutritional, physiological and functional characteristics of plant proteins. This presentation will cover the evaluation of novel plant proteins from camelina, and pennycress, highlighting their structural and functional properties as impacted by extraction methodology and modification, as well as potential applications. Structural characteristics and functional properties of the protein concentrates, isolates and hydrolysates will be discussed and compared to reference proteins, whey protein isolate (WPI) and soy protein isolate (SPI).

Stable isotopes: An effective tool for wheat kernel and its products geographical origin traceability

B. GUO (1), Y. Wei (1), W. Syed Abdul (1), H. Liu (1)

(1) Institute of Food Science and Technology, Chinese Academy of Agri Sciences, Beijing, China

Wheat is an important cereal crop providing foods for half of the world's population. With the development of internationalization and globalization, wheat and its processed products are transported worldwide, which will bring food quality and safety management problems. Stable isotopic fingerprints analysis is an effective method for food geographical origin traceability, which has been successfully used for the food quality and safety management. The feasibility of using this method in tracing wheat geographical origin traceability has already been preliminarily verified. But the stable isotopic fingerprints can be affected by many factors, such as regions, wheat varieties and planting years, and how the processing methods influencing the stable isotopic fingerprints is still unknown. Whether it can be used for wheat products geographical origin traceability needs to be explored. The aim of the study was to solve these problems. Ten wheat varieties were selected and were planted in three regions for five years. Stable isotopes of carbon, nitrogen, hydrogen in wheat kernel were tested by isotope ratio mass spectrometry (IRMS) and strontium was tested by thermal ionization mass spectrometry (TIMS). The effects of region, genotype, harvest year and their interactions on the $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^2\text{H}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ were analyzed. Changes in stable isotopic fingerprints for wheat milling fractions and products along noodle processing were also analyzed. The results showed that although the stable isotopes in the wheat kernel were significantly influenced by the region, genotype, harvest year and their interactions, region accounted for the largest proportion of the total variation. Processing has no significant effect on the stable isotopes of wheat flour. In conclusion, stable isotopic fingerprints analysis is an effective tool for wheat and its products geographical origin traceability.

Effects of germination conditions of brown rice in relation to flour physicochemical properties and bread qualities

Y. J. WANG (1), W. Wunthunyarta (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

Gluten-free products from rice are gaining popularity among consumers because of its hypoallergenic characteristic. The absence of gluten results in inferior bread qualities such as hard texture, reduced volume and shorter shelf-life, which can be improved by the addition of external hydrolytic enzymes. Hydrolytic enzymes are activated during germination to stimulate plant growth, and hence these enzymes may function similarly to the external enzymes to improve gluten-free bread from brown rice. Therefore, this objective of this work was to investigate the activities of amylases and protease in germinated brown rice (GBR) from different germination conditions and their impacts on flour properties and bread qualities. Long-grain brown rice (BR) was germinated aerobically and anaerobically for 2 and 4 days, and then assayed for alpha-amylase, beta-amylase, alpha-glucosidase, and protease activities, foaming capacity and sugar content. Breads were prepared from GBR along with BR (control) and evaluated for specific volume, texture, retrogradation and starch characteristics. The results showed that GBR under aerobic condition for 4 days contained greater activities of hydrolytic enzymes than those under different conditions. Germination significantly increased foaming capacity (30-130%) and sugar content (100-1,300%) of BR flour, which was attributed to higher protease and amylase activities, respectively. Breads prepared from GBR flour showed a greater specific volume (4-10%), a reduced hardness (34-90%), and a lower starch retrogradation (66-90%) compared with the control. A strong positive correlation was found between enzymes activities in GBR and specific volume and reduction in hardness ($r = 0.80-0.97$) of bread from GBR. After stored for 7 days, breads prepared from GBR flour exhibited no change in specific volume and less hardness and retrogradation than the control bread, which was supported by the significant reduction of starch molecular size. In conclusion, the hydrolytic enzymes activated from germination significantly improved physicochemical properties of BR flour and consequently bread qualities. Furthermore, rice germinated under aerobic condition for 4 days exhibited better properties.

Mexican ancestral ingredients added to wheat flour produce a bread with bioactive compounds, a high nutritional quality and good appearance

A. M. C. DE LA BARCA (1), E. L. Mercado-Gómez (1), N. G. G. Heredia-Sandoval (1), A. R. Islas-Rubio (1)

(1) Research Center in Food & Development, AC, Hermosillo, Sonora, Mexico

Ingredients of the rich Mexican ancestral diet added to wheat flour can result in bread of high nutritional and functional quality. The objective of this study was to prepare breads with blends of wheat, amaranth and sweet potato flours, optimizing technological properties of doughs, functional and nutritional quality of breads by response surface methodology. Proximal and bioactive compounds of each flour were analyzed; then, a central rotatory compound design with a 15 blends' matrix was made. The model included linear, quadratic, and interaction of factors. Chemical composition, mixograph and viscosity properties of the flour blends were analyzed; and adjust of prediction models was done. Breads, including the only wheat as control, were prepared according to AACC Approved Method 10-10B with modifications in fermentation time, no punching, and reduced sugar content. Specific volume, chemical composition and bioactive compounds of breads were evaluated. The amaranth flour contained 18% protein, 7.4% lipids (41% of them ω -3/ ω -6), and 15% dietary fiber. The sweet potato flour contained ca. 15,000 μ g β -carotenoids/100 g and is a good source of total phenol compounds (235 mg GAE/100 g); both flours presented a high antioxidant activity (20-40 μ mol ET/g). Prediction models were adjusted using data of the flour blends: mixing time (MT), peak dough resistance (PDR), set back (SB) and break down (BD). Interaction between wheat and amaranth flours significantly affected to MT, PDR and SB, while the amaranth and sweet potato flours' interaction only affected to BD. Additionally, PDR was influenced by any of the three components. After optimization, four blends were stated with 63-76% wheat, 13-30% amaranth and 7-11% sweet potato flours. For bread-making, longer mixing times were used for the blends in comparison with control bread. The 1-4 blends breads had specific volumes of 3.25 ± 0.16 , 3.19 ± 0.04 , 3.59 ± 0.14 , and 3.61 ± 0.13 g/cm³, respectively. These values were comparable ($p > 0.05$) to that of control bread (3.47 ± 0.27 g/cm³). Loaves' crust appearance of two of the blends was uniform, but one of them presented no homogeneous crumb. The breads prepared with more sweet potato and less amaranth developed cracks in the crusts, although the crumbs were homogeneous. The optimum blend contains 68.7% wheat, 22.7% amaranth, and 8.6% sweet potato flours, which produced a bread with the best appearance, similar to that of control bread, but it was richer in protein quality, fiber and bioactive compounds.

Effects of sugars and sugar alcohols on the retrogradation of wheat starch gels

M. C. ALLAN (1), L. J. Mauer (1)

(1) Purdue University, West Lafayette, IN, U.S.A.

Starch retrogradation is a post-gelatinization process wherein amylose and amylopectin rearrange to form entanglements, short-range molecular order, and crystalline double helical aggregates. Retrogradation is undesirable in some products, such as in bread staling, and desirable in others, such as for the formation of resistant starch. Sugars are known to influence starch retrogradation, but comparative studies encompassing a variety of sugar and sugar alcohol types and concentrations are lacking. Therefore, the objectives of this study were to compare the effects of 15 sugars and 5 sugar alcohols at select concentrations on the retrogradation of wheat starch and develop an understanding of the influence of sugar stereochemistry thereon. Retrogradation of 10% w/v wheat starch gels at 4°C, with and without 10-50% w/w of each sweetener, was monitored over 28 days by documenting absorbance changes at 620 nm. Significant differences in retrogradation were found between sweetener types and concentrations. Some sweeteners did not alter retrogradation compared to the control, including raffinose, mannitol, and trehalose. Maltitol, xylitol, glucose, fructose, and sucrose slowed retrogradation at low concentrations ($\sim \leq 20\%$ w/w) but increased retrogradation at high concentrations ($\sim \geq 30\%$ w/w). Allulose and L-sorbose slowed retrogradation at high concentrations but had no effect at low concentrations; on the contrary, maltose, mannose, and galactose slowed retrogradation at low concentrations but had no effect at high concentrations. The 5-carbon sugars (xylose and ribose) and tagatose slowed retrogradation at all concentrations. Other sweeteners had no effect on retrogradation at low concentrations but increased retrogradation compared to the control when concentrations increased: these were isomalt, isomaltulose, and sorbitol. Concentration-based effects could have been attributed to sweeteners at low concentrations acting as interfering agents in starch-starch interactions, while at high concentrations the sweeteners may have competed for water and thereby promoted starch-starch interactions. Differences between the sweeteners were likely due to intrinsic properties (such as solute radius and the number of non-axial hydroxyl groups) which affect intermolecular hydrogen bonding tendencies. Sugar alcohols tended to increase retrogradation more than the sugar counterparts, likely due to the greater molecular flexibility of the open ring structure and the extra hydroxyl group of sugar alcohols promoting more hydrogen bonding crosslinks between starch chains. These findings improve the understanding of the effects of specific sweeteners on starch retrogradation and can be used in formulation strategies to better assist in delaying or promoting retrogradation in starchy foods.

Glyphosate overview and effects on mineral nutrition of plants

S. O. DUKE (1)

(1) USDA-ARS, National Products Utilization Research Unit, Oxford, MS, U.S.A.

Glyphosate chelates divalent metal cations. Some scientists have claimed that part of glyphosate's phytotoxicity is due to this property and that the mineral nutrition of glyphosate-resistant (GR) crops is disrupted by glyphosate treatment. GR crops are made resistant with transgenes encoding a GR form of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), the molecular target of glyphosate. EPSPS is an enzyme of the shikimate pathway and is not associated with plant mineral nutrition. GR crops are fifty-fold resistant to glyphosate. This alone indicates that the phytotoxicity of glyphosate is unrelated to mineral nutrition. Extensive field studies at multiple sites over multiple years have found no effects of glyphosate, the GR transgene, or their combination on the mineral nutrition of GR crops. Furthermore, the yield of GR cotton, soybean, and maize have increased at a constant rate for the more than 20 years since their introduction. This is inconsistent with any adverse effects on plant mineral nutrition.

Effect of bioprocessing on the surface properties of wheat bran and its ability to bind aflatoxin

N. H. MAINA (1), H. Nihtilä (1), R. Coda (1), H. Koivula (1), K. Katina (1)

(1) University of Helsinki, Department of Food and Nutrition Sciences, Helsinki, Finland

Wheat bran, is a major side stream from industrial roller milling of wheat. It can be used in food products to improve the nutritional profile. We have recently shown that bioprocessing of bran with microbes and enzymes improves its technological and nutritional properties. Furthermore we have also shown that bioprocessing results may alter the surface properties of the pericarp layer of bran. In this study, bioprocessing effect on soluble fibres was further evaluated and the ability of the processed bran to bind aflatoxins was determined. Commercial wheat bran was studied as untreated bran (native bran) and after bioprocessing with enzymes and lactic acid bacteria. The bioprocessed bran was evaluated for soluble fibre and insoluble fibre and the topography of the pericarp layer of bran analyzed using Atomic Force microscopy properties. The ability of the processed and native bran to bind aflatoxin was evaluated by determining the amount of aflatoxin in the supernatant after centrifugation using HPLC. The study showed a significant increase in reducing sugars and also water extractable arabinoxylans. Our previous results have shown that after bioprocessing the bran surface smooths compared to the native bran and had an increase in number and size of pores. The surface pore width in was between 0.5-5 μm , with the smaller

sizes being more frequent. The study showed an increase in aflatoxin binding that could be related to the observed changes in surface properties.

Amylose and amylopectin roles in the structurally driven formation of slowly digestible starch from fully gelatinized starch

L. ROMAN (1), J. C. Yee (1), A. M. R. Hayes (2), E. Bertoff (3), B. R. Hamaker (2), M. M. Martinez (1)
(1) University of Guelph, Guelph, Canada; (2) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.; (3) Bertoff Solutions, Turku, Finland

Amylose (AM) and amylopectin (AP) have been reported to contribute to gel properties through the formation of AM-AM, AP-AP and AM-AP physical junction zones (PJZ) during retrogradation. However, the influence of each of these interactions on the formation of structurally-driven slowly digestible starch (SSDS) has not been studied, since both AM and AP were usually present in the starch samples. This understanding is especially interesting for sago and banana starches, which were previously reported to be highly prone to form SSDS. In this work, for the first time, mechanistic information on the retrogradation and digestion behavior of sago (21.4% AM) and banana (30.4% AM) retrograded starches is provided in the presence and absence of AM. These results were compared to those from commercial maize (33.8% AM) and potato (17.4% AM) starches, and their waxy counterparts. Starch retrogradation behavior was assessed by thermal and rheological methods during 7 days of storage. The molecular fine structure and the hydrodynamic radius (R_h) of AM and AP were also analyzed (HPSEC-RI). In general, the absence of AM led to an increase in the total amount of amylopectin re-associations (DSC) and a decrease in the elastic modulus development (G') of gels during storage, which is logical considering the higher amount of AP and absence of AM, respectively. Interestingly, these events did not occur in potato starch, whose waxy counterpart exhibited a lower enthalpy for retrograded AP and higher G' development. Among AM-containing samples, G' at 85°C of gels after 7 days of storage were significantly lower for potato, confirming the lower propensity of potato AM, with significantly higher degree of polymerization (1650 DP) than the rest of the AM with DP ranging from 840 to 1,316, to participate in AM-AM interactions and contribute to PJZ that build gel structure. In terms of digestibility, maize and potato starch exhibited a decrease in digestion profile through retrogradation that was relatively similar in presence and absence of AM. Nonetheless, AM-free banana, and especially sago starches, displayed a dramatically higher reduction in digestion profile compared to their AM-containing counterparts. This occurrence could indicate that 1) AM of banana and sago does not intervene in the formation of SSDS and/or; 2) that AP from banana and sago could intrinsically form AP-AP interactions that are highly prone to form SSDS. This work provides unique understanding on the interplay of AM and AP to form SSDS and contribute to gel texture.

Fermentation-process monitoring of spontaneous sourdoughs made with wheat flours from different wheat-growing countries during two months of backslopping

M. OSHIRO (1,2), R. Momoda (1), M. Tanaka (1), T. Zendo (1), J. Nakayama (1)
(1) Laboratory of Microbial Technology, Faculty of Agriculture, Kyushu University, Fukuoka, Japan;
(2) Yamazaki Baking Company Limited, Ichikawa, Japan

Background: Spontaneous wheat sourdough has been traditionally used to produce baked- and steamed-goods in the world. Recently, the use of wheat sourdough in Japan has gained popularity due to increased consumer demand. Japanese bakers occasionally select a wheat flour of spontaneous sourdough by a criterion of the wheat-growing country in order to distinct their sourdough characteristics. However, the effect of the wheat-growing country on wheat sourdough fermentation is still unclear. To this end, the fermentation processes of three spontaneous sourdoughs using wheat flours of different growing countries, France, North America, and Japan, respectively, were tracked by both microbial community analysis and targeted-metabolite determination.

Materials and Methods: All wheat flours were obtained from flour milling companies in Japan. The dry matter percentages of flour ash were 0.63, 0.51, and 0.61, those percentages of flour protein were 11.4, 12.2, and 13.7, France, North America, and Japan, respectively. Three hundred grams of spontaneous sourdough in a 1.5-L plastic container was backslopped 32 times over a time of period of two months. The dough yield (weight of the dough/weight of the wheat flour \times 100) was set at 200. In each backslopping step, fermentation was carried out at 30°C for 8 h, and then stored at 4°C until the next backslopping step. The microbial communities were analyzed by both culture-dependent and culture-independent methods. The concentrations of both lactic acid and ethanol of sourdoughs were assessed by HPLC and enzyme electrode method, respectively. **Results:** During two months of sourdough backslopping, the bacterial communities evolved through three phases that were driven by different groups of lactic acid bacteria (LAB) species. The dynamism among the metabolites also differed, depending on the species composition of the LAB and yeast communities. In one sourdough, the growth of *Saccharomyces cerevisiae* was detected along with a concentration of increased ethanol, while in the other two sourdoughs, *Wickerhamomyces anomalus* was detected without ethanol production. Regarding the LAB communities, two sourdoughs were eventually co-dominated by *Lactobacillus plantarum* and *Lactobacillus brevis*, while the other sourdough was eventually dominated solely by the heterolactic fermentative bacterium

Lactobacillus fermentum, and ethanol was produced at the same level as lactic acid. Further research is needed to understand the effect of the wheat-growing area on spontaneous wheat sourdough fermentation.

Evaluation of hard red spring wheat flours by glutopeak at varied speed profiles

K. WHITNEY (1), S. Simsek (1)

(1) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Evaluation of refined wheat flour is critical for determining quality and end-use application. Flour testing methods should be fast and simple and allow for discrimination between refined flours of various quality. The glutopeak instrument is one such testing method that may allow for determination of flour quality quickly and easily. This study aims to determine the speed profile for the glutopeak, which best allows for determination of flour quality and discrimination between flour types. Samples of Glenn and Prosper hard red spring wheat were milled on a Buhler MLU-202 laboratory mill and a Quadrumat Jr. mill. Samples were then analyzed with the glutopeak at the following speeds: 1,900, 2,000, 2,100, 2,200, 2,300, 2,400, 2,500, 2,600 and 2,700 rpm. The peak times ranged from 39.5 to 172.0 seconds, the maximum torque ranged from 47.0 to 79.5 glutopeak units (GPU), and the aggregation energy ranged from 1,327 to 2,117 cm². Peak times decreased as speed increased, while maximum torque and aggregation energy increased as speed increased. There were significant ($p < 0.05$) differences in peak times, maximum torque and aggregation energies between varieties and between mill types. The glutopeak was able to differentiate between the varieties and the mill types at all speeds. The peak time, maximum torque and aggregation energies were significantly ($p < 0.05$) different between varieties and between mill types at all speeds. Comparing varieties, the differences in peak time and maximum torque decreased at higher speeds, but differences between aggregation energies of the varieties increased at higher speeds. It will be beneficial to test a wider range of flours at these speeds and determine which speed will best relate to other flour quality parameters. Overall, the glutopeak is a simple and quick method for differentiation of flours from different sources (varieties or mills).

Cereal bioactives: Can they contribute to health function beyond fiber?

M. FERRUZZI (1)

(1) Plants for Human Health Institute, N.C. State University, Kannapolis, NC, U.S.A.

Health benefits associated with whole grain cereal consumption has often been linked with their contribution to dietary fiber or other macro/micronutrients. However, cereals remain a significant source of dietary bioactive compounds including phenolics, carotenoids and tocopherols. The extent to which these bioactive components contribute to whole grain health functionality remains an open research question. This presentation will describe both phenolic and carotenoid content of select cereals (maize, sorghum and oats), their fate through processing to traditional products and explore the potential impacts these bioactives may have on human health with examples of phenolic-starch interactions (oats) and carotenoid-vitamin A contributions through biofortification (sorghum and maize). Maize and sorghum are staple grains that are well known as sources of dietary phenolics including phenolic acids and flavonoids. More recently, these staples have been targeted for biofortification to increase the content of pro-vitamin A carotenoids. With significant focus on achieving nutritional targets, the impact of post-harvest handling, milling and processing on the stability and bioavailability of these bioactives has also been explored. Carotenoid stability and eventually bioavailability is impacted at each step in the value chain including post-harvest drying, milling, and subsequent product transformation. Examples of these impacts will be described including changes through wet cooking, extrusion and fermentation of whole grain maize. The association between whole grain oat consumption and a reduced risk of type 2 diabetes has been often described relative to the ability of oat fiber to modify glycemic response. However, oats are a rich source of bioactives including phenolic acids and avenanthramides. The abilities of these oat components to contribute to observed health benefits have been investigated. While oat phenolics appear to only have modest impacts on starch digestion, they do attenuate glucose transport in Caco-2 human intestinal cells in a dose-dependent fashion (0-100 mM). Interestingly, these effects persist during digestion of whole grain oat foods including wet cooked porridges, a puffed cereal and a snack bar made from a select oat cultivars. Type of processing had a more significant impact to bioaccessibility of phenolics than cultivar and subsequent intestinal glucose transport was reduced from foods with higher phenolic bioaccessibility such as the puffed cereal. These results suggest that oat phenolics might contribute, in part, to observed glycemic responses from whole grain oat products and these effects are likely associated to oat phenolic content and their bioaccessibility from consumer foods.

Grains as a source of microbiota accessible carbohydrates

D. ROSE (1)

(1) University of Nebraska, Lincoln, NE, U.S.A.

Dietary fibers exhibit a range of health benefits from the cholesterol-lowering effects of soluble oat fiber to the improvements in bowel function and regularity of insoluble wheat fibers. However, there is compelling evidence that many of the benefits of dietary fibers are related to their fermentation by gut bacteria. The term “microbiota

accessible carbohydrates” (MAC) describes the carbohydrates that are metabolically available to gut microbes for fermentation. MAC support the growth of beneficial bacteria while preventing the growth of less desirable microbes that thrive when MAC are limiting. The fermentation of MAC by the microbiota results in the production of several physiologically important metabolites, especially short chain fatty acids (SCFA). These metabolites are absorbed by the host and have multiple effects locally on intestinal function as well as systemic roles in appetite control, insulin secretion, lipid metabolism, and inflammation, among others. Although grain-based foods contribute more than half of total fiber to a typical diet, results from human feeding trials have indicated that only about 25-35% of the dietary fibers in grains are available for fermentation by the microbiota compared to 75-90% for fruit and vegetable fibers. This low MAC content may severely limit the beneficial impact that grain-derived dietary fibers can contribute to human health. Our recent research has shown that typical food processing operations such as extrusion and breadmaking can be used to manipulate the fermentation of dietary fibers by the microbiome. In some cases, food processing can double MAC and lead to significant improvements in metabolic health outcomes. However, the effects are microbiome-specific. This suggests an insight into why individuals often have differential responses to dietary interventions and may lead to a “personalized nutrition” strategy where dietary recommendations for grain products are managed based on an individual’s microbiota phenotype.

3-Deoxyanthocyanidins increase protein matrix formation, altering starch digestion in cereal porridges

L. C. R. SCHMIDT (1), B. R. Hamaker (1)

(1) Whistler Center for Carbohydrate Research, Department of Food Science, Purdue University, West Lafayette, IN, U.S.A.

The human diet has shifted to more refined foods and ingredients, contributing to rising metabolic disease rates associated with long-term consumption of foods causing swift blood glucose response. Foods resulting in a more moderate blood glucose curve are considered healthier by increasing satiety via extending energy release and absorption, and by reducing oxidative stress. Sorghum products contain naturally slowly digested forms of carbohydrate, as the starch portion is less readily digested than many other cereals. The matrix of sorghum porridges contains kafirin protein bodies which are highly crosslinked around gelatinized starch, while developing matrices in other cereals aggregate and collapse. The 3-deoxyanthocyanidin pigments, present in all sorghums, may account for the difference by forming stable protein matrices containing starch and by partially inhibiting access of α -amylase to starch, reducing overall starch digestion. In order to assess the contribution of 3-deoxyanthocyanidin compounds to matrix formation and associated changes in digestion, a 3-deoxyanthocyanidin found in sorghums, apigeninidin, was added to a yellow corn flour slurry and heated to a porridge, then subjected to *in vitro* α -amylase digestion. The porridge microstructure was examined by means of confocal microscopy using double-labeling with fluorescence markers for carbohydrate and protein. Additionally, the association between apigeninidin (0-50 μ M, pH 6.8) and a model protein, ovalbumin (5 μ M, pH 6.8), was assessed utilizing native tryptophan fluorescence quenching spectroscopy from 25-95°C. Addition of apigeninidin significantly decreased rate of initial starch digestion compared to untreated control. After 5 and 10 min, the amount of released reducing sugars was lower ($p < 0.05$). However, from 20-120 min, no differences were observed in starch digestion. Microstructure of apigeninidin-treated samples was significantly altered, as the zein-containing protein bodies demonstrated areas of extensive web-like structures and less protein aggregation. Through 30 min α -amylase digestion, the protein matrix of treated corn porridges remained largely intact. Fluorescence quenching provided binding information between ovalbumin and apigeninidin, with static quenching determined as the main quenching mechanism. Increasing temperature increased the number of binding sites (from 0.585 to 0.907) and association constant K_A (1.60×10^2 to $8.12 \times 10^3 \text{ M}^{-1}$), indicating stability of the complex increased above ovalbumin melting temperature. Apigeninidin addition to corn flour porridge increased protein matrix formation, likely due to hydrophobic interactions increasing stability for sulfhydryl-disulfide interchanges. Specifically modifying the food matrix may allow for foods designed with enhanced health benefits, including modulating glycemic response and the delivery of macronutrients to the distal ileum to trigger the ileal brake.

Nitrogen and sulfur effects on winter wheat quality

T. L. WILSON (1), M. Guttieri (2), N. Nelson (1), A. K. Fritz (1), M. Tilley (3)

(1) Kansas State University, Manhattan, KS, U.S.A.; (2) USDA ARS CGAHR, HWWGRU, Manhattan, KS, U.S.A.; (3) USDA ARS CGAHR, Manhattan, KS, U.S.A.

Grain protein concentration and composition are key factors in winter wheat quality. Elevated asparagine concentration in wheat flour also can lead to acrylamide production in baked food products, which can be a health concern. Asparagine concentration represents the acrylamide-forming potential of flour. And, unlike acrylamide, asparagine can be measured cost-effectively. The objectives of this study were to determine the effect of genotype, nitrogen (N), and sulfur (S) fertility on protein concentration, protein quality, dough rheology, and asparagine concentration in winter wheat. The experiment was set up in a 3 \times 2 \times 4 factorial in 2017 and 3 \times 2 \times 5 factorial in 2018. There were 3 levels of N (56, 101 and 146 kg ha⁻¹ as urea), 2 levels of S (0 and 22 kg ha⁻¹

as ammonium sulfate), and 4 levels of genotype (cvs. Everest, Fuller, Jagger, and 2137) in 2017 with an additional genotype (cv. SY Monument) added in 2018. Treatments were arranged in a split-split plot design with four replications each year. Protein composition was evaluated as the percent polymeric protein using size exclusion high performance liquid chromatography. Solvent retention capacity was evaluated using the whole grain SDS-SRC hybrid method. In both years, the ratio of polymeric to monomeric protein was increased by sulfur fertilization, although in 2017 total protein decreased due to dilution. In 2017 asparagine concentration in grain was affected by N, S, genotype, and an N by genotype interaction. Without S, Fuller and Jagger had asparagine concentrations of 20.7 to 21.0 $\mu\text{mol/g}$ and Everest and 2137 had lower asparagine concentrations of 12.8 to 13.8 $\mu\text{mol/g}$ ($p < 0.05$). When S was applied, asparagine concentrations declined to $<3 \mu\text{mol/g}$, and genotypes were not different from each other. In 2018 treatment effects were not significant. In 2018, S application increased SDS-SRC from 217% to 308%. Treatment effects on dough rheology were evaluated in the 2018 trial using the farinograph. Sulfur application increased average farinograph stability from 9.2 min to 14.6 min. Farinograph stability was effectively predicted by the whole grain SDS-SRC test ($R^2 = 0.78$). Sulfur deficiency is increasingly common in agricultural soils due to lack of S fertilization, increasing yields removing more S from the soil, and the Clean Air Act improving the removal of S emissions from industrial sites. Therefore, information from this study will help producers manage sulfur-deficient fields to improve grain quality and food safety while maximizing yield potential.

Effect of fine grinding on fermentation performance and in situ fiber conversion in dry grind ethanol process

C. V. KURAMBHATTI (1), D. Kumar (1), K. D. Rausch (1), M. E. Tumbleson, emeritus (1), V. Singh (1)
(1) University of Illinois Urbana-Champaign, Urbana, IL, U.S.A.

Increased risk of extinction of fossil fuel resources has encouraged production of renewable fuel alternatives. Bioethanol is a renewable liquid fuel which is extensively used in transportation sector. Currently, in the US about 90% bioethanol is produced using corn dry grind process. In the dry grind process, corn is ground using hammer mill. Ground corn is mixed with process water to make slurry, which is processed for conversion to ethanol. Further grinding of corn slurry can increase enzyme accessibility of storage and structural carbohydrates, leading to higher ethanol production. Fine grinding potentially acts as a pretreatment step for fiber conversion in dry grind process. The objective of our study was to evaluate the effect of disk milling of corn slurry to improve conversion of starch and fiber to ethanol in dry grind ethanol process. Disk milling (3 cycles: three passes through the disk mill) of slurry prepared from corn ground using 3 mm hammer mill sieve (same size as used in commercial dry grind process) increased post-fermentation ethanol concentration by 4%. However, improvement in ethanol concentration was not observed by disk milling slurry prepared from ground corn produced using 0.5 mm hammer mill sieve. Grinding corn to a small particle size prior to disk milling released most of the bound starch making disk milling of slurry ineffective in releasing additional starch. In addition to disk milling, addition of 30 FPU/g fiber cellulase during fermentation increased ethanol yield in dry grind process by 0.14 gal/bushel and decreased NDF content in DDGS by 30.8%. We hypothesize that combining disk-milling with cellulase addition would lead to a higher increase in fiber conversion and ethanol yield.

Surface-active proteins and lipids in sponge cake batter foam

S. C. PYCARELLE (1), K. Brijs (2), J. A. Delcour (2)

(1) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Heverlee, Belgium; (2) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium

Sponge cake, a foam-type cake, is traditionally prepared from wheat flour, sugar, eggs and leavening agents. High quality sponge cakes are obtained by incorporating high levels of small gas cells during mixing which then remain present in the batter until the cake structure sets. Gas cells are surrounded by a liquid phase, the air-liquid interface (ALI) which contains surface-active molecules such as proteins and lipids. As in most food systems, both molecule types adsorb at the ALI in cake batter. However, due to their opposing stabilization mechanisms they negatively impact the incorporation and stability of gas cells in the batter. We here determined the presence of protein and lipid from both flour and egg at the ALI in batter prepared from flour, sugar, eggs and leavening agents. Hereto, a foam separation protocol was developed. Sponge cake batter was diluted with deionized water and whipped to form foam which was then isolated at three time points after whipping. These foam fractions are believed to represent the ALI in sponge cake batter as they contain a large ALI at which surface-active molecules adsorb. Content and composition of protein and lipid in batter and isolated foam fractions were determined. Foams isolated at later stages had a higher protein and a lower lipid content than foams isolated just after whipping. Furthermore, it was observed that disulfide bonds were formed between ovalbumin molecules and that α - and γ -gliadins had a higher affinity for the ALI than other proteins. Flour lipids had a higher affinity for the ALI than egg lipids. We concluded that both protein and lipid from flour and egg adsorb at the ALI in sponge cake batter. Proteins however, appeared to have a more determining role at the ALI than lipids as they were enriched in the foam over time. Optimizing the functionality of surface-active molecules that are already endogenously present in food could be a valuable next step to develop products with cleaner labels.

Wheat flour solvent retention capacity: Repeatability and reproducibility performances of a new AACC standard measurement method (56-15.01).

A. DUBAT (1), M. Berra (1), B. K. Baik (2)

(1) CHOPIN Technologies, Villeneuve la Garenne, France; (2) USDA-ARS-CSWQRU Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.

Solvent retention capacity (SRC) is an analytical method used to measure the contribution to water absorption of the main functional flour polymers (gluten protein, starch, and pentosans). Originally established to evaluate soft wheat flour functionality in the United States, the method is gaining acceptance worldwide and is now applied to many wheat types and disciplines in wheat variety development and flour processing across the globe. The first approved standardized method recognized in the industry was AACC Approved Method 56-11.02. However, this manual method is extremely operator-dependent, due to the need for consistent agitation during the initial hydration phase and intermittent agitation thereafter. Differences in human execution can introduce variation in results, making it difficult for SRC parameters to be effectively integrated into flour specifications. Laboratories have mechanized different parts of the method in attempts to improve accuracy and precision; however, no formal standardized solution has been introduced in the industry. To address this situation, CHOPIN Technologies developed an automated system, based on the concepts of the AACC method, with the aim of eliminating all potential operator impacts on the test and standardizing tubes and centrifugation conditions. This method has been evaluated through a collaborative study involving 12 laboratories that analyzed 12 flour samples in duplicate with 4 solvents (water, sucrose, sodium carbonate, and lactic acid). The automated SRC tests appear to be highly repeatable and reproducible. Differences in the measured SRC values between laboratories are expected to be lower with the use of the automated CHOPIN-SRC tests because of the much lower relative SDs between laboratories compared with AACC Approved Method 56-11.02. The study also demonstrated that the tests are applicable to wheat flours with much wider ranges of SRC values than those previously believed to be acceptable, thus they can be used for the evaluation of not only wheat with a soft kernel texture and low protein content, but also for wheat with a hard kernel texture and high protein content. This method has been approved by the Soft Wheat and Flour Products Committee and also by the Approved Methods Technical Committee as AACC Approved Method 56-15.01 on the condition of revision.

A comparison between grain and flour characteristics of timely sown and late sown Indian bread wheat varieties

N. SINGH (1)

(1) GNDU Amritsar, Amritsar, India

A comparison between the grain and flour quality of timely sown wheat (TSW) and late sown wheat (LSW) from sixteen Indian bread wheat varieties was done. TSW and LSW had vegetative period of 91 and 64 days against maturation period of 86 and 47 days, respectively. TSW showed higher grain weight and diameter and lower grain hardness index than LSW. Flours milled from LSW showed lower L* value and higher protein content, ash content, gluten content and gluten index than flours from TSW. Delayed sowing lowered the flour recovery, damaged starch content and pentosans content. LSW of majority of varieties showed higher levels of all categories of gliadins (α , β , γ and ω) than TSW. LSW also showed higher accumulation of high molecular weight-glutenin subunits of 122 kDa and 84 kDa than TSW. On the contrary, the delayed sowing did not affect the accumulation of albumins. Water absorption capacity and degree of softening decreased while dough development time and dough stability increased with delayed sowing. The differences in damaged starch content and pentosans as well as accumulation of gliadins and glutenins between LSW and TSW were responsible for difference in their functionality.

Consumer sensory evaluation and texture profile analysis of vegetable hamburger patties with high moisture meat analogs: Peas, lentils, and faba beans

T. KIM (1), R. Miller (1), H. Laird (1), M. N. Riaz (2)

(1) Sensory Science Laboratory, Department of Animal Science at Texas A&M University, College Station, TX, U.S.A.; (2) Extrusion Technology Program, Process Engineering R&D Center at Texas A&M University, College Station, TX, U.S.A.

Pulses have gained interests in plant-based meat sources due to their nutritional profile including high-protein content, concerns about allergens and genetically modified organisms. The objective of this study was to understand consumer perceptions and instrumental textural properties of vegetable hamburger patties made with high moisture meat analogs (HMMA) texturized with pulse proteins (PLP). HMMA treatments (73.4% protein) were initially prepared with wheat-gluten (15%), canola-oil (6%), and one protein treatment. The protein treatments were prepared with either commercial pea-protein (55.4% protein; T1), lentil-protein (55.4% protein; T2), or faba-bean protein (61.5% protein; T3) mixed with pea-isolates (85% protein). The control was prepared with soy-concentrate (76% protein; C1) with soy-isolate (90% protein). These premixed ingredients

were texturized using a twin-screw extruder (TX-52) with an attached cooling chamber. After production, samples were frozen (-18°C) until further experiment. Frozen HMMA treatments were thawed for 24 hours at 4°C, boiled for 2 minutes, and ground using a 9 mm plate (Comitrol-3500). Patties were formulated with chilled water, binders, flavors, and shortening and formed with a patty maker with a 2.54 cm plate (Supermodel-54 Food Portioning Machine). Patties were cooked to 70°C internal degree of doneness. Patties were cut into 4 wedges to serve one wedge to each consumer. Consumers (n = 80) evaluated cooked-appearance, overall, overall-flavor, and overall-texture liking attributes. Texture analysis (TA-XT2 Texture Analyzer) was also performed on the patties. Compared to the control, patties with PLP had similar liking scores ($P > 0.05$) in cooked-appearance, overall, and overall-flavor, but patties with T3 was lower ($P < 0.05$) in overall-liking, and all patties with PLP was lower ($P < 0.05$) in overall texture liking. The protein source in vegetable patties containing HMMA did not significantly ($P = 0.1$) affect hardness but did significantly affected cohesiveness ($P = 0.002$). C1 had the highest cohesiveness and gumminess compared to other samples except T2 in which gumminess was not significantly different ($P = 0.009$) from C1. Other patties containing PLP did not have significantly different cohesiveness and gumminess. Therefore, PLP can be an alternate source of soy to produce HMMA since consumers scored a similar liking of vegetable proteins containing different PLP. In addition, the cooking yield of the samples containing PLP was higher than C1 and needed relatively less cooking time. Although the textural properties were lower in cohesiveness and gumminess for the vegetable patties containing PLP, these proteins might provide a unique combination of attributes and attract consumers.

Introduction – Sustainable diets/sustainability

J. W. FINLEY (1)

(1) U.S. Department of Agriculture, Beltsville, MD, U.S.A.

Assumptions associated with sustainable food systems are up for debate. Are goals best served by intensifying production on existing lands and systems or is a shift to plant-based diets more sustainable? Recommendations must be made in collaboration with the food producers to reduce resistance from perceived changes in demand and profitability. This session will explore the approaches and consequences of both.

The effects of temperature, formulation and packaging type on water activity shifts of extended shelf life bakery items

M. J. RICHARDSON (1), S. Walker (1), A. H. Barrett (1)

(1) CCDC Soldier Center, Natick, MA, U.S.A.

Baked cereal items undergo degradation post processing and during storage. The type and extent of degradation is related to the product's water properties, formulation, processing, and storage conditions. Current bakery items have consistently shown signs of physical, chemical, and sensory degradation during storage and fielding which has resulted in decreased acceptability. Water activity measurements are temperature sensitive. Both the AOAC official method 978.18 and ISO 21807 require measurements at 25°C. However, the military requirements mandate three years storage at 26.7°C and six months storage at 37.8°C; additionally actual storage temperatures could be as high as 48.9°C. This effort showed a_w measured at the required temperature and actual storage temperatures where different. These differences may have adverse effects on safety, eating quality, and overall acceptability of extended shelf life bakery items. In one study shelf stable brownies, cornbread, and two types of cookies were commercially processed and packaged in poly trays. The cornbread had a target $a_w < 0.86$, while the other bakery items had a target $a_w > 0.89$. Samples were equilibrated and measured at four different temperatures. In another study, isotherms were generated at three different temperatures for in-house/commercially produced shelf stable items, including cornbread, yellow cake and chocolate cake. The items were packed in a poly tray (PT) or institutional size pouch (ISP). Samples were stored for four weeks at 48.9°C and 6 months at 37.8°C. For both studies, a_w , pH, mechanical texture, color, and sensory analysis were conducted initially and after storage to determine the effects of formulation packaging. Results show a_w shifts were observed for all products. The direction of the shift was due to temperature, product type, and packaging type and indicates changes in moisture binding. The cornbread a_w was 0.818, and 0.856 for 25.0°C, and 48.8°C respectively. This increased shift can adversely affect product safety, since it created an environment that can support microbial growth. The brownie a_w was 0.862, and 0.826 at 25.0°C and 48.8°C respectively. Though this shift did not affect safety, it did affect eating quality. Generated isotherms verified a_w shift and can be used to predict a_w of items stored at various temperatures, not the recommended measurement temperature. Isotherms can be a tool during development. It can identify the effects of packaging, formulation and temperature and determine if a_w shifts take place.

Influence of the quantity and quality of the additional protease on swelling of the gluten-free rice flour bread

E. ARAKI (1)

(1) Institute of Crop Science, NARO (NICS), Tsukuba, Ibraki, Japan

Objectives: We have already developed a method for producing gluten-free rice flour bread using rice flour batter increased viscosity by incubation with the addition of protease from koji (rice malt). The purpose of this study was to clarify the influence of the quantity and quality of the eight proteases of different properties derived from *Aspergillus* sp., *Bacillus* sp., *Rhizopus* sp., and *Carica papaya* on swelling of the gluten-free rice flour bread. **Methods:** For bread making, white rice flour of “Koshihikari” prepared by a jet mill under wet condition was used. Each protease was added at a rate of 1 to 5,400 units per ml of rice flour batter and incubated for 2 to 24 hours at 25 to 65°C. After incubation, sugar, salt and dry yeast were added to the rice flour batter. Subsequently, the batter was yeast fermented, followed by baking. The swelling of the bread was evaluated by the height from the bottom of the bread to the highest position, and the bubbles in the bread internal phase was evaluated by visual observation of the bread cross section. **Results:** First, incubation temperature was examined using proteases from koji (rice malt). The bread made with the protease-added rice flour batter that had been incubated at 60 to 65°C for 15 hours did not swell. When using the protease-added rice flour batter incubated at 25 to 35°C for 15 hours, the bread was slightly swollen but the bubbles of the internal phase were large. On the other hand, at 45 to 55°C, the breads swelled, and fine bubbles were observed. Next, rice flour batter adding various proteases was incubated at 55°C for 15 hours to make bread, it was possible to make good swelling bread with all the proteases used. However, the amount of protease needed to make a bread with fine bubbles in the internal phase and good swelling varied from 7 to 1,800 U/ml, depending on the protease. In addition, in the rice flour batter in which the amount of protease added was increased, it was possible to produce a good swelling bread with an incubation time shorter than 15 hours. From these results, in the gluten-free rice flour bread manufacture proposed by us, it was shown that various proteases could be used by adjusting the addition amount and incubation time of rice flour batter.

Assessment of genetically engineered traits in heat-treated samples using digital PCR

T. DEMEKE (1), M. Eng (1)

(1) Canadian Grain Commission, Winnipeg, MB, Canada

Many countries have established regulatory and labelling requirements for genetically engineered (GE) traits, which requires the development and use of accurate testing methods. Digital PCR (dPCR) has become a promising alternative to real-time quantitative PCR (RT-qPCR) for identification and quantification of GE traits. The advantage of digital PCR is that there is no need to use standard curve or reference materials to carry out the procedure. Erroneous results may be obtained if the standard curve is not optimal in the case of RT-qPCR. In general, high quality DNA is required for obtaining accurate PCR results. Food processing results in degradation of DNA, which in turn affects PCR results. Use of degraded DNA for PCR may not provide accurate quantitative results for assessment of GE traits. The objective of the study was to evaluate the simulated effect of processed vs. non-processed samples for testing of GE traits using dPCR. Ground canola and soybean samples were heat-treated for various times in order to enhance DNA degradation and determine the impact on dPCR. Expected dPCR values were obtained for three of the four GE events tested for both treated and non-treated samples. Higher than expected values were observed for one of the GE events. Overall, dPCR can be used for assessment of GE traits in processed samples. However, verification of the dPCR method for each GE trait is recommended, as there can be variation.

Impact of amylose variation in Svevo durum wheat on technological properties and starch digestion and glycaemic index

M. J. SISSONS (1,2), D. Lafiandra (3), F. Sestili (3)

(1) NSW Department of Primary Industries, Tamworth, Australia; (2) NSW Department of Primary Industries, Calala, Australia; (3) University of Tuscia, Viterbo, Italy

Objective: Evaluate the impact of a wide variation in amylose content (~2 - 60%) in the same genetic background on semolina properties, pasta quality and in vitro/in vivo starch digestion. Using a common genetic background, durum wheat Svevo was manipulated using TILLING and crossing with donor lines to produce genotypes with amylose content varying from ~2-60%. Grain was milled into semolina and evaluated using AACC and Megazyme methods for protein, colour, resistant and total starch and amylose while dough was evaluated with mixograph and glutopex. Spaghetti was made on 1 kg scale and evaluated using AACC Approved Methods. In vitro starch digestion of pasta was measured using pepsin/ α -amylase/amyloglucosidase method. Glycaemic index was measured on 10 subjects using established method of University of Sydney (SUGiRS). **Findings:** The high amylose (>40%) lines (HA) had lower grain weight and starch content with higher protein content. The HA types (40 and 60% amylose) tended to have weaker dough based on mixograph and very low (~2% amylose) and high amylose genotypes had higher dough water absorption. The HA genotypes had lower cooking times and higher cooking loss compared to Svevo control (33% amylose) while the low amylose (~2%) made stickier and softer

pasta. All lines had lower pasta firmness corrected for protein content relative to Svevo showing an optimal level of amylose influences pasta. However, resistant starch was increased in HA lines (7.4 vs. 0.7%) with other benefits such as a lower extent and rate of *in vitro* starch digestion. Human glucose tolerance tests indicated that an amylose content above ~45% is needed to lower pasta GI. Details of the relationship between amylose content and these properties will be presented. **Conclusions:** This is the first report of the impact in a common durum wheat background of a wide range in amylose content on pasta and dough quality together with *in vitro* and *in vivo* starch digestion comparisons. This information will be useful to the cereal grain community.

Effects of extrusion process parameters on textural properties of high-moisture meat analogues from blend of soy protein isolate, wheat gluten and corn starch

T. T. Maung (1), G. H. RYU (1,2)

(1) Kongju National University, Yesan, South Korea; (2) Kongju National University, Choongnam, South Korea

Recently, global meat consumption is expected to reduce according to consumer's dietary behavior changes with health, ecological, social and ethical reasons. Attempts have been made to substitute real meats with meat analogues processed from plant protein-based ingredients by means of high-moisture extrusion process. Meat analogues from soy protein isolate (SPI) and wheat gluten (WG) could imitate the real meat in fibrous structure, appearance, functional and nutritional properties. Corn starch (CS) as a binding agent of protein molecules also plays an important role in producing high-moisture meat analogues. Although many researchers have been revealed that high-moisture extrusion of these ingredients could texturize the product as similar to muscle meat, more research is needed for complete understanding and optimization of extrusion process parameters which influence the characteristics of final products. The present study was conducted to investigate the effects of high-moisture extrusion process parameters on textural properties of meat analogues using blend of SPI, WG and CS as a raw material. Meat analogues were extruded from mixture of SPI, WG and CS (50:40:10 respectively) using a twin-screw extruder equipped with a long cooling die. The extrusion process conditions were varied as 55 and 65% feed moisture content, 150 and 170°C barrel temperature, and 150 and 200 rpm screw speed. The specific mechanical energy (SME) input and the product textural properties including springiness, cohesiveness, chewiness, hardness and degree of texturization were investigated. The results showed that feed moisture content was a more important factor on SME and product textural properties than other parameters. All the meat analogues were successfully texturized at 65% moisture content using cooling die into highly fibrous structures. Their textures could be further controlled by the barrel temperature and screw speed. Different SME were also obtained by changing the extrusion process parameters and it was observed that lower SME was better for higher texturization degree. Lower SME input and thus better texturization was obtained through high moisture content (65%), high barrel temperature (170°C) and low screw speed (150 rpm) during extrusion. All the products extruded under low feed moisture were found to be rigid and hard when compared with those extruded under high feed moisture. This study provided the valuable information regarding the optimum process conditions during high-moisture extrusion. The results from this study could be applied for direct control of textural properties of high-moisture meat analogues using SPI, WG and CS mixture as raw material.

The challenges and benefits of dry yellow split pea flour inclusion

C. A. PRICE (1), B. Smith (2), A. M. Kiszonas (3), C. F. Morris (3)

(1) Washington State University, Pullman, WA, U.S.A.; (2) University of Idaho, Moscow, ID, U.S.A.;

(3) USDA-ARS WWQL, Pullman, WA, U.S.A.

The market for yellow dry split peas (DSP) is extremely underutilized. The main purpose for these DSP is for animal feed, meaning that the value is low for what DSP have to offer like 25-27% more dietary fiber and double the protein of other cereal grains. By making this an active ingredient in breads and other baked goods, as an example, replacing 5% of standard wheat flour for with dry split pea flour (DSPF) in about 2% of products, this would result in a demand for 42 million pounds of DSPF, the market would increase exponentially. In this study, the characteristics of DSPF were tested to determine how much can be incorporated and how it would affect bread and other bakery applications and to further test on the flavor and aroma profile to improve consumer acceptance of DSPF. There are some inherent challenges to working with a product lacking gluten and having a flavor with low consumer acceptance. The beginning stages of testing focused on milling and how DSP behaved in a large, pilot scale Miag mill. It was concluded that reduction system was a similar yield to a hard wheat which yields 50-60%. After determining the percentage yield from each stream, particle size was analyzed. The DSPF followed a similar trend to wheat, that the later the mill stream was, the larger the particle size and the greater the starch damage. The results for each flour test will help determine the streams that will make a flour mixture, similar to standard wheat flour, that will then be substitute into bread and other bakery products. DSPF can be used to increase the fiber and protein in any baked product that uses flour. In addition to the dietary improvement it will also increase the demand for DSP and help the market.

A novel starch crop contains more resistant starch after cooking

X. ZHAO (1), M. Andersson (2), R. Andersson (1)

(1) Department of Molecular Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden; (2) Department of Plant Breeding, Swedish University of Agricultural Sciences, Alnarp, Sweden

Starch makes up a large part of energy in many people's daily diet. Considering that we eat a lot of potato as a starchy, staple food, high-amylose potato was successfully developed by plant breeders at Swedish University of Agricultural Sciences through genetic modification of the parental cultivar Dinamo, by down-regulating two starch branching enzymes. Tubers from one high-amylose line and its parental cultivar were analyzed for resistant starch content using a K-RSTAR 09/14 kit from Megazyme according to AOAC Method 2002.02. Size exclusion chromatography and high performance anion exchange chromatography were applied to analyze the molecular structure of starch. This high-amylose potato gave a three-fold higher resistant starch (13% of dry matter) than the parent (4% of dry matter) after cooking, and the resistant starch level further increased to around 20% of dry matter after one-day storage in fridge. The high resistant starch content was attributable to a unique starch structure. A high amylose content usually gives a high content of resistant starch in cooked starchy food. The structure analysis revealed an increased ratio of amylose and a unique amylopectin with much longer outer chains that give properties similar to amylose. After cooking and cold storage, the unique amylopectin recrystallizes, and after that it is not as easily accessed by enzymes, which means it is more resistant and takes longer time to digest. If such new starch sources would be commercially available in the future, it might have a positive impact on public health, since resistant starch is a dietary fiber with a lot of benefits for our body. Therefore, it is also very important to gain detailed knowledge of new starches with varying ratios and structures of amylose/amylopectin. Thus we may better understand the biosynthesis of starch as well as to further explore the relationships between structure and functional properties of starch. Then we may custom-tailor starch at the genetic level in different crops for food and nonfood applications with desired functional properties in a sustainable way without further physical or chemical modifications of starch.

Analysis of glyphosate residues and its fate during wheat processing

S. TITTEMIER (1), L. Bestvater (1), J. Carlson (2), J. Kletke (2), M. S. Izydorczyk (1), B. X. Fu (2)

(1) Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, Canada; (2) Canadian Grain Commission, Winnipeg, MB, Canada

Glyphosate is the active ingredient in some of the most used herbicides on a global scale. This widespread use, coupled with general consumer concern regarding pesticide residues in food, renders glyphosate an important subject for the cereal grain science community. The objective of this work was to investigate the distribution of glyphosate and its degradation product aminomethylphosphonic acid (AMPA) in milling fractions of wheat. Six samples of Canada Western Red Spring wheat were pearled to obtain four successive fractions each representing approximately 5% of the initial kernel mass. The remaining scoured kernels were also collected and analyzed in a fifth fraction. Portions of the same six wheat samples were milled in duplicate on a Buhler laboratory scale mill, and nine milling product streams were collected. Straight grade flour and bread was prepared from selected samples. All pearling and milling product fractions, dough, fermented dough, bread crust, and bread crumb were analyzed for glyphosate and AMPA using solvent extraction with derivatization and liquid chromatography-tandem mass spectrometry. The analytical method had a limit of quantitation of 0.1 mg/kg for both analytes. Glyphosate was the only residue detected in samples; the degradation product AMPA was not detected in any sample. The concentration of glyphosate decreased from the first to the fourth pearling fractions, and further decreased in the remaining kernels. Concentrations in the first pearling fraction, representing the outermost kernel layers, ranged from 5.57 to 15.36 mg/kg whereas concentrations in the remaining kernel mass ranged from 0.51 to 1.24 mg/kg. On average, 50% of the total mass of glyphosate resided in the outer 17% of the kernels' mass. In a similar fashion, 83% of the total mass of glyphosate in the wheat was associated with the bran, shorts, and feeds milling fractions. No changes in glyphosate concentration were observed during the preparation of dough, fermented dough, and bread. In addition, no differences in glyphosate concentration were observed between the crust and crumb of the baked white bread. Concentrations of glyphosate residues from whole grain wheat to white bread decreased by a factor of 3.6.

Influences of hydrothermal and pressure treatments of bran on the quality and sensory attributes of whole wheat steamed bread and pancakes

F. MA (1,2), Y. Lee (1,3), E. Park (4), J. Kim (2,5), Y. Luo (4), S. R. Delwiche (4), B. K. Baik (1)

(1) USDA-ARS Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.; (2) Department of Horticulture & Crop Science, The Ohio State University, Wooster, OH, U.S.A.; (3) Rural Development Administration, National Institute of Crop Science, Suwon, Korea; (4) USDA-ARS Food Quality Laboratory, Beltsville, MD, U.S.A.; (5) Chonbuk National University, Jeonju, Korea

Whole grain products provide consumers with many nutritional advantages and health benefits; however, consumer acceptance of such products is still much lower compared to refined flour products, due to inferior product quality and taste. To mitigate the detrimental effects of wheat bran on whole wheat product quality and sensory attributes, we pre-treated wheat bran with autoclaving, roasting, jet-cooking, extrusion, puffing and high-temperature-high-pressure (HTHP) cooking, and determined the effects on whole wheat dough mixing properties, and on the quality and sensory attributes of a whole wheat dough-based product (steamed bread, SB) and a batter-based product (pancakes). Reductions in mixograph absorption of whole wheat meals (WWMs) by 1-6% were observed with all the pre-treatments of bran. The midline peak time (MPT) of WWM increased by 0.2 min with the extruded bran, whereas the MPT decreased by 0.1-0.5 min with the autoclaved, roasted or HTHP cooking bran. HTHP cooking of bran increased whole wheat SB volume and specific volume score by 65 mL and 4.0, respectively, but was detrimental to spread ratio score (SRS) and product flavor, texture and overall quality. When compared to the SB made with untreated bran, the extruded bran formulation improved crumb structure, SRS and springiness of whole wheat SB, and resulted in equivalent surface smoothness, stress relaxation score, chewiness, flavor, texture and overall quality. No apparent quality improvement of whole wheat SB was observed with autoclaving, roasting, jet-cooking and puffing of bran. Decreases in the batter flow, batter specific volume and pancake diameter of WWMs by 0.1-4.1 cm, 4.5-9.8 g/mL and 2.5-6.4 mm, respectively, were observed with all the pre-treatments of bran. Roasting, jet-cooking, extrusion and puffing of bran exhibited no positive effects on the sensory attributes of whole wheat pancakes, while autoclaving of bran improved the moistness of whole wheat pancakes, and resulted in comparable product flavor, texture and overall quality, when compared to pancakes made with untreated bran. For both SB and pancakes, roasting, puffing and HTHP cooking of bran exhibited detrimental effects on the product flavor, texture and overall quality. Extrusion and autoclaving of bran could be effective ways to improve the processing quality of whole wheat SB and the moistness of whole wheat pancakes, respectively. This information will help food manufacturers select an effective way to improve the quality attributes of whole wheat dough-based and batter-based products with high nutritional values.

Preparation of resistant starch-enriched cooked rice product by combination of rice types and cooking methods

H. R. Kim (1), A. R. Ryu (2), J. S. HONG (1), H. D. Choi (1)

(1) Division of Strategic Food Research, Korea Food Research Institute, Wanju-gun, Jeollabuk-do, South Korea; (2) Technical Service Center, Korea Food Research Institute, Wanju-gun, Jeollabuk-do, South Korea

Rice (*Oryza sativa* L.) is widely used in commercial food products where it is mainly consumed in the form of intact kernels after cooking with water. With recent interest on the increasing resistant starch (RS) content of food, lowering digestibility of rice has been challenged due to its high starch content and rather high GI value. However, to the best of our knowledge, there is no particular method yet for lowering digestibility of cooked rice when it is consumed as intact grains. This study was aimed at developing a cost-effective and simple method to prepare RS-enriched cooked rice. Four types of rice, white and brown rices of normal or high amylose rice cultivar (*Saemimyeon*, 26.7% amylose content), were prepared. The rice (50 g) was soaked in 1.3-fold tap water for 30 min, cooked by conventional electronic cooker (100°C, 45 min) or retort type cooking (121°C, 30 min), and dried at 90°C for 4 h. The content of RS was analyzed using AACC method (Resistant Starch Assay Kit, Megazyme) after grinding. High-amylose cultivar and retort type cooking resulted in higher RS content than normal rice and conventional cooking, respectively, while the degree of milling (white or brown rice) did not have a significant effect ($p > 0.05$) on the RS content. The combination of high amylose brown rice cooked by retort type cooking had the highest RS content (2.63%) among all treatments, and was chosen to investigate the effect of various additives. Addition of citric acid and soybean oil when the rice was soaked in water, significantly ($p < 0.05$) induced the formation of additional RS, while other food additives such as amino acids, mineral salts, or soluble fibers showed no positive changes. The most effective treatment was obtained by addition of citric acid up to 30-40 mg/mL per 50 g of rice, resulting in additional 2.9-fold increase of RS. Refrigeration storage did not change its RS content further. Overall, the RS-enriched cooked rice produced by this simple and easy method can possibly be utilized for convenience meal products or ingredient for rice flour-based products requiring low-GI properties.

Evaluation of pasting and gelling properties of commercial flours under high heating temperatures using Rapid Visco Analyzer 4800

T. Z. YUAN (1), S. Liu (1), M. C. Reimer (2), C. Isaak (2), Y. Ai (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada; (2) Perten Instruments Inc., Winnipeg, MB, Canada

Rapid Visco Analyzer (RVA) is a rotational viscometer with temperature ramping capability, and it is widely used in the food industry to assess the performance of food ingredients. The existing models of RVA instrument in the market, however, can only be operated at a heating temperature up to 95°C, which thus cannot meet the needs of evaluating the behaviors of food ingredients under higher processing temperatures, such as in retorting and extrusion. In the present study, RVA 4800, the latest model of the instrument with high-temperature capability, was used to examine the pasting properties of commercial cereal (*i.e.*, hard and soft wheat, rye, brown and white rice, sorghum, normal and high-amylose maize), pseudocereal (*i.e.*, amaranth and quinoa), root (*i.e.*, tapioca), and pulse (*i.e.*, yellow pea and yellow lentil) flours at a heating temperature of 95-140°C. As the holding temperature increased, the pasting temperature and peak viscosity of most flours were not altered. Starch contents of the flours were positively correlated with their peak viscosities (p value < 0.01) at different heating temperatures, whereas protein contents showed the inverse correlations (p value < 0.01). Pulse flours exhibited more prominent peaks in the pasting curves at holding temperatures of 110-140°C, which could be explained by that the disruption of protein and fiber matrix allowed the starch granules to swell to a greater extent. In general, an increased breakdown viscosity, reduced setback and final viscosities were observed when the waxy and normal flours (starch containing 3.9-38.4% amylose) were pasted at higher heating temperatures, which could be attributed to thixotropic thinning and molecular degradation. In contrast, high-amylose maize flour (starch containing 78.2% amylose) exhibited an increased setback and final viscosity at elevated cooking temperatures due to the complete starch gelatinization. Consequently, high-amylose maize flour paste cooked at 140°C developed the firmest gel among all the flours. The different pasting and gelling properties of the commercial flours as revealed by RVA 4800 under different cooking temperatures will be meaningful for utilizing them to prepare diverse food products with enhanced quality and nutritional value.

Unraveling prolamin–polyphenol interactions through fluorescence quenching experiments

I. J. JOYE (1), J. W. Salamun (1), G. Davidov-Pardo (2), M. Corradini (3)

(1) University of Guelph, Guelph, ON, Canada; (2) California State Polytechnic University, Pomona, CA, U.S.A.;

(4) Department of Food Science, University of Guelph, Guelph, ON, Canada

In addition to the health benefits that have been ascribed to the consumption of polyphenols, these components also receive attention as quality improving components for food. However, their use as nutraceutical and quality-improving ingredients in food is often hindered by their incompatibility with the food matrix, such as low water solubility, chemical instability, and compromised bioavailability. Encapsulation of polyphenols in prolamin nanoparticles can overcome these issues. However, the optimization of polyphenol encapsulation within these nanoparticles to achieve high stability and efficient delivery requires to gain insights on the polyphenol-protein interactions. Fluorescence quenching experiments were used to study the interaction of polyphenols with a variety of cereal prolamins. Resveratrol and anthocyanins interacted with all different prolamins studied. Resveratrol *e.g.* had a higher binding constant for zein than for gliadin at 35°C. Analysis of the thermodynamic parameters suggested that resveratrol–gliadin binding mainly occurs through hydrophobic interactions while the binding with zein is predominantly mediated through hydrogen bonds. Similar experiments were performed on anthocyanins and prolamins. Different interaction types were also found for these anthocyanin-prolamin combinations. This information is crucial to rationalise ingredient selection and production of protein nanoparticles and microparticles for encapsulation, protection and release of polyphenols and potentially other bioactive compounds.

Vulnerability analysis using evidence-based traceability in the grain supply chain

R. SHARMA (1), C. R. Hurburgh (1), S. Chopra (1), G. Mosher (1)

(1) Iowa State University, Ames, IA, U.S.A.

The grain supply chain is a complex network of various supply chain participants—farmer, grain elevator, grain processor, distributor, and end-consumer. Each supply chain participant performs several activities supporting their underlying objectives. There is growing interest in traceability in the grain supply chain, to meet business transparency needs and consumer expectations. This presentation will analyse the approach of identifying critical traceability events (CTE) and corresponding key data elements (KDE). The CTE-KDE approach is evidence-based, it identifies and documents activities performed by each supply chain participant then assigns a set of information items to each critical event as KDE. For example; storage of grain is identified as a CTE performed under grain elevator, the necessary KDE will include- location of storage bin and supplier details. Also, the CTE-KDE approach is specific to traceability objectives. Some of the examples of traceability objectives are (i) documenting chain of custody; (ii) protecting brand integrity; (iii) meeting customer demands; (iv) ensuring fair global trade; (v) recording sustainability of processes across the supply chain. The CTE-KDE approach

requires verifiable data, and an ability to assess graduated levels of success based on data. Data amount and quality is often the weakness of software-driven traceability systems. This paper proposes the use of vulnerability analysis to predict levels of success in a given CTE-KDE situation. A vulnerability analysis model identifies, quantifies, and prioritizes the various factors responsible for reducing the efficacy of a system. Vulnerability analysis measures system attributes (data) relating to (i) frequency of occurrence; (ii) degree of impact of occurrence; and (iii) likelihood of detection. This paper applies vulnerability analysis as a standard method for identifying when and how a traceability system will fail. Vulnerability analysis of an evidence-based CTE-KDE framework accounts for complex interactions among supply chain participant's critical activities. The need for standard measures of evaluating traceability systems is clear. Such an analysis must restrict critical traceability events to be measurable events and key data elements to measurable system attributes.

“Super soft” wheat kernel texture

C. F. MORRIS (1), N. Kumar (2), M. I. Ibba (2), A. M. Kiszonas (1), J. M. Orenday-Ortiz (2)

(1) USDA-ARS WWQL, Pullman, WA, U.S.A.; (2) Washington State University, Pullman, WA, U.S.A.

Kernel texture in wheat is an essential aspect of flour quality and utilization. In general terms, there are three kernel texture classes that follow the presence, absence, and haplotype of the *Hardness* locus, which is comprised of the puroindoline a and b genes/proteins (Pina and Pinb). Wild type Pina and Pinb produce soft endosperm texture, with Single Kernel Characterization System (SKCS) phenotypes of ~25-30. However, a novel “Super Soft” kernel phenotype has been observed in both *Triticum aestivum* and *T. turgidum* subsp. *durum*. This phenotype is characterized by SKCS values as low as -9. A Super Soft white winter club line, SS163, was isolated and crossed to the soft white spring wheat cultivar Alpowa. A Super Soft spring-habit back-cross-2 (Alpowa recurrent parent derivative (‘BC2SS163’) was isolated, and crossed again to Alpowa; 40 selected progeny were advanced to the F6 and grown in head rows, and then grown in field plots the following year. In the F6, SKCS ranged from -2 to +21. In the F7, SKCS ranged from -7 to +4. Quadrumat break flour yields ranged from 52.5 to 66.7% and 48.1 to 60.1%, years 1 and 2, respectively, and were not well correlated with SKCS. ‘Normal’ soft varieties averaged 22.7 SKCS, and 49.6% break flour yield. Independently, a Super Soft phenotype was observed in durum wheat. An F6 RIL population was developed from the durum cultivar ‘Creso’ and a soft homoeologous recombinant line possessing the *Hardness* locus. GBS was performed on 426 RILs and identified major additive QTL on 3AL and 6AS. Complete grain, milling, flour, SRC, and baking trials are underway and will be presented at the annual meeting. Overall, results have advanced the understanding of the genetic inheritance, endosperm morphology, and functional quality associated with the Super Soft kernel phenotype. Current studies are working towards identifying the genetic basis and physical-chemical mechanism of the Super Soft trait.

Effect of chemical oxidizers and enzymatic treatments on dough rheology

P. TOZATTI (1), M. T. Nickerson (1), E. J. Hopkins (1), P. J. Hucl (2), C. Briggs (2)

(1) University of Saskatchewan, Saskatoon, SK, Canada; (2) Crop Development Centre, University of Saskatchewan, Saskatoon, SK, Canada

To overcome deficiencies in wheat quality, exogenous components can be incorporated to alter the functionality of the gluten proteins as a means to improve bread properties. These additives include chemical oxidizers, such as azodicarbonamide, ascorbic acid, and peroxides. However, the use of enzymes is attractive to the baking industry as an alternative to chemical oxidizers, as dough strengtheners, resulting in cleaner labels products (i.e., fewer ingredients). The quality parameters (proximate analysis, flour yield, gluten properties) and dough strength (i.e., empirical and fundamental rheology) of different wheat cultivars ranging in gluten strengths from weak (Harvest), intermediate (Lillian, CDC Plentiful and Stettler) and strong (Glenn) were analysed with the addition of chemical oxidizers (i.e., ascorbic acid, azodicarbonamide) or commercial enzymes (i.e., glucose oxidase and fungal xylanase). The overall goal of this study was to examine the effect of various chemical oxidizers (ADA, ascorbic acid) and commercial enzymes (glucose oxidase and fungal xylanase) on the dough handling properties of dough prepared using five different commercially grown hard red spring cultivars, representing a range of gluten strengths. The cultivar-type was observed to have a fundamental role in the results in relation to the oxidizers and enzymes used. Glenn showed better quality attributes compared to the other cultivars, and responded well to additives, especially glucose oxidase which significantly improved dough strength. Glucose oxidase also improved the dough handling of weaker cultivars. Overall, the addition of enzymes resulted in comparable dough handling perhaps to chemical oxidizers when added at 50 or 100% of the permitted levels, but no differences were seen as a function of concentration.

Morphological and molecular evolution of filamentous starch granules of banana ('Red Dacca') during fruit development

E. AGAMA-ACEVEDO (1), J. N. Reyes-Atrizco (1), J. D. Hoyos-Leyva (1)
(1) CEPROBI-IPN, Yautepec, Mexico

Unripe banana shows high starch content in the pulp, and among the banana varieties studied, "purple" banana (*Musa*AAA subgroup *Red dacca*) showed starch granules with filamentous shape. These granules are not a result of two or more starch granules fused together to form elongated starch granules, as observed in high amylose starch. Therefore, the aim of this work was to evaluate the morphological, structural and molecular evolution of main components in the development of this morphology. Starch was isolated from unripe banana fruits harvested at 6, 12 and 16 weeks after inflorescence emergence (6-SD, 12-SD and 16-SD, respectively). Morphology of the starch granules changed during development of the fruit, starting with semi-spherical shape (3.6 μm) at 6-SD, progressing to an oval shape (6.1 μm of width and 16.5 μm of length) at 12-SD, and then reaching filamentous shapes (6.9 μm of width and 24.3 μm of length) at 16-SD. Maltase cross in the filamentous starch granules corroborated that these are individual granules where the concentric rings are perpendicular to the direction of granule growing. The results of crystallinity percentage, temperature and enthalpy of gelatinization indicated that during evolution of the starch granule morphology, the molecular order was higher. The double helical structures, responsible of the internal packing of starch granules appeared when the filamentous starch granules are formed, which can decrease the hydrolysis rate. The amylose/amylopectin ratio did not change during development of the fruit, the length of amylose chains was heterogeneous at 6-SD, changing to homogeneous length at 16-SD. In contrast, the chain-length distribution of amylopectin showed that A, B1, B2 and B3 chains are simultaneously synthesized when the starch granule has filamentous shape and are not the result of the increase in the percentage of long chains (B2 and B3) as it was previously considered. Filamentous starch granules are produced due to evolutionary process originated by a modification in the disposal of the concentric rings from a radial to axial arrangement, leading the starch granule to increase in size just in one direction of the plane and transforming its shape from semi-spherical to filamentous.

Optimizing the functionality of carbohydrates for health enhancement through processing

Y. VODOVOTZ (1)

(1) The Ohio State University, Columbus, OH, U.S.A.

Over the years, refined carbohydrates have been associated with health-related adverse outcomes such as obesity, and diets that eliminate them are promoted for rapid weight loss. However, complex carbohydrates and prebiotic fibers are essential for providing energy and enhancing digestive and heart health. Therefore, the carbohydrate structure and function is key in understanding its potential impact upon health. Among carbohydrates, sucrose has been widely used in food preparation not only because promotes sweetness but also its functional properties. However, over-consumption of sucrose may result in serious health risks. Although non-caloric sweeteners have been extensively used to replace the sweetness in various food products, substituting the functionality of sucrose remains a challenge. To improve texture when utilizing non-caloric sweeteners, sugars are replaced by bulking agents such as maltodextrins resulting in products leading to hyperglycemia and hyperinsulinemia. Furthermore, food formulations containing starches result in products with high glycemic indexes. On the other hand, fibers exhibit good nutritional properties, but they are difficult to incorporate in large quantities in foods without affecting their textural properties. This presentation will describe carbohydrates whose functionality can be enhanced by processing to promote health benefits. Galacto-oligosaccharides (GOS) are non-digestible food ingredients that have been shown to increase populations of health-promoting species of gut bacteria and could be used to substitute sugars. A variety of GOS products can be produced, resulting in versatile ingredients with different GOS purity levels. Application of these GOS products in the U.S. is currently limited, and few studies have investigated the effect of the addition of GOS on physicochemical properties of foods. The effect of the addition of GOS on physical characteristics such as water sorption, thermal properties, glass transition of model foods such as candies are discussed in this presentation. Moreover, suitable physical and enzymatic modification of fibers can be used to improve their functionality for higher incorporation in food formulations. Physicochemical parameters used to characterize changes in fibers that favor their incorporation in foods are also discussed in this presentation.

Dietary fibers for specific targets in the gut microbiota

T. CANTU-JUNGLES (1)

(1) Purdue University, West Lafayette, IN, U.S.A.

Diet has an important role shaping function and composition of the gut microbial community. However, the most used prebiotic dietary fibers present variable effects when administered to distinct individuals. The overall microbial community composition and competitive pressures seem to dictate microbial response to easily accessible and fermentable dietary fibers such as fructooligosaccharides and inulin. We propose that the use of more complex dietary fibers to target specific gut microbes minimize gut bacterial competition for substrate and

thus, resulting in similar fiber response across different subjects. Dietary fiber characteristics that could increase specificity and promote a predictable and targeted modulation of gut microbes will be discussed.

The effects of extended hydration time on dry expanded pet food

E. W. MAICHEL (1), L. Keller (1), S. Alavi (1)

(1) Kansas State University, Department of Grain Science and Industry, Manhattan, KS, U.S.A.

Preconditioning in dry kibble pet food extrusion has always been a part of the process to produce a nutritional and palatable diet. One rule of thumb has been “The Longer, The Better”, but with economic and equipment concerns in consideration also. The usual hydration time has been the retention time of the preconditioner; time that material is in a preconditioner ranges from a few seconds to a few minutes, depending on the size of the conditioner. This study used three hydration regimes in the processing of dry expanded pet food using extrusion: I) water and steam addition in the preconditioner with no pre-hydration (control), II) pre-hydration for 30 minutes followed by only steam addition in the preconditioner and III) pre-hydration for 60 minutes followed by only steam addition in the preconditioner. Hydration regime I corresponded to “normal” processing and the raw material was at the usual moisture level of about 12% (wet basis) before entering the preconditioner. Pre-hydration (regimes II and III) resulted in less steam absorption during preconditioning, possibly due to less condensation and lack of contact of steam with water droplets. The resultant product however was lower in bulk density (401-426 g/L) and piece density (0.484-0.514 g/cm³) as compared to the control (457 g/L bulk density and 0.553 g/cm³ piece density). Regime III with greater pre-hydration time led to the highest expansion and lowest bulk and piece densities. The average crushing force (measured using texture analyzer under compression mode) was also slightly lower (24.0-24.4 kg-f) for product processed using the pre-hydration regimes as compared to the control (24.7 kg-f). Results indicated that pre-hydration might be an effective way to create a more extensible melt in the context of high protein pet food formulations, leading to greater expansion. This study has significance for the pet food industry as it provides a potential new tool for altering the physical properties such as expansion and texture of products and in turn impacting their palatability.

Effect of drying conditions on pasting properties of rice

S. G. ACQUAAH (1), T. Siebenmorgen (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

Commercial rice-drying operations involve the use of heated air to enhance drying rate. Greater drying-air temperatures may enhance drying rate without compromising head rice yield if rice is properly tempered. Such high-temperature drying and tempering conditions could, however, affect rice pasting properties. This study investigated the effect of drying conditions (air temperature and relative humidity, as well as drying and tempering durations) on changes in pasting properties of rice. The results showed that while drying air temperature appeared to have the most impact on the pasting properties of dried rice, the impact of air temperature could be compounded by how long the rice was tempered. Also, despite drying air relative humidity (RH) being a parameter of relatively lesser impact, its effect on pasting properties could be indirect as RH influences the duration that it takes rice to dry to a desired final moisture content. These results show that changes in rice pasting properties due to drying were not only dependent on the drying air temperature but also on how long the rice was exposed to a given temperature during drying and tempering. Further investigations into the impacts of drying treatments on rice functionality to ascertain the limits of drying in terms of impacting pasting properties of rice are being explored.

Rheological properties of starch nanoparticles from pea starch

H. DONG (1), T. Vasanthan (1)

(1) University of Alberta, Edmonton, AB, Canada

Pulse grain value-added processing activities are growing in Canada due to increasing demand for nutritive plant protein. Starch is the major by-product of pulse protein refining, and therefore finding novel applications to pulse starches by nanoparticulation technologies will positively impact the Canadian grain industry. Starch nanoparticles (SNP) were isolated from field pea starches as well as commercial corn and potato starches. The rheological properties, of the aqueous SNP suspension was investigated. SNP suspensions of 1-5% (w/v) were prepared and rheological tests at room temperature were performed using a rheometer. Viscosity was measured as a function of shear rate, where shear rates applied ranged from 0.01 to 100 s⁻¹ in an upward sweep followed immediately by a downward sweep from 100 to 0.01s⁻¹. Three sweep cycles were conducted consecutively in order to understand the thixotropic behavior of each sample. The frequency sweep test was employed to evaluate the changes in the viscoelastic modulus as a function of angular frequency ranging between 0.1-10 rad/s. The temperature ramp test was carried out to determine the relationship between viscoelastic modulus and temperature. Freshly cooked pea starch paste (3-5%, w/v) exhibited significantly lower viscosity and higher pseudoplasticity and thixotropy when compared to SNP suspensions at the same concentrations. Interestingly,

pea SNPs suspension showed an excellent non-thixotropic behavior, demonstrating the aptitude of the suspension to instantaneously recover from the applied stress or strain. This was further confirmed by their highly elastic character ($G' > G''$). Furthermore, SNPs from native starch showed low thermal stability (i.e. high heat sensitivity), indicated by the change of flow behavior as a function of temperature. This may be due to swelling, partial melting and solubilization of SNP upon heating. The data suggest that careful selection of processing conditions, such as heating temperature and shearing conditions, is required to achieve the target functionality of SNPs in food industry applications.

Rheological characterization of nixtamalized corn dough

S. BRYAN (1), G. Vericel (2), L. Bosc-Bierne (2), A. Dubat (2)

(1) Unity Scientific, Lenexa, KS, U.S.A.; (2) CHOPIN Technologies, Villeneuve la Garenne, France

Corn can be nixtamalized (soaked and cooked in an alkaline solution) for improving its nutritional value, flavor and aroma and for reducing mycotoxins. The nixtamalized corn is then grinded in order to obtain a dough (masa) which will be used to produce tortilla chips (nacho type). No satisfying rheological method is known to analyze nixtamalized corn dough. As a result, industrial producers face problems during process due to a lack of prior characterization. The objective is to find a rheological method able to analyze nixtamalized corn dough in a repeatable and discriminative way. Three nixtamalized corn doughs of various quality (good, medium and bad) were tested with the Mixolab. A specific tool called “dough kit” was used to directly analyze pre-made dough. A protocol called “Chopin+90g” has been applied. This protocol is similar to the standard protocol (AACC Approved Method 54-60.01) except for the dough weight (90 grams). All analyses were made in duplicate to evaluate the repeatability of the method. In order to evaluate the significance of the results, an ANOVA test coupled to an HSD interval of Tukey was used. The results showed this protocol allowed the assessment of nixtamalized corn dough: The repeatability results are very good given the low standard deviations obtained (0.07 in average taking into account all parameters and all samples). The statistical analysis proves that the method is discriminative: C2, C3 and C4 torques are parameters that allow to classify efficiently the different qualities of doughs. Finally, the results are consistent with the quality of the flours: when the dough is heated, the lower the torques, the better the sample process performances. For example, the lower the C3 parameter is, the better the behavior of the dough during process is (2.67 Nm for bad quality dough, 2.37 Nm for good quality dough). Rheological properties of nixtamalized corn doughs can be evaluated and the quality of such products can be predicted thanks to the Mixolab.

Resistant starch type 2 from high amylose cereal grains and its effect on glucose and insulin homeostasis

K. HARRIS (1)

(1) Bay State Milling Company, Quincy, MA, U.S.A.

Traditional grains are processed into a refined flour ingredient via milling techniques that remove the outer layers of a cereal grain and grind the starchy endosperm into an ingredient devoid of dietary fiber. The frequent use of refined grain flour in processed foods is contributing to the fiber deficient diet commonly followed in Western societies. Breeding techniques that modify the starch synthesis pathways within the cereal grain endosperm can cause downregulation and/or silencing of the starch branching enzymes, which subsequently yields high amylose starch granules. As a result, the processing of these high amylose grains creates a refined flour with both functionality and fiber benefits that can be used to make healthier processed foods. A review of the literature was conducted to study the effects of resistant starch type 2 derived from high amylose grains on acute and long-term measures of glucose and insulin response. High amylose corn is well-known within the industry of having beneficial effects on blood sugar management. In 2016, Ingredion’s high amylose cornstarch was approved for an FDA Qualified Health Claim due to its possible role in Type 2 Diabetes prevention. Studies conducted on high amylose wheat, rice, and barley are limited but do show health benefits for acute measures of glucose and insulin response. A recently published clinical trial reported a significant decrease in postprandial glucose and insulin response in healthy subjects who consumed 5.7 g of resistant starch from high amylose wheat compared to the 0.5 g resistant starch dose from common wheat.

Impact of protein/starch ratio on cat food palatability

P. GOZE (1), J. Rogues (1), A. De Ratuld (1)

(1) Diana Petfood, Elven, France

Cat kibbles are dry food products made of an extruded core base matrix coated with fat and palatability enhancers. Each year, thousands of new dry cat foods are launched worldwide with increasing diversity in varieties and formulas. Compared to dogs, nutritional requirements of cats do not differ in such an extent; indeed, adult cats have very similar weights with low limited breed effect and physiological variation according to life stages (except kittens and during gestation and lactation periods). A complete geometric analysis of macronutrient selection (Hewson-Hughes et al., 2011 – Waltham Institute) reveals that cats regulate the macronutrient composition of their diets towards a target composition: 52% of protein, 36% of fat and 12% of

carbohydrate. A first study was launched to collect the characteristics of 261 dry cat foods representative of the global market. Over 10,000 physico-chemical data and descriptive data such as range level, shopping country, composition and price were collected. Kibbles were then mapped according to their key physico-chemical attributes, macronutrient composition and palatability performance. To better understand this mapping, we focused on studying deeper the impact of protein/starch ratios. The main purpose of this work was to confirm the animal's preferences of the high protein diet evaluated by different palatability approaches, with limited variations in term of sourcing quality. Five cat formulas were designed based on the average physico-chemical data obtained from the mapping, with different protein/starch ratios, ranging from 25:45 to 45:25 (protein%:starch%). Fat content was set at a stable value. All kibbles were produced with the same manufacturing equipment targeting the same final moisture level, and coated with the same palatants. Kibbles were tested for palatability in cat expert panels with versus test and monadic testing. It allows an in-depth evaluation of the food's palatability performance by giving information such as food attractivity. All the results showed similar conclusions and confirmed that cats preferred high protein kibbles. Besides ratio, the impact of protein and starch origin and manufacturing process on cat food palatability and nutritional performance are still being investigated. The objective is to find the ideal balance between the matrix formula and the palatants to design the healthiest and most palatable kibble.

How does supercritical carbon dioxide and ethanol extraction influence the physicochemical properties of pea flour?

S. VATANSEVER (1), C. A. Hall III (1)

(1) North Dakota State University, Fargo, ND, U.S.A.

Dry pea (*Pisum sativum* L.) flour is a high value ingredient for incorporating into cereal-based foods for nutritional enhancement and for producing gluten-free foods. However, its undesirable flavor limits its usage in food market. To address this flavor issue, a novel and green approach, supercritical carbon dioxide + ethanol (SC-CO₂ + EtOH) extraction was used as a deodorizing method to improve organoleptic property of pea flour. Additionally, pea flour with different particle sizes (approximately 250, 150, and 106 µm) were investigated to illustrate their impacts on physicochemical properties. Physicochemical properties of pea flour samples, including two main effects (extraction and particle size), were investigated using approved official methods, Megazyme kits, rapid visco analyzer, and colorimetry. The flours had moisture, ash, protein and lipid contents (% , d.b.) between 2.09 and 10.1; 2.60 and 2.81; 20.84 and 26.51; and 0.42 and 1.92, respectively. Furthermore, total starch, resistant starch and damaged starch contents (% , d.b.) were between 34.97 and 55.37; 0.56 and 2.99, and 0.25 and 1.99, respectively. The extraction caused the reduction in moisture, resistant starch, damage starch, and lipids and proportionately increased total protein content. The extraction did not damage starch further. Water soluble index was significantly reduced for flours of different particle sizes, indicating that extraction had an adverse effect on protein solubility. The flour samples became lighter in color after the extraction due to removal of carotenoids present in pea flour. The flour with the largest particle size had significantly lower protein, total starch, and damage starch than flour with smallest particle size. The flour with particle size around 150 µm had the highest protein content while the flour with the finest particle size had the highest total and damage starch. Pasting properties of eight pea flours were also varied. After the extraction, the pasting temperature of flour samples increased slightly and decreased based on particle size. However, pasting time tended to increase after treatment. All viscosity parameters (e.g., breakdown, setback) of the flour with the finest particle size decreased significantly with the extraction but increased for the flour with the largest particle size. The SC-CO₂ + EtOH extraction along with different particle size flours caused differences in physicochemical properties of flour samples. Thus, these results support the use of treated flours in lower viscosity applications compared to non-extracted pea flour.

Pasta from pulses: Conventional extrusion or extrusion-cooking?

A. MARTI (1), A. Bresciani (1)

(1) Department of Food, Environmental and Nutritional Sciences, University of Milan, Milan, Italy

Nowadays, consumer demand for healthy foods with low environmental impact is growing. Pasta from pulses represents a potential solution that the food industry could offer to meet current consumer needs. Indeed, pulses are rich in fibre and proteins and are more sustainable than cereals. Moreover, the absence of gluten makes them suitable for people suffering from celiac disease and/or gluten intolerance. It is known that gluten-free pasta production from rice or corn is produced by conventional extrusion of pregelatinized flour (labelled here as process A) or by extrusion-cooking of native flour (process B). In the case of pulses, limited information is available regarding which technology is better (process A or B) to obtain a product with desirable quality. To answer this question, this work focused on understanding the relationship between raw materials and processing conditions and their effect on pasta quality. Pasta from rice and red lentils was prepared using two technologies. Process A consisted in a conventional extrusion of flour from pregelatinized grains, while process B involved extrusion cooking of native flour. The effect of processing on starch properties was assessed by measuring starch susceptibility to α -amylase hydrolysis (AACC Approved Method 76-31.01) and by evaluating pasting properties

(MVAG, Brabender). The weight-increase of cooked pasta, the loss of solids in cooking water and textural characteristics were evaluated. The pasta-making process significantly affected starch properties, promoting a high degree of gelatinization which was notable by the increase in starch susceptibility to α -amylase hydrolysis and by the decreased capacity to form a gel during the MVAG test. However, the extent of starch modifications differed according to the type of raw materials (rice and red lentils) used. This could be due to differences in composition (i.e. amount of fiber, starch, and proteins) and/or starch organization. Finally, both pasta-making processes were found to be effective in obtaining gluten-free pasta from either rice or red lentils. However, samples from process B resulted in pasta with a non-homogeneous structure, showing some non-hydrated points that might affect both water absorption and textural properties. Based on the results process A seems to be the more suitable process for producing pasta from red lentils.

Investigation and application of surface-enhanced Raman spectroscopy (SERS) for high-throughput analysis of pesticide residues in animal and human foods

K. M. LEE (1), D. Yarbrough (2), M. Kozman (2), T. J. Herrman (1), D. Kurouski (2)

(1) Texas A&M AgriLife Research, College Station, TX, U.S.A.; (2) Texas A&M University, College Station, TX, U.S.A.

Surface-enhanced Raman spectroscopy (SERS) was investigated to explore a possibility of Raman technique as an efficient and simple analytical tool for high-throughput analysis of pesticide residues in grain-based animal and human foods. In this study, animal feeds were spiked at different concentration ranges of chlorpyrifos (0.0-20 mg/kg) and aldicarb (0.0-100 μ g/kg). The pesticides were extracted from the spiked animal feeds using a series of extraction media. Gold nanoparticles for SERS measurements were prepared and mixed with 10 μ L sample extract and 3 μ L 1% NaCl solution to collect Raman spectra. SERS spectra of sample extracts were further preprocessed to develop the chemometric models for classification of pesticide-spiked samples and quantification of pesticides in the sample extracts. Average normalized Raman spectra representing four different concentration groups of each pesticide showed a distinctive difference in Raman signal intensity, which tended to be in proportional to a concentration of feed samples spiked with different levels of pesticides. The chemometric classification models developed and validated showed acceptable correct classification rates in the ranges of 66.7-100% for chlorpyrifos and 70-100% for aldicarb. It is noteworthy that any chemometric models applied to validation datasets didn't misclassify the samples contaminated with the selected pesticides as pesticide negative (false negative). The quantification models including multiple linear regression (MLR) and partial least squares regression (PLSR) showed a good quality of linear regression with a coefficient of determination of 0.865 and 0.861 for chlorpyrifos and aldicarb, respectively. The slope of the regression curve was close to 0.9 and the prediction errors (RMSEP) were smaller for both pesticide samples (2.92 mg/kg for chlorpyrifos and 11.53 μ g/kg for aldicarb). As a result, the values predicted by the developed models were not significantly different with those of a reference method (GC-MS) at a significance of $P < 0.05$. RPD (the standard error of cross-validation against the standard deviation of the reference values) values of the MLR models were 2.13 for chlorpyrifos, and 2.64 for aldicarb. The present study results clearly indicate that SERS spectroscopic method could be more ideal and promising analytical tool for high-throughput analysis of grain-based feeds and foods contaminated with pesticides than most analytical methods commercially available in the market. The proposed method can serve as a powerful and valuable screening tool for risk management of food and feed safety on the market.

Antioxidant phytochemicals in peanuts and their sprouts

H. CORKE (1), R. Gan (1)

(1) Shanghai Jiao Tong University, Shanghai, China

Peanut (*Arachis hypogaea* L.) is a popular edible seed and its sprouts provide a fresh vegetable rich in natural antioxidants. Diverse peanut varieties are cultivated in China, but there has been little work on the effect of germination on antioxidant phytochemicals in Chinese peanut cultivars. In this study, we evaluated the total phenolic content (TPC), total flavonoid content (TFC), antioxidant activity, and phytochemical profiles of selected Chinese peanut cultivars and their sprouts. Antioxidant phytochemicals varied widely in the seven selected peanut cultivars. Cultivar *Xiao-shi-li-hong* had the highest TPC and antioxidant activity, and 45 phytochemical compounds were tentatively identified in it using ultra-high performance liquid chromatography-quadrupole time-of-flight mass spectrometry (UPLC-QTOF-MS). Germination overall significantly increased TPC, TFC, and antioxidant activities in peanut cultivars. Sprouts from cultivar *Xiao-shi-li-hong* again had the highest TPC and antioxidant activity, with 36 phytochemical compounds tentatively identified, most of which were flavonoids. These findings highlight the value of peanuts and their sprouts as good natural sources of antioxidant phytochemicals for human consumption and functional food development.

Physicochemical properties of Canadian high- and low-tannin faba beans (*Vicia faba* var. *minor*) with sprouting treatment

J. HAN (1), S. P. Johnston (1), A. Buchko (1), M. Sigvaldson (1), P. Soladoye (1), R. Akkad (2), J. M. Curtis (2)
(1) Food Processing Development Centre, Alberta Agriculture and Forestry, Leduc, AB, Canada; (2) University of Alberta, Edmonton, AB, Canada

Faba bean (*Vicia faba* var. *minor*) has been grown in Canada since the early 1970s, but in recent years, production of faba bean has seen rapid growth in the Canadian prairies due to its agronomic and nutritional merits. Canada grows a dozen cultivars in two types of faba beans, high- (or regular) tannin and low-tannin. Due to their high protein, folate and manganese contents, the faba bean has huge potential to be used in various food applications. Two varieties each of high- and low-tannin faba bean types were studied for their physicochemical and sensory characteristics before and after sprouting treatment. An increasingly popular trend of sprouting grains, as a vehicle for enhancing nutritional and enzymatic characteristics, the process offers the potential to ameliorate faba beans as a food ingredient. Profiles of three enzymes (i.e. α -amylase, protease and lipoxygenase) activities as well as anti-nutritional compounds content, including vicine and convicine, in faba beans before and after sprouting treatment were studied. Lipoxygenase activities significantly decreased ($p < 0.05$) in all varieties after sprouting whereas tannins and α -amylase activities, specifically in the high-tannin varieties, generally decreased compared to untreated samples. Although values were not significantly different ($p < 0.05$), protease activities generally increased in all varieties compared to untreated samples. No significant differences ($p < 0.05$) were found between sprouted and untreated faba bean samples for vicine and convicine although vicine content was approximately 20-39% higher in the low-tannin samples while convicine contents in both high-tannin and low-tannin varieties were similar. Whilst the low-tannin faba beans were generally perceived to have less beany flavour/aroma compared to high-tannin ones, a trend for reduced beany flavour/aroma was observed with sprouting treatment. Similarly, a higher sweet and savoury taste was observed in sprouted high-tannin varieties. Sprouting significantly reduced the distinct split pea flavour and aroma in the both low-tannin and high tannin varieties. Further investigation of nutritional and enzymatic properties, as well as characterization of aroma and flavour, in sprouted faba beans is also ongoing.

Cricket flour, analytical tools and bread making

A. DUBAT (1), L. Bosc-Bierne (1), G. Tawil (1), O. Le Brun (1), P. T. Fleury (2)
(1) CHOPIN Technologies, Villeneuve la Garenne, France; (2) LEMPA, Laboratoire National de la Boulangerie Pâtisserie, Rouen, France

According to the United Nations, Food and Agricultural Organization, insects such as crickets, mealworms and grasshoppers are nutritional powerhouses. Rich in proteins, low in lipids and sugars, flours made from insects are an excellent way to improve the nutritional composition of the cereal products. However, those products will certainly have an impact on the rheological properties of dough and on the final product. The first question was to know if all cricket flour were performing in an equal manner. Tests conducted on an adapted Mixolab protocol showed evidences that analysis “pure” cricket flour is possible, the analysis is repeatable and allows discrimination between lots and, even more, between providers. The second part of the study consisted in measuring the breadmaking behavior of blends consisting of standard flour (French-baguette type) and cricket flour. Eight blends were created ranging from 0% cricket flour to 10% cricket flour. Breadmaking tests were done at LEMPA and rheological analysis (Mixolab and Alveolab) at CHOPIN application laboratory. Results showed that the acceptable maximum percentage of cricket flour for breadmaking is 2.5% above this limit, dough lacks elasticity, volume is drastically reduced, color is to reddish and smell is strongly impacted. Same trends were observed on both laboratory tools, with big impacts on extensibility, stability, starch gelatinization, among other indicators. The conclusions of this study are that Insect flour use in French bread-making, without altering the dough machinability or organoleptic quality of the finished products, is possible if not exceeding a certain amount. The use of Alveograph and Mixolab can help define and adapt this limit according to the respective quality of cricket and wheat used flours.

Biochemical components of wheat grain associated with endosperm detachment from bran and flour yield

T. JI (1), F. Ma (1,2), B. K. Baik (3)
(1) USDA-ARS Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.; (2) Department of Horticulture & Crop Science, The Ohio State University, Wooster, OH, U.S.A.; (3) USDA-ARS-CSWQRU Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.

Although flour yield is of great concern to wheat millers, an understanding of the grain traits that influence flour yield is still lacking. Endosperm separation from bran during roller milling, expressed by the proportion of remnant endosperm, was identified as one of the major factors influencing the flour yield potential of wheat grain in our previous study. However, little is known about the endosperm characteristics governing its detachment from bran during roller milling. The objective of this study was to identify the biochemical characteristics of the outer endosperm (OE) associated with endosperm separation from bran during roller milling, and subsequently

with flour yield. The biochemical compositions of the OE, flour and bran of ten SRW wheat varieties exhibiting a large variation in flour yield were determined and their relationships to flour yield were examined. Wheat grain was milled to obtain flour and bran using a modified Quadrumat Senior experimental milling system. The OE was obtained by further passing the bran through the break-roll unit three times. The flour yield of ten soft red winter wheat varieties ranged from 66.7 to 75.9% and 1.7 to 3.7%, respectively. The protein, starch, arabinoxylan (AX), and phytate contents of the OE ranged from 12.6 to 18.4%, 60.2 to 67.3%, 1.7 to 2.1%, and 0.2 to 0.4%, respectively, among the ten varieties. The ash, water-soluble AX, water-insoluble AX and beta-glucan contents of the OE ranged from 0.6 to 1.1%, 0.3 to 0.6%, 1.2 to 1.7%, and 0.3 to 0.5%, respectively. The ash, water-soluble AX, water-insoluble AX, and beta-glucan contents of the OE exhibited significant relationships with flour yield at $P < 0.01$, $P < 0.05$, $P < 0.01$ and $P < 0.01$, respectively. Wheat varieties showing a flour yield higher than 75% were higher in ash, water-insoluble AX and beta-glucan contents of the OE than the varieties with a flour yield lower than 68% by averages of 0.3, 0.3 and 0.2%, respectively. The ash and water-soluble AX contents of flour also exhibited significant relationships with flour yield at $P < 0.01$. The water-soluble AX, water-insoluble AX and beta-glucan contents of the OE seem to influence endosperm separation from bran during roller milling of wheat grain. Outer endosperm that is low in water-soluble AX, and high in water-insoluble AX and beta-glucan, may facilitate efficient detachment of endosperm from bran during roller milling, positively contributing to flour yield.

Impact of pre-harvest glyphosate use on wheat protein composition

S. SIMSEK (1)

(1) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Pre-harvest aids are used to encourage uniform crop maturation and timely harvest. During wheat cultivation, pre-harvest aids are recommended to be applied a week prior to harvest, during the ripe stage of physiological maturity. At times, some grains may not be at this stage due to non-uniform maturation. In this context, the goal of this study was to determine the effect of pre-harvest aid timing on the chemistry of wheat gluten proteins and shikimic acid accumulation. For this purpose, a greenhouse study was conducted where pre-harvest aid was sprayed at soft dough and ripe stage to wheat cultivar 'Glenn'. For the control samples, water was sprayed instead of the pre-harvest aid at the same developmental stages. Samples were collected prior to spraying and every three days until harvest. Whole wheat flour samples were then analyzed for amino acid composition, secondary protein structure, gluten protein composition and molecular weight as well as shikimic acid accumulation. The results of the study indicated that pre-harvest aid application does not impact the amino acid composition, protein secondary structure and gluten protein composition. However, pre-harvest aid application decreased the molecular weight of SDS extractable and unextractable proteins, and significantly increased the amount of shikimic acid accumulation, especially when applied at soft dough stage. Thus, this study indicates that pre-harvest aids can cause significant differences in the physicochemical and functional properties of wheat gluten proteins by affecting the molecular weight of proteins, while significantly increasing the shikimic acid content in affected plants.

Varietal and location effects on antioxidant potential of pinto and black beans

A. M. MAGALLANES LOPEZ (1), J. Osorno (1), S. Simsek (2)

(1) North Dakota State University, Fargo, ND, U.S.A.; (2) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Dry beans have a high concentration of phytochemicals, which can act as antioxidants. Therefore, the consumption of dietary antioxidants from dry beans may reduce disease risk. The aim of this research was to determine the metal chelating ability and antioxidant potential of phenolic extracts of three varieties of pinto (Lariat, Monterrey, and ND-Palomino) and black (Eclipse, Zorro, and Loreto) beans. Beans were grown in 2018 at Forest River, Hatton, and Prosper, in North Dakota. Extractable phenols were extracted with acidified methanol-water (50:50) and acetone-water (70:30). Phenolic content was measured by Folin-Coilteau reaction. Metal chelating activity was measured by reaction with ferrozine. Antioxidant properties were studied by free radical scavenging assay (ABTS), and free reducing antioxidant power (FRAP). Loreto had significantly ($p < 0.05$) lower extractable phenols (5.1 mg GAE/g), significantly ($p < 0.05$) higher metal chelating activity (8.1 mg EDTA eq/g), and significantly ($p < 0.05$) higher antioxidant capacity than the other black beans. Among pinto bean varieties, Monterrey had significantly ($p < 0.05$) higher extractable phenol content (6.3 mg GAE/g), and antioxidant capacity (ABTS 10.4 mg TROLOX eq/g, FRAP 7.0 mg TROLOX eq/g). Growing location had a significant ($p < 0.05$) impact on extractable phenols and antioxidant capacity of pinto beans. Whereas, for black beans location did not significantly ($p < 0.05$) impact extractable phenols, but there were some significant ($p < 0.05$) differences in antioxidant capacities. Overall, growing location may have minimal effect on antioxidant potential of black beans, but location may need to be considered in order to maximize antioxidant potential of pinto beans. These results suggest potential to enhance antioxidant capacity from the intake of black beans grown in North Dakota.

Using consumer sensory evaluation to compare dietary fibres in enriched breads for Ontario schools

R. WHITE (1), L. Duizer (1), I. J. Joye (1), D. El Khoury (1)

(1) University of Guelph, Guelph, ON, Canada

The discrepancy between recommended and actual fibre consumption in Canadian diets is reported as the Fibre Gap. Current high-fibre bread products are poorly accepted by children and adolescents compared to refined bread products due to poor texture and increased bitterness. To bridge this gap and increase functionality to partially-baked (par-baked) bread products, dietary fibres from Ontario-grown crops (barley, flaxseed, and quinoa) were formulated into bread products aligning with recommendations in the Ontario School Food and Beverage Policy. Bread was prepared according to the American Association of Cereal Chemistry method for Optimized Straight-Dough Bread-Making (AACC Approved Method 10-10-03). Bread loaves enriched with the above dietary fibres were developed, containing 4% dietary fibre per serving. Fibre from barley and quinoa was extracted using an aqueous enzyme-assisted method, while flaxseed fibre was simply extracted with water. After extraction, the fibre fractions were freeze-dried. All bread loaves were prepared one day before the sensory panel and kept in an air-tight wrap until serving. A consumer panel (n = 45) measured liking and preference for the enriched and control bread products. The four samples were presented in randomized order, labeled with three-digit blinding codes in isolated booths under white lights. The samples were cut into uniform 2 cm slices with the top crust. Filtered tap water was used as a palate cleanser between samples. Overall appearance, texture, and taste were evaluated on a 9-point hedonic scale where 1 was “extremely dislike” and 9 was “extremely like”. 5-Point Just-About-Right (JAR) scales measured liking of outer crust appearance, crumb texture, and crumb moisture. A ranking scale measured overall preference where 1 was “most liked” and 4 was “least liked”. From an appearance and taste perspective, barley and flaxseed samples were not significantly different from the control. Quinoa-enriched loaves, however were liked significantly less than the control loaves with scores of 4.2 and 4.8, respectively. For texture, the flaxseed bread had the highest liking (7.2) and was even liked significantly more than the control product. Similar results were observed for ranking tests where flaxseed was liked the most and quinoa was liked the least. JAR scales provided insights for specific attributes of the bread samples. Results will be used along with further sensory measures that characterize bread loaves for selecting which enriched par-baked bread products to present at an in-school consumer sensory panel. This will work to gauge adolescent’s preferences and nutrition attitudes towards fibre-rich foods to help bridge the Fibre Gap.

Application of CRISPR gene editing in wheat

S. PEARCE (1)

(1) Colorado State University, Department of Soil and Crop Sciences, Fort Collins, CO, U.S.A.

Genome editing tools, such as CRISPR/Cas9, provide the unprecedented ability to induce specific changes to an organism’s DNA. In crop breeding, CRISPR can be used to rapidly introduce beneficial genetic variants and thus has enormous potential to accelerate the development of improved varieties. Numerous genes have already been edited in wheat and barley and the possibilities for future applications are rapidly expanding as genomic analyses uncover genes associated with traits of interest. In order to fully realize the potential of CRISPR in agriculture, it will be necessary to overcome technical challenges, such as the efficient application of CRISPR in elite varieties, and for this technology to be accepted by consumers.

Effect of amphiphilic polysaccharides on 3-deoxyanthocyanin stability in a beverage model

J. F. BRANTSEN (1), J. M. Awika (1)

(1) Texas A&M University, College Station, TX, U.S.A.

3-Deoxyanthocyanins (3-DXA) from sorghum have great potential as natural food colors because of their unique stability to heat, high pH, and various additives, compared to anthocyanins. However, the lack of substitution on C3 increases 3-DXA hydrophobicity, resulting in rapid self-association in aqueous solutions. The objective of this study was to determine the effect of amphiphilic polysaccharides on the stability of 3-DXA in a model beverage. Beverage solutions were made by solubilizing DE (degree of esterification) 38-86 pectin or gum Arabic (0.5 g/L) with 3-DXA in citrate buffer (pH 3). Ascorbic acid (0.5 g/L), sucrose (65 g/L), and preservative (0.15 g/L sodium benzoate) were added before pasteurizing at 95°C for 10 min. Solutions were then stored for 5 days at 25°C. Absorbance spectra were recorded with an UV-Vis spectrophotometer. After pasteurization, 3-DXA color retention was greater (50-80%) in solutions with polysaccharides compared to solutions without polysaccharides (40%). With DE ≤ 54 pectin, 73-78% of 3-DXA color was preserved, compared to 61% with DE 86 pectin and 48% with gum Arabic. After 5 days of storage, 3-DXA color was similarly preserved to the greatest extent with DE ≤ 54 pectin (71-75%) compared to DE 86 pectin (48%), gum Arabic (33%) or with no polysaccharide added (23%). The structure of the polysaccharide affected 3-DXA color, with lower DE pectin conferring a greater protective effect on 3-DXA color. This could be driven by hydrogen bonding between pectin and 3-DXA that is likely greater with lower DE pectin compared to higher DE pectin or gum Arabic. Polysaccharides overall reduced 3-DXA color loss in a model beverage, potentially expanding the usability of these pigments as natural food colors.

Using polyphenol–protein complexes to alter rheology/end-use properties

O. H. CAMPANELLA (1), M. Ferruzzi (2)

(1) The Ohio State University, Columbus, OH, U.S.A.; (2) Plants for Human Health Institute, N.C. State University, Kannapolis, NC, U.S.A.

Polyphenols are products derived from plant sources and extracts such as tea, apple, cocoa and grape, to name a few. Given their recognized positive benefits to human health their incorporation in processed foods is continuously expanding. However, as more foods are formulated the potential of interactions between polyphenols and food components such as proteins and polysaccharides may alter not only the polyphenol bioavailability but also the physical/chemical properties of the foods associated to their texture. These interactions include those that promote cross-linking of proteins, gelatinization of starches, and can potentiate the formation of macronutrient-polyphenol complexes with multiple effects, often associated with enhancement of polyphenol benefits. However, studies have also shown that indigestible or insoluble complexes between polyphenols and proteins or fibers may be formed, limiting the beneficial nutritive value of foods, and potentially reducing polyphenol. There are several factors that govern the interaction of polyphenols and food components, which include the chemical structure of the polyphenols, the type and structure of the food matrix (protein, carbohydrate and lipids) and conditions such as pH, ionic strength, temperature and concentration, thus insights to better control the activity of polyphenols in food are needed. Specifically, the effects of interactions of proteins and carbohydrates with selected flavonoids will be discussed.

Effects of sodium bisulfate (SBS) and pH on survival of Shiga-toxigenic *Escherichia coli* (STEC) during tempering of wheat

A. DELIEPHAN (1), J. Dhakal (1), G. Aldrich (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

Recent disease outbreaks from Shiga-toxigenic *Escherichia coli* (STEC) strains (O121, O26) in the US have been associated with contaminated wheat flour. As wheat milling does not involve any lethality steps to control pathogen contamination, antimicrobial intervention steps in wheat tempering could potentially minimize microbial loads. Sodium bisulfate (SBS) is a known antimicrobial agent with strong acidic properties, but there is no available information relating its microbicidal effects and pH. The objective of this study was to investigate the effects of SBS and pH in reducing STEC contamination in wheat during tempering. In a previous study, the minimum inhibitory concentration of SBS required to inhibit the growth of STEC surrogate *Escherichia coli* ATCC 1427 was determined as 0.25%. Hard red winter wheat was inoculated with *E. coli* (~10⁶) and tempered to 16% moisture (wet basis) using the following concentrations of SBS solution in water (w/v): 0.25%, 0.5%, 1%, 5%, 10%, 15%, or 20%, along with a control treatment. The treated wheat was incubated for 1 h at 37°C, and the pH was measured by diluting the samples in deionized water at a ratio of 1:10 by weight. The *E. coli* counts were enumerated by spread-plate method using tryptic soy agar. Logarithmic reductions of the bacterial counts were calculated and the treatment means were separated using Tukey's studentized range test. Tempering water pH of 2.4, for 20% SBS solution, resulted in the highest reduction ($P < 0.05$) of 2.8 log colony forming units (CFU) per gram in *E. coli* counts when compared with the control pH of 7.0, with a bacterial count of 6.2 log CFU/g. However lowering the pH below 6.0 did not affect the log reduction of bacterial counts. These results suggest that tempering of wheat using SBS solution at pH levels below 6.0 could potentially control STEC contamination during wheat processing prior to flour production.

Effect of soluble dietary fibre extracted from barley on mixing properties, dough rheology and water mobility

N. V. PATHIRANNEHELAGE (1), I. J. Joye (1)

(1) University of Guelph, Guelph, ON, Canada

The consumption of dietary fibre by the Canadian population, despite its association with a range of health benefits, is well below the recommended intake levels. One of the reasons cited by consumers for the low intake levels of dietary fibre is the perceived lower palatability of fiber-rich products. The aim of this study was to gain insight in the molecular interactions and structures in dough and bread as affected by the substitution of part of the wheat flour with enriched dietary fibre fractions. In this abstract, focus will be laid on the evaluation of the effect of dietary fibre rich in beta-glucan on dough and bread properties. A beta-glucan rich dietary fibre fraction (BDF) was obtained from barley wholemeal using an aqueous enzyme-assisted extraction procedure. Dough samples were substituted with 4.0, 6.0 and 8.0 w/w% extracted BDF. Water absorption and mixing characteristics were determined using farinograph and mixograph analysis, respectively. Freezable water content (DSC), water mobility using T₂ relaxation times (NMR) and dough rheology were also evaluated. BDF substitution of flour led to a significant increase in water absorption and peak mixing time in farinograph and mixograph analyses, respectively ($p < 0.05$). Increasing BDF substitution levels reduce the freezable water content significantly: the percent reduction in freezable water content was 14.0%, 17.2% and 22.4% for 4.0%, 6.0% and 8.0% BDF

substitution levels. T_2 relaxation times of dough samples also showed a significant reduction with increasing BDF substitution level. Dietary fibre rich in beta-glucan causes changes in dough viscoelastic properties: increasing BDF substitution levels led to an increase in storage modulus (G') and a reduction of $\tan \delta$ pointing to a more pronounced elastic behavior of dough made with BDF. Bread volumes were also reduced with increasing BDF substitution levels. Addition of water to the dough recipe exceeding the farinograph water absorption level results in a noteworthy reduction of G' and a concomitant increase of the specific loaf volume of the resulting bread products.

Optimization of pretreatment conditions for corn germ meal to develop a model hydrothermal pretreatment process for lipid producing energy crops

Y. JIA (1), D. Kumar (1), B. S. Dien (2), V. Singh (1)

(1) University of Illinois Urbana-Champaign, Urbana, IL, U.S.A.; (2) USDA ARS NCAUR, Peoria, IL, U.S.A.

Large-scale availability of low-cost oil feedstocks is a major hurdle in the commercial success of economically viable renewable fuels. Through the efforts from the Center for Advanced Bioenergy & Bioproducts Innovation (CABBI), high yielding energy crops are being engineered to accumulate lipids, which would open the way for production of large quantities of vegetable oil per unit land. These crops, however, are still in an early stage of development. The challenge of utilizing these feedstocks depends on efficient recoveries of oil and cell wall saccharides, which can be converted to biofuels or chemicals. The low concentration of lipids in biomass would make it difficult and expensive to extract oil. The objective of this work is to investigate the approach of hydrothermal pretreatment to increase the oil concentrations and improve the saccharification of pretreated solids. Pretreatment of biomass would solubilize hemicellulose and partially remove lignin, producing oil-enriched solids that should be more amenable to efficient and inexpensive oil extraction. Corn germ meal, solid residues after oil extraction from corn germ, was used as a model feedstock. Germ meal contained 30.8% cellulose, 22.3% hemicellulose, 13.5% lignin, and 2.25% oil. The germ meal was pretreated at 20% solid loading at 160 and 180°C for 10 and 15 minutes using hot water. Composition analysis of raw and pretreated germ meal was performed using standard National Renewable Energy Laboratory (NREL) protocols. Pretreated liquid was analyzed to determine soluble sugars and inhibitory compounds. The oil concentrations in raw germ meal, pretreated liquid, and pretreated solids were determined using solvent extraction techniques [1]. The oil was analyzed for measurement of polar and non-polar lipids and their compositions. Raw germ meal and pretreated solids were hydrolyzed with cellulase enzyme to determine the effect of pretreatment on cellulose conversion. Through pretreatment, the oil concentrations in pretreated solids were increased to 4.88-9.13%, and 63-100% of hemicellulose were hydrolyzed and removed from the pretreated solids. Cellulose conversion during hydrolysis of pretreated germ meal ranged from 67 to 99%, significantly higher than untreated germ meal. The pretreatment conditions leading to maximum hemicellulose solubilization and minimum inhibitory compounds formation without negatively affecting oil quality, would be used to investigate saccharification and fermentation of germ meal in future work. **Literature Cited:** Huang, H., et al. 2017. Evaluation of the quantity and composition of sugars and lipid in the juice and bagasse of lipid producing sugarcane. *Biocatalysis and Agricultural Biotechnology* 10:148-155.

Effect of condensed tannins on rye and barley flour functionality

A. L. GIRARD (1), J. M. Awika (1)

(1) Texas A&M University, College Station, TX, U.S.A.

Tannins, especially condensed tannins (proanthocyanidins, PA), can strongly complex wheat gluten through hydrogen bonding and hydrophobic interactions, which alter gluten functionality. Barley and rye proteins are closely related to gluten, but do not have equivalent viscoelasticity. This study aimed to determine the effect of PA (mean DP = 19.5) on functionality of barley and rye flours. Flours were mixed with PA (0-25 mg PA/g flour) and assessed for dough extensibility (TA.XT2 Texture Analyzer) and starch pasting properties (Rapid ViscoAnalyser, RVA). Proanthocyanidin addition (2.5 mg PA/g flour) increased the force required to extend rye flour dough by 34% and increased extensibility by 19%. Similarly, previous work showed PA improved tensile strength of wheat flour doughs by complexing gluten proteins. PA had a negligible effect on barley dough extension properties. This suggests that, like wheat, rye storage proteins interact with PA, but at 2.5 mg PA/g flour, barley proteins were not significantly altered. Addition of 25 mg PA/g flour increased barley and rye flour RVA peak viscosity by 1.9 \times ; the increased viscosity during cooking suggests increased polymer size. Interestingly, rye flour, but not barley, had a viscosity increase beginning at \sim 60°C that plateaued (730 cP) before reaching the starch pasting peak viscosity (3,360 cP). This suggests rye prolamins are denaturing during the initial heating process, exposing hydrophobic amino acid residues for interaction with PA, similar to an observation we recently reported for wheat gliadins. The evidence suggests rye proteins interact with PA via mechanisms like those of wheat gluten proteins, but barley has different interaction mechanisms. PA may be a useful natural additive to improve dough strength and batter viscosity of rye products.

Introduction to modified starch: Examples, pros and cons

S. SIMSEK (1)

(1) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Native starch is a stabilizer and regulator in food products; however, some of its characteristics are limiting factors in its industrial food applications. The diversity of the modern food industry and the variety of food products require that starch be able to tolerate a wide range of processing techniques, storage, and final preparation conditions. These demands are met by chemical and physical modification of native starches. Chemical modification is often done by the treatment of native starch with small amounts of approved chemical reagents. Octenylsuccinic anhydride (OSA) esterified starch is one type of chemically modified starch obtained by esterification of OSA groups on repeating anhydroglucose units along the starch chains. Such modification imparts a partial hydrophobic character to the starch and weakens the internal bonding keeping the granules intact. OSA rice and tapioca starches were analyzed using microscopy, liquid chromatography and nuclear magnetic resonance (1H-NMR). The chain length distribution of amylopectin suggested that OSA groups were not present in the amylopectin portion of the starch. 1H-NMR analysis of pure amylose and amylopectin fractions indicated that OSA substitution was present only in amylose fractions of rice and tapioca starches. Esterification with 3% OSA results in starch that has OSA substituted mainly on amylose chains or possibly on amylopectin chains that have been hydrolyzed from the amylopectin molecules during esterification. Another mechanism for starch modification is physical modification; and is considered relatively simple, inexpensive and safe because it requires no chemicals or biological agents. It is more connected to the emerging concept of 'green chemistry' for environmentally friendly applications. In one study, effect of eight hydrothermal treatments on the properties of oat starch were studied. Treatments were selected based on heat treatment applications in oat industry. Oat flours were treated with boiling in ethanol, toasting, steaming and/or autoclaving. Oat starch was isolated from flours and the starch characteristics were determined. Amylose content ranged from 18.7 to 34.0% and was significantly ($P < 0.05$) different among treatments. Starch molecular weight was also significantly ($P < 0.05$) different among hydrothermal treatments. Hydrothermal treatment significantly ($P < 0.05$) impacted oat starch functionality by altering the gelatinization, pasting and retrogradation properties. Hydrothermal treatment impacted starch digestibility, and estimated glycemic index ranged from 68.4 to 100.4. Overall, chemical and physical modifications to starch can change their chemical and physical properties and result in substantial changes to their functional properties. These changes can increase their value and usefulness in many applications.

Arabinoxylan: A versatile cereal polysaccharide

S. SIMSEK (1)

(1) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

The plant cell wall, a complex network of non-starch polysaccharides, lignin and proteins, is the first barrier to pathogenic attack. Type II cell walls are rich in (glucurono-) arabinoxylans [(G) AXs, 20–40%] and mixed linkage glucans (10–30%), but contain only about 5% pectin. Non-starch polysaccharides in cereal cell walls mainly consist of (G) AXs. AX consists of a linear backbone of β -1,4 linked xyloses with some residues carrying either a single arabinose residue on C-3 or two arabinose residues on C-2 and C-3, and arabinose groups may be esterified with ferulic acid. AXs are divided into water extractable AX (WE-AX) and water unextractable AX (WU-AX), which comprise 25% and 75% of the AXs present in wheat flour, respectively. In contrast, corn AX are mostly soluble. Total AX contents of wheat, rye and corn bran are between 5-8%, 5-12%, and 30-40%, respectively. Biological source, growing environment and kernel tissue location influence the content and structure of cereal AXs. AX have important physiological roles in cereals and their structural features influence their functionality in this regard. Plant pathogens generally secrete enzymes in order to degrade plant cell walls. As part of the plant's defense mechanism, cereal grains synthesize polysaccharides, such as AX, which are resistant to hydrolysis. AX content in wheat is significantly ($P < 0.001$) influenced by the interaction of genotype and location. On the other hand, genotype had a significant ($P < 0.01$) impact on A/X ratio in wheat. In addition to importance in plant systems, AX play an important role in processing and end product quality, as well as, being an important part of human health and nutrition. AX an important part of dietary fiber content of cereal foods, and they can impact gut health and immunity. Gut microbes have evolved to contain enzymes, receptors and transporters that achieve degradation and utilization of AX, despite the complex and variable structures of AX from different sources. We have determined that the structure of AX can promote or hinder the growth of specific bacterial strains in the gut. AX can also serve as immunomodulators and our research indicates there are structure driven immunological properties for wheat bran derived AX. We have observed strong correlation between AX structure and production of IL-8 and TNF- α pro-inflammatory cytokines. Overall, cereal arabinoxylans are diverse polysaccharides which have important functions beginning with plant physiology, disease response and finally effecting human health.

The effect of genotype and environment on the asparagine content of peas

L. MALUNGA (1), S. Joseph (1), T. Warkentin (2), N. Ames (1)

(1) Agriculture and Agri-Food Canada, Winnipeg, MB, Canada; (2) University of Saskatchewan, Saskatoon, SK, Canada

The formation of acrylamide, a potential carcinogen, during food processing has been attributed mainly to the presence of its precursors free asparagine and reducing sugars. Therefore strategies to reduce asparagine concentration in grains have been persistently explored. However, limited data exist on the asparagine concentration in peas. The effect of genotype and environment on the asparagine concentration in peas was investigated in this study. Five genetically diverse pea cultivars were grown in 2 locations in Saskatchewan, Canada over 2 years (2016 and 2017). The asparagine concentration of ground pea flour was analyzed using ultra high-performance liquid chromatography. The mean asparagine concentration of peas ranged from 275 to 742 µg/g on a dry basis. Asparagine concentration was generally greater in peas grown in 2016 compared to those of 2017. Analysis of variance showed that the asparagine concentration in peas was significantly affected by genotype ($p < 0.0001$), year ($p < 0.0256$) and the interaction of year and location ($p < 0.0003$). Thus, breeding and/or agronomic strategies to mitigate the asparagine concentration of peas should be explored.

Development and evaluation of limited water soaking condition on the fortification of rice by parboiling

A. JANNASCH (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

Micronutrient deficiency disorders are widespread in predominantly rice-consuming countries, particularly in South Asia and Africa. Approximately 15-20% of the global milled rice is consumed in parboiled form. Accordingly, parboiled rice is an effective vehicle for micronutrient fortification without changing consumer eating habits and the existing infrastructure and technology in those countries would make it possible to produce fortified rice at a low cost. However, the conventional parboiling process consumes tremendous amounts of water during soaking, generating about 1-1.2 kg wastewater per kg of paddy. Disposal of untreated wastewater results in nutrient overload in soil and therefore presents a serious environmental concern. In this research, a limited water soaking method was developed and evaluated for the effectiveness of fortification and reduction of fortificant usage. The limited-water soaking was achieved by using vacuum packaging and soaking one part of rice in 0.5 parts of soaking solution. In contrast, the conventional parboiling process (excess-water soaking) uses one part of rice and two parts of soaking water. Rice was fortified with calcium (50 g/L), iron (200 mg/L) and their combination (50 g/L Ca + 200 mg/L Fe) along with a control (no minerals). The amount of wastewater and total solids in wastewater, milling quality, and mineral content of the fortified rice were determined. Results showed that limited-water soaking not only reduced the amount of effluent by 86% on average, but also the amount of total solids in wastewater by up to 82.6%. Fortified rice by limited-water soaking showed a similar head rice yield and mineral uptake as the conventional soaking. Calcium and iron content in head rice was increased by up to 1,000 mg/kg and 20 mg/kg, respectively. Rice simultaneously fortified with calcium and iron can contribute to 17% of the recommended dietary allowance (RDA) for calcium and to 31% (male) and 14% (female) of the RDA for iron per serving. In conclusion, the limited-water soaking method has great potential to reduce the cost of fortification and wastewater treatment without affecting milling quality and fortification efficiency.

Influence of particle size on the flow properties of bread flour

A. SUPRABHA RAJ (1), B. Zaitoun (2), R. Martin (3), K. Siliveru (3)

(1) Kansas State University, Manhattan, KS, U.S.A.; (2) Food Science Institute, Kansas State University, Manhattan, KS, U.S.A.; (3) Grain Science and Industry, Kansas State University, Manhattan, KS, U.S.A.

Differences in the particle size has been found to influence the physical, chemical, and flow properties of flour. The research is focused to study the effect of particle size on the flow properties of hard wheat flour. Hard red winter (HRW) and Hard red spring (HRS) wheat flours were sieved to three different fractions: <45 µm, 45–106 µm, and >106 µm. The samples were evaluated for physical (shape, bulk density, tapped density, true density, and angle of repose), chemical (proximate analysis), and flow (dynamic, bulk, and shear) properties. Bulk density of the fractions increased with increase in particle size; as was the tapped density. Highest value for angle of repose, 45.32° was reported for HRW 1 (i.e., <45 µm) followed by HRS 1 sample (44.42°). Bulk and tapped density of the powder were correlated to Hausner ratio (HR) and compressibility index (CI) to represent the flow parameters. HR of the fractions varied from 1 to 1.22. Samples with particle size <45 µm had relatively higher values of CI. These (HR and CI) flow indices indicate “excellent” flow characteristics to the fractions with larger particle size. The shape characterized by circularity (0.775–0.807) had no significant variation ($P > 0.05$) among particle sizes. Results indicated that HRS samples were more elongated than HRW samples. The flowability represented in terms of basic flow energy, stability index (SI), flow rate index (FRI), specific energy (SE) and conditioned bulk density varied across the particles. SI, SE and FRI of HRW 1 samples were 1.14, 11.87 and 1.43 respectively; higher than the counterparts. HRW 1 also reported the maximum wall friction of 24.05° among

samples. Flow function (ratio of major principal stress to ultimate yield strength) varied significantly ($p < 0.05$) among the flour fractions. The HRW(S) 3 were classified as “easily flowing” powder whereas HRW 1 samples were “very cohesive” as per the categorization based on flow function. HRW 1 samples also had higher values for cohesion and angle of internal friction. This indicate the potential for bridging/arch formation during discharge of the HRW 1 powder. In general, cohesion, ultimate yield stress and angle of internal friction of HRW samples were higher than HRS samples.

Gliadin nanoparticle formation through liquid antisolvent precipitation: A deeper look into its molecular mechanism

I. J. JOYE (1), M. Corradini (2)

(1) University of Guelph, Guelph, ON, Canada; (2) Department of Food Science, University of Guelph, Guelph, ON, Canada

Gliadin molecules are promising building blocks for colloidal systems that can be used for the protection and controlled release of bioactive and quality improving molecules in the functional food, cosmetics and pharmaceutical sector. One technique to produce these gliadin-based colloidal particles is liquid antisolvent precipitation (LAS). Despite the simplicity and versatility of the LAS particle production process, the underlying protein conformational changes and interactions are ill-understood and the process can be best-described as a black box. The objective of this study is, hence, to non-invasively monitor the (sub- and supra-) molecular changes gliadin undergoes during the particle production process. Hereto, steady-state fluorescence experiments using the proteins' intrinsic fluorophores, *i.e.* tryptophan and tyrosine, combined with dynamic light scattering tests were used to study gliadin behavior while steadily decreasing the solvent quality. A model of the changes occurring during particle formation was proposed. In comparison to globular proteins, gliadin did not undergo large unfolding processes, but rather aggregates into larger structures. This information is useful to advance the rational design of these gliadin-based colloidal particles beyond the current black box approach and empiricism. As such, novel routes for gliadin use in the functional foods sector may be opened up.

Determination of protein content in soybean meal using hyperspectral imaging

P. T. G. DANTES (1), C. R. Hurburgh (1)

(1) Iowa State University, Ames, IA, U.S.A.

Soybean meal is the second highly consumed animal feed ingredient next to corn. Protein and amino acid contents are the most important quality factors. Protein correlates well but not perfectly with amino acid composition. Non-uniform distribution and varying amino acid profiles have made protein content, and by inference amino acid contents, hard to measure. In this study, near-infrared (NIR) reflectance hyperspectral imaging (HSI) (SWIR microHSI™ from Corning, Inc.) was used to predict protein content of soybean meal and to show the distribution of protein content in a soybean meal sample. Total of 189 soybean meal samples with 10 regions of interest per sample were analyzed using a reflectance NIR HSI system in the 850 to 1700 nm wavelength. Mean spectra, which were preprocessed using standard normal variate, and reference % protein content measurements were the input data in the partial least squares (PLS) regression for model calibration. The final model achieved root mean square error (RMSE), R^2 and standard error (SE) of 0.699, 0.835 and 0.699, respectively. The model was then used to predict and visualize protein content distribution in a sample. The performance of the model for soybean meal protein content is relatively low as compared to NIR models for whole grains, but it is comparable with other NIR models for soybean meal. This study serves a precursor to the use of imaging technology to measure amino acid composition (*i.e.*, lysine, methionine, and cysteine) in soybean meal and other animal feed ingredients.

Phytoglycogen (PG) to enhance the solubility and in vitro efficiency of resveratrol

J. CHEN (1)

(1) Purdue University, West Lafayette, IN, U.S.A.

Resveratrol (RES)'s poor solubility leads to incomplete absorption and low bioavailability. An increasing number of studies have aimed at preparing novel RES delivery system for enhanced bioavailability through improving RES solubility and stability. However, in food application, there is a lack of all natural, food-grade and economically viable carrier to enhance RES solubility and bioavailability. Therefore, the aim of this study is to investigate the capability of phytoglycogen (PG), a naturally occurring and biodegradable dendrimer-like biopolymer, to improve RES water solubility and bioavailability. RES and PG were incorporated by co-solvent mixing followed with spray drying at PG/RES ratios ranging from (4/1, 10/1, 20/1 and 50/1). The obtained PG-RES solid dispersions were evaluated for RES solubility, crystallinity, PG-RES interactions and caco-2 monolayer permeation. Results showed that the instant solubility of RES reached 289.6 $\mu\text{g/mL}$ at PG:RES of 50:1 compared with 45.6 $\mu\text{g/mL}$ of RES alone. X-ray powder diffraction result suggested a significant reduction of RES crystallinity in RES-PG solid dispersion. FTIR spectra indicated the formation of hydrogen bond between RES and PG. For caco-2 cell monolayer permeation test, the results showed that PG-RES solid dispersion enhanced

the cellular membrane permeation of RES by 1.28 to 1.8 fold, which was associated with the improved solubility and stability of RES. The presented work indicates PG particulates may interact with RES through hydrogen bonding, and act as physical barriers that prohibit the recrystallization of RES. These interactions facilitate the incorporation of RES into the PG particulate, and therefore improves the dispersity of RES. This study showed that PG, a plant-based natural polymer, has promising potential to deliver poorly soluble food active ingredients.

Zinc retention in biofortified rice after parboiling and milling

V. TALEON (1), S. Gallego (2), J. C. Orozco (2), C. Grenier (3)

(1) International Food Policy Research Institute, Washington, DC, U.S.A.; (2) International Center for Tropical Agriculture, Cali, Colombia; (3) CIRAD, UMR AGAP, Montpellier Cedex 5, France

To improve the Zn status in deficient populations, biofortified rice varieties with higher zinc content are being developed. Rice is frequently parboiled in South Asia. Zinc retention after parboiling and milling at different degrees was evaluated in three biofortified and two non-biofortified rice genotypes using an inductively coupled plasma optical emission spectrometer. Zinc content of non-parboiled brown rice was 13.4–35.1 $\mu\text{g g}^{-1}$. After parboiling, zinc content in brown rice was 13.5–36.8 $\mu\text{g g}^{-1}$. Zinc content after $7.5 \pm 0.5\%$ degree of milling (DOM7) was 9.2–33.8 $\mu\text{g g}^{-1}$ (63.8–89.6% retention) for non-parboiled rice, whereas, for parboiled rice soaked at room temperature significantly lower values were observed 8.1–23.2 $\mu\text{g g}^{-1}$ (49.8–71.3% retention) ($p < 0.05$). Lower zinc retention was observed when the non-parboiled (54.0–80.0%) and parboiled (46.9–57.6%) grain was milled at 10% degree of milling. The differential of zinc content between biofortified and non-biofortified genotypes was significantly larger (8.0 $\mu\text{g g}^{-1}$) in milled rice (DOM7) compared to brown rice which had a differential of 6.0 $\mu\text{g g}^{-1}$ ($p < 0.05$). The distribution of zinc in the grain of biofortified rice evaluated was more homogeneous than in the grain of non-biofortified rice. In general, zinc from inner endosperm moved towards the outer layers during parboiling which was removed during milling. These results suggest that biofortified rice could provide higher zinc intake to populations that consume rice as a staple but the benefit of consuming biofortified rice could be negatively impacted by parboiling and excess milling.

Influence of tempering condition and mill type on whole grain flour milling in hard red spring wheat

J. B. OHM (1), L. Dykes (2), J. A. Anderson (3)

(1) USDA-ARS, ETSARC, Cereal Crops Research Unit, Hard Spring & Durum Quality Lab, Fargo, ND, U.S.A.; (2) USDA ARS ETSARC Cereal Crops Research Unit, Fargo, ND, U.S.A.; (3) University of Minnesota, St. Paul, MN, U.S.A.

Consumption of whole grain flour (WGF) is recommended due to health benefit. However, demand of WGF is limited due to low processing and end-product quality. Wheat flour quality is significantly affected by milling variables including wheat tempering condition and mill design, but few reports have been available regarding WGF quality in hard red spring (HRS) wheat. This research was performed to examine the influence of wheat tempering treatment on WGF quality characteristics when different milling procedures were used in HRS wheat. Wheat tempering treatments were combinations of three levels of moisture content (10, 13, and 16%) and three storage days (1, 2, and 3 days after tempering). The WGF samples were obtained by two experimental whole grain milling (EWGM) procedures using the Quadrumat Sr. and Udy mills. Kernel characteristics were examined using the Single-Kernel Characterization System (SKCS). Tempering moisture level (TML) was identified as a primary factor to influence most quality characteristics of WGF. The SKCS hardness parameters such as hardness index, peak force, and modulus of endosperm elasticity showed lower values as TML increased. However, damaged starch content of WGF increased as TML increased. The EWGM procedures showed a contrasting difference in particle size distribution of WGF samples. As TML increased, coarse particle fraction ($>0.25 \mu\text{m}$), which was mainly composed of bran particles, increased in WGF samples obtained from the Quadrumat Sr. mill but decreased in WGF samples from the Udy mill. Image analysis showed that mean bran particle size was larger for WGF samples obtained from the Quadrumat Sr. mill than those from the Udy mill. TML also had a significant effect on mixing characteristics analyzed using the mixograph. Specifically, mixograph peak time was significantly longer when TML was higher. WGF samples produced by the Udy mill showed higher starch damage and longer mixograph peak time when compared to those from the Quadrumat Sr. mill. Significant linear correlation coefficients appeared for starch damage ($r = 0.625$, $P < 0.001$) and mixograph peak time ($r = 0.759$, $P < 0.001$) between Quadrumat Sr. and Udy mills. These results indicate consistency between two milling procedures in evaluating wheat samples for starch damage and mixograph peak time. The EWGM procedure using a Udy mill is less laborious and time-consuming than the procedure using a Quadrumat Sr. mill. The results indicate that the EWGM procedure using a Udy mill might be used for the evaluation of WGF quality traits, including starch damage and mixing property for HRS wheat samples.

The Professor Torbert's story – A case study from the U.S.A.

E. ROCHEFORD (1)

(1) NutraMaize, West Lafayette, IN, U.S.A.

NutraMaize's variety of high carotenoid orange corn was originally developed by its cofounder, Professor Torbert Rocheford of Purdue University, as part of HarvestPlus' effort to help address vitamin A deficiencies in sub-Saharan Africa. While the original target was increasing its provitamin A carotenoid content, the process also produced significantly higher levels of xanthophyll carotenoids, resulting in lutein and zeaxanthin (L/Z) levels that are to 2-3× higher than those found in yellow corn (3-5 mg/100 g vs 0.8-2 mg/100 g, average 1.5 mg/100 g). Similar to global biofortification efforts, NutraMaize is now implementing its high carotenoid orange corn in the developed world in the hopes of impacting the health status of another at risk population—aging individuals with low L/Z status. L/Z have garnered significant attention for their health protecting effects, particularly against Age Related Macular Degeneration (AMD). NutraMaize has initiated this effort by launching a line of premium milled products under its own consumer brand “Professor Torbert's Orange Corn,” which is both introducing consumers to the benefits of orange corn, including its improved taste, as well as raising awareness about the broader global biofortification movement. With funding from an NSF STTR NutraMaize is also breeding new varieties specifically focused on developing yield competitive hybrids with increased L/Z concentrations (target 4-5× yellow corn) that can be used to deliver more L/Z to Americans through widely consumed food products such as breakfast cereal, tortillas, and snacks. Simultaneously, with funding from a USDA SBIR NutraMaize has demonstrated that orange corn can be used in poultry feed to significantly increase L/Z concentrations in egg yolks (2× yellow corn), which are already a widely consumed and highly bioavailable source of L/Z for Americans. Taken together, there is reason to believe NutraMaize's orange corn has the potential to help close the gap between current average L/Z consumption levels, and those associated with reduced risk for AMD (1-2 mg/d vs 6-12 mg/d).

Structure, function and evolution of starch binding domains

S. Janecek (1), F. Marecek (1), E. A. MacGregor (2), B. SVENSSON (3)

(1) Slovak Academy of Sciences, Bratislava, Slovakia; (2) 2 Nicklaus Green, West Lothian, U.K.; (3) Department of Biotechnology and Biomedicine, Lyngby, Denmark

The starch binding domains (SBDs) have been described in fifteen different families based on sequence similarity. The purpose is to compare individual SBDs from these different families with regard to binding specificity and binding site structure as well as domain architecture of the enzymes they are part of. The comparison is based on multiple sequence alignments and phylogenetic analysis. The three-dimensional structures illustrating the molecular interactions with the alpha-glucan ligands are shown either as determined experimentally by X-ray crystallography or nmr spectroscopy or as modelled. Experimental binding assays include SPR, pull-down, affinity gel electrophoresis, ITC and fluorescence difference spectrometry. The different families are all shown in one constructed comprehensive phylogenetic tree. They are combined with a host of different enzyme specificities including amylases, beta-amylases, glucoamylases of glycoside hydrolase families 13, 14 and 15 as well as enzymes of GH57, and glucosyltransferase family 5 (involved in starch biosynthesis), glucan water dikinases, protein phosphatases, lytic polysaccharide monoxygenases, AMP-activated protein kinase, and a number of different alpha-glucan binding proteins. Some SBDs have one and others have two binding sites. SBDs belong to carbohydrate binding module families 20, 21, 25, 26, 34, 41, 45, 48, 53, 58, 68, 74, 82 and 83. Of these three-dimensional structures are available except for CBM 45, 53, 74 and 82 and 83. The different levels of relatedness between the individual families and the significance of binding motifs will be discussed. This work is supported by The Danish Council for Independent Research | Natural Sciences (to BS) and the Slovak Science Grant Agency Vega (to SJ)

Extrusion solutions for meat alternatives

B. PLATTNER (1)

(1) Wenger Manufacturing Inc., Sabetha, KS, U.S.A.

In grocery stores and supermarkets plant-based meat products that replicate beef or chicken have become common. For a variety of reasons, many have chosen to reduce their overall meat consumption, but not everyone is willing to give up the texture and flavor of meat. As the consumer demand for these products has grown, the food processing industry has focused great effort in creating high quality, plant-based meat products. Some of these are extremely close to meat in texture, mouth feel, aroma, and flavor. Extrusion has long been used to produce a variety of textured protein products. They have been primarily used as meat extenders, been based on soy and wheat protein, and often have a negative connotation due to texture and flavor. The recent explosion of plant-based meat is partially driven by the developments in raw material technology to produce innovative protein concentrates and isolates that in turn create much higher quality final products from a texture and flavor profile. When combined with advanced extrusion technology, the resulting products have begun to truly mimic meat. Extrusion cooking has been defined as the “process by which moistened, expansile, starchy and/or

proteinaceous materials are plasticized in a tube by a combination of moisture, pressure, heat and mechanical shear. This results in elevated product temperatures within the tube, the gelatinization of starchy components, the denaturation of proteins, the stretching or restructuring of tractile components and the exothermic expansion of the extrudate.” When mechanical and thermal energy are applied during the extrusion process, the macromolecules in the proteinaceous ingredients lose their native, organized structure and form a continuous, viscoelastic mass. The extruder barrel, screws, and die align the molecules in the direction of flow. This realignment exposes bonding sites which lead to cross-linking and a reformed, expandable structure and is responsible for the chewy texture in fabricated foods. There are three basic extrusion platforms that can be utilized for creating texturized product. They include dry extrusion, high moisture extrusion, and a thermal process known as the power heater. Each of these methods create unique fiber structures so it is vitally important to understand not only the final application but how the properties of various ingredients, processing conditions, and ultimately the equipment specifications impact the final texture.

Sensitive and specific detection of buckwheat allergenic protein Fag e 2 in heat-processed food

Y. HARADA (1), M. Tsuna (1), H. Okusu (1)

(1) Nippon Flour Mills Co., Ltd., Kanagawa, Japan

Buckwheat (*Fagopyrum esculentum*) is a nutritious and health-promoting grain that contains beneficial antioxidant components, such as rutin, and buckwheat is consumed world-wide. However, especially in Japan and East Asia, some individuals suffer from buckwheat allergy. Even at a low concentration (ppm range), if present in foods, buckwheat protein can cause severe anaphylactic shock. Therefore, a specific and sensitive buckwheat detection system is needed by the food industry. In this study we report a buckwheat detection system based on the preparation of buckwheat-specific monoclonal antibodies. Buckwheat 2S albumin (Fag e 2) shows a high reactivity against immunoglobulin E (IgE) of buckwheat-allergic patients. Moreover, the Fag e 2 protein has a high tolerance against heat and enzymatic digestion, such that Fag e 2 would be expected to be detectable in grilled or boiled foods. Amino acid sequences of Fag e 2 were determined in 10 seeds each of 6 different buckwheat cultivars (two each Japanese and Chinese, one American, and one Brazilian). Knowing the amino acid sequences, three Fag e 2 variants were chosen to cover structural variations of Fag e 2 in the samples of buckwheat. Those three variants were used as mixed antigen. Monoclonal antibodies were obtained by immunization of BALB/c mice with the mixed antigen, and were evaluated for reactivity against each buckwheat cultivar, and against cross reactivity with other food materials. After the tests, three monoclonal antibodies were selected for further study. Surface plasmon resonance (SPR) analysis revealed that the K_D values of the three antibodies ranged from $0.33\text{-}5.1 \times 10^{-9}$ M. With those monoclonal antibodies, enzyme linked immunosorbent assay (ELISA) and lateral flow assay (immunochromatography) were developed, which were used, respectively, to detect 7 pg/mL of Fag e 2 by ELISA and 5 ng/mL by immunochromatography. Furthermore, the new immunochromatographic assay was used to successfully detect 10 ppm of total buckwheat protein (standard in Japanese Food Labeling Act) in heat-processed foods, including cookie, crepe, and donut.

Effects of isomaltodextrin on rheological properties of model starch gels and its application in baked products as a promising source of fiber

F. FANG (1), A. Diatta (1), H. Watanabe (2), O. H. Campanella (1), B. R. Hamaker (1)

(1) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.; (2) Hayashibara Biochemical Laboratories Inc., Okayama, Japan

Isomaltodextrin (IMD) is a highly-branched dietary fiber consisting of glucose residues being linked through α -1,6 (~49%), α -1,4 (~19%), α -1,4 (~17%, nonreducing end group), α -1,3 (~3%), α -1,3,6 (~7%) and α -1,4,6 (~5%) glucosidic linkages. Due to its high solubility and low viscosity, IMD is a promising food ingredient that increases dietary fiber content in food products with minimized negative impacts on food textures. The objective of this study was to investigate the rheological properties of IMD solutions and its impact on model starch gel properties, and to develop applications of IMD as a promising source of fiber in baked products. Flow behaviors of IMD solutions were measured at different temperatures (5-95°C) and concentrations (10-50% w/w). The impact of IMD on viscoelasticity of model starch gels were studied using small amplitude oscillatory shear frequency sweep tests at a strain amplitude in the linear regime. After storage, degree of starch retrogradation and microstructure of starch gels with the presence of IMD were studied using differential scanning calorimetry (DSC) and cryo-scanning electron microscopy (SEM). Quality of baked products containing IMD as a “good” source of fiber was evaluated by texture analysis (e.g., hardness and adhesiveness). Concentrated IMD solutions displayed typical Newtonian fluid rheological behavior. Their viscosities had a positive correlation with concentration and a negative correlation with temperature. The addition of IMD to starch improved its gel strength showing as a higher value of storage modulus (G'), but there was no change in elasticity (phase angle). Upon storage, the degree of starch retrogradation was significantly increased with the presence of IMD showing a denser and smaller pore structure in starch gels. In addition, baked products containing IMD showed an acceptable texture and a similar appearance as the control sample with the absence of IMD.

Distribution of octenylsuccinate substituents within a single granule of modified potato starches determined by Raman microspectroscopy

Z. SUN (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

Octenylsuccinic anhydride (OSA)-modified starches were prepared in granular form from waxy potato, and normal potato starches at two levels (3% and 9%, based on the weight of starch) of OSA reagent. The distribution of OS groups at five positions within a single starch granule was determined by Raman microspectroscopy. OSA-modified starch had one additional peak at $1,670\text{ cm}^{-1}$, indicative of the carbonyl group in OS group bound to starch molecules. For each Raman spectrum obtained at a given position on a starch granule, the ratio of the band areas of carbonyl ($1,679\text{ cm}^{-1}$) to starch ($2,910\text{ cm}^{-1}$) was calculated. Raman spectroscopy results suggested that OS groups were grafted on the surface of starch granules. Compared with previous study on maize starches, the intensity in hilum area of potato starches was not increased.

Commercialization of varietal specific plant-based protein supply chains

S. M. FINNIE (1)

(1) Bay State Milling, Quincy, MA, U.S.A.

Demand of plant-based protein is rising, mainly driven by consumers who are trying to increase overall protein in their diet while reducing their consumption of animal protein due to concerns related to the environment, personal health and animal well-being. The increase in protein consumption has led food manufacturers to source plant-based ingredients with increased levels of protein. High protein naked oats, an Identity Preserved crop, can provide a sustainable solution for food manufactures requiring whole food ingredients with an elevated level of protein (20%). Besides protein content, protein quality is also increasing in consumer awareness. Protein quality is measured using the Protein Digestibility Corrected Amino Acid Score (PDCAAS). Leveraging proprietary PDCAAS data for a variety of grains and seeds, a synergistic increase in protein quality was demonstrated using blends of high protein naked oats and chickpeas. This presentation will also discuss the complexity of building sustainable supply chains of identity preserved crops that can be leveraged to deliver nutritional differentiation to food manufacturers and consumers.

Characteristics of air-classified fractions from various pea varieties

N. WANG (1), L. Maximiuk (1)

(1) Canadian Grain Commission, Winnipeg, MB, Canada

Pulses are rich sources of complex carbohydrates, protein, vitamins and minerals and are generally consumed after cooking both in whole seeds or decorticated splits. Recently, interest has grown in separating pulses into protein and starch fractions using wet or dry fractionation process. The objective of this study was to investigate the effect of variety and crude protein content on characteristics of air-classified fractions from field peas. A laboratory air classifier was used to separate pea flour into protein-rich and starch-rich fractions. Four commonly grown pea varieties, each with two levels of protein content, were selected for this study. Crude protein content overall varied from 18.3 to 27.9 g/100 g dry matter. Proximate composition of air-classified pea fractions were analyzed according to published methods. Analysis of variance showed that variety and crude protein content in pea flour had a significant effect on protein and starch content in starch-rich fraction, and starch content in protein-rich fraction. Yields for both starch-rich and protein-rich fraction were significantly affected by variety. It was found that protein content in pea flour was positively correlated with protein contents in both starch-rich ($r = 0.98$, $P < 0.001$) and protein-rich fraction ($r = 0.98$, $P < 0.001$), but negatively correlated with starch contents in both starch-rich fraction ($r = -0.88$, $P < 0.001$) and protein-rich fraction ($r = -0.84$, $P < 0.001$). Protein content in pea flour was also positively related with ash content ($r = 0.81$, $P < 0.001$) and phytic acid content ($r = 0.77$, $P < 0.001$) in the starch-rich fraction, but negatively related with total dietary fiber ($r = -0.91$, $P < 0.001$) in the protein-rich fraction. The fractions will have potential for use in food manufacturing as ingredients.

A scientific investigation into the impact of pre-harvest glyphosate application on oat milling quality

N. AMES (1), C. Willenborg (2), S. Tittlemier (3)

(1) Agriculture & Agri-Food Canada, Winnipeg, MB, Canada; (2) University of Saskatchewan, Department of Plant Sciences, Saskatoon, SK, Canada; (3) Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, Canada

Glyphosate can be applied to oats as a pre-harvest drying aid, but more research is needed to determine whether this agricultural practice impacts milling quality or nutritional composition. Controlled field experiments were designed to study the influence of glyphosate application timing (at 20, 30, 40, 50 and 60% seed moisture content (SMC)), cultivar maturity (early/medium and very late maturity), plant stand (250 and 500 seeds per square meter) and harvest management (pre-harvest glyphosate at SMC 30%, swath at 35% SMC and straight combining at 12.5% SMC) on oat quality. Experimental plots were replicated and grown at two locations in Saskatchewan over multiple years. The harvested oat samples were assessed for a number of quality traits

including milling yield, groat breakage, colour, beta-glucan, protein, total starch, flour slurry pasting, flake water absorption and flake granulation. Research results will be discussed to provide the oat industry with scientific information on the impact of agricultural management practices on oat milling quality, thus helping the sector to achieve quality targets that are required for food oats.

Changes of wheat phenolic antioxidants and baking properties during early-stage germination

W. TIAN (1), Y. Li (1), R. A. Miller (1), L. C. Ehmke (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

This study reported changes in baking properties, total phenolic content, antioxidant activity, and phenolic acid composition of three hard red winter wheat varieties during the early stage of seed germination. The wheats were sprouted at 30°C and 95% relative humidity to achieve different germination levels based on falling number ranges (550 seconds for control flour; 350 (low), 250 (medium), and 120 (high) seconds for sprouted flours, respectively). Average germination times were 7, 8, and 10 h for the low, medium and high germinated samples, respectively. Most baking properties of sprouted whole flour were comparable to the control flour. However, total phenolic content, flavonoid content, phenolic acids, as well as antioxidant activity of sprouted flour were lower than the control flour. To our knowledge, this is the first study that reported both baking properties and antioxidant potential of sprouted whole wheat flour from early-stage germination. The study deepens the understanding of seed germination and the potential use of sprouted flour in baking industry.

Effects of cooking methods and storage conditions on the *in vitro* digestion rates of Chinese noodles

Y. Tian (1), M. Li (1), A. Tang (2), M. Yao (1), B. GUO (1)

(1) Institute of Food Science and Technology, Chinese Academy of Agri Sciences, Beijing, China; (2) Food Science and Engineering College, Beijing University of Agriculture, Beijing, China

Cooking and storage can influence the content of resistant starch (RS) and digestion rates of carbohydrate-containing food. This study aims to investigate how the relatively high digestion rate of white-salted noodles can be altered by varying the cooking and storage methods. Cooking methods (boil, steam, stir-fry, fry and microwave heating) were chosen to cook the noodles to the degree of ready to eat. The cooked noodles were then stored under temperatures of -18, 4 and 25°C for 4, 24 and 48 h to simulate the routine eating habits. The RS content and the *in vitro* digestion rate of the noodles were analyzed. Microwave-heated and stir-fried noodles contained higher resistant starch content (0.99 ± 0.05 and $0.59 \pm 0.01\%$, respectively), and the fried noodles showed the lowest (0%), which were consistent with the results of digestion rate that a negative correlation existed between RS content and digestion rate of noodles. During storage, the RS content of noodles was the highest when it was stored at room temperature and with the lowest digestion rate than at lower temperature. RS content increased with storage time especially for microwaved noodles (2.08 ± 0.06 after storage at 25°C for 24 h), but there was no significant difference in the digestion rate for noodles stored for 4 h and 24 h. Resistant starch content can somehow explain the digestion rate, and the size of the starch crystal rather than the degree of crystallinity formed during storage may explain the varied digestion rate, which will be analyzed soon.

Can traditional or new methods differentiate gene edited grain in the supply chain

R. D. SHILLITO (1)

(1) BASF Corporation, Morrisville, NC, U.S.A.

Prior talks in this symposium will have outlined the application of precision editing of plant DNA. This presentation will examine methods that might be applied should it be desired to detect such products in the food and feed supply chain. The focus will be on DNA-based detection methods as these are most likely to be used for regulation or labeling efforts. PCR methods that are used for the detection of “traditional” genetic modifications in plants rely on the precise binding of primers and probes to the target DNA. These methods are suitable for detection of inserts, and possibly of significant deletions, and regulatory agencies have stringent performance requirements for them. It will be a challenge to meet these requirements for small or single base changes in bulk grain samples. It is also impossible to differentiate such edits from background mutation processes that could result in similar genomic changes in plants. Identification will be even more difficult when the grain comes from multiple sources, as is normal in international trade. Improvements of PCR technologies such as digital PCR do not mitigate these challenges. New technologies have been proposed as providing potential alternatives for the detection of small changes resulting from editing, such as isothermal DNA amplification, including the use of CRISPR-Cas9. I will also discuss the feasibility of using these technologies.

Use of microwave assisted extraction to increase sorghum (*Sorghum bicolor*) polyphenolic extraction efficiency

K. M. DUKE (1), J. M. Awika (1)

(1) Texas A&M University, College Station, TX, U.S.A.

Sorghum is abundant in unique polyphenolics associated with many health benefits; the compounds are mostly concentrated in the bran, a common milling waste product. Efficiently extracting the compounds from sorghum bran could add value to sorghum processing waste and expand food and other applications of the bioactive compounds from sorghum. This study explored the effect of microwave assisted extraction (MAE) technology on the extraction efficiency and phenolic profile of sorghum grain bran. Phenolics were extracted from white, lemon yellow, and red sorghum brans with 1% HCl in methanol using a conventional method (control) or MAE (Mars 5, CEM Corporation) at 600 or 1,200 W for 5, 10, or 15 min. Extractable phenolic content was estimated using the Folin-Ciocalteu method, and the phenolic profile was analyzed with reversed-phase HPLC-MS. MAE increased extractable phenolic yield by an average of 14–52% vs control for the different sorghum types. The highest increase in extractable phenols (mg gallic acid equivalents, GAE/g) due to MAE was in white sorghum bran (5.8 vs 3.8 for control), whereas the lowest increase was in lemon yellow bran (14.0 vs 12.3 for control). The 1,200 W microwave energy level consistently produced higher (average 12%) phenolic yield in all samples vs 600 W. MAE also altered the phenolic profile of the different sorghums: three new major phenolic peaks were identified as feruloyl rhamnosides and contributed 2.3–2.7 mg/g of the MAE extracted phenolics in the different samples. Ferulic acid is abundant in plant cell walls and the release of these sugar bound derivatives indicates MAE-induced cell wall breakdown contributed to the increased extractability of sorghum phenolics. Using MAE to extract polyphenolics from sorghum bran could simultaneously add value to sorghum milling waste stream while producing natural bioactive compounds for various applications.

Global CRISPR/gene editing and research tracker – Interactive database that maps regulations, new products and NGO activities

J. ENTINE (1)

(1) Genetic Literacy Project, North Wales, PA, U.S.A.

Solution-oriented thought leaders can help drive public and policy consensus around gene editing and biotechnology-based innovations in food production, nutrition and sustainable farming. These new tools are needed in the face of challenges posed by population growth, food insecurity, environmental and climate-related stresses as well as changing consumer demand. The revolutionary tool driving this change is gene editing in all its various forms including CRISPR. However, the full utilization of these tools is not guaranteed. Pragmatic and ethical considerations, and pushback from numerous environmental groups opposed to biotechnology innovation may restrict their potential. Demands are already being made for strict, and possibly suffocating, regulation—some judiciously crafted and others driven by interest groups, from industry to advocacy NGOs. As we learned with the tragedy over the introduction of transgenics in agriculture, influencing public opinion and guiding sensible legislation will determine whether we fully exploit the potential of fast-evolving biotechnology tools. For this to happen, it's critical that all stakeholders are aware of the global regulatory landscape. In a commitment to transparency, the Genetic Literacy Project has developed a world-wide, interactive tracker (to be actively updated) that provides researchers, media, industry, policymakers and NGOs updated summaries and details of evolving gene editing regulation focused on: (1) agricultural New Breeding Techniques, in crops and animals; (2) human gene editing, including gene therapy and germline editing; and (3) gene drives, including their use in agriculture and pest amelioration.

Genetic variation affecting falling number and pre-harvest sprout in winter wheats

M. J. GIROUX (1), J. Vetch (1), J. M. Martin (1)

(1) Montana State University, Bozeman, MT, U.S.A.

Pre-harvest sprouting (PHS) is the precocious germination of grain prior to harvest which negatively impacts seed and end use quality. PHS is evaluated in two ways: visual inspection or the falling number (FN) test. Low FN values denotes PHS induced starch and protein degradation. This negatively impacts producer prices resulting in global losses of up to \$1 billion per year. Thus, identifying PHS resistance mechanisms and the development of wheat varieties which have inherently high FN is important. The first objective of this study is to investigate PHS differences resulting from the allelic variation of *TaPHS1* and *TaMKK3* loci in a winter wheat biparental population. The second objective is to identify differentially expressed genes between PHS resistant and susceptible varieties that may be impacting seed dormancy at harvest. The third objective is to identify additional genes associated with FN changes. In a previous study, approximately ~50 Montana grown spring and winter wheat varieties were assessed for PHS susceptibility and FN, and we determined that *TaPHS1* controls a significant portion of PHS variability among winter wheat varieties. However, *TaPHS1* did not explain PHS variation among the spring wheats we surveyed. In the current study, a winter wheat biparental population was used to test the role of *TaPHS1* and *TaMKK3* alone and in combination upon PHS susceptibility. Seed-specific

expression levels of *TaPHS1* and *TaMKK3* and other genes involved in seed maturation and dormancy were assessed via RNAseq analysis of parent lines varying in PHS susceptibility and the results indicate little change in overall gene expression. To investigate genetic factors that may impact FN variation unrelated to seed dormancy, three sets of spring wheat isolines were studied. These were red and white isolines, and those varying for the presence or absence of *Glupro* or *Gli-B1* genes. Results indicate that *TaPHS1* variation has a greater impact on PHS susceptibility in winter wheat than does *TaMKK3*. RNAseq expression data analysis is in progress. Significant FN variation (in the absence of PHS damage) exists across elite cultivars. The presence of the *Glupro* gene increased FN values by approximately 20 seconds. Presence of favorable *Gli-b1* and red vs white seeds had no observable effect on FN. Future work will include biparental QTL analysis in an effort to detect novel loci affecting falling numbers variation.

Agronomic and grain quality attributes of hard red winter wheat from a new, sustainable grain production platform

A. MENSE (1), A. Jackson (2), Y. W. Lee (1), K. Kephart (3), P. Kerr (1)

(1) Indigo Ag., Inc., Boston, MA, U.S.A.; (2) Indigo Ag., Inc., Charlestown, MA, U.S.A.; (3) Indigo Ag., Inc., Brookings, SD, U.S.A.

Wheat contains a substantial amount of protein and is a staple crop that provides the global population with a significant percent of their dietary energy; however, the annualized incremental improvement in wheat yield worldwide may be insufficient to feed a growing human population. Therefore, investment in technologies to increase yield gain and quality as well as promote sustainable farming practices for crops experiencing volatile environmental conditions is critical to feeding the world. Due to limited information on the effect of treating seed wheat with natural beneficial plant-associated microbes on grain quality, Indigo Ag. Inc. works to understand these interactions. Commercial hard red winter wheat (HRWW) acres were planted with certified seed treated with plant associated-microbes, aided by crop protection technologies and agronomic services throughout the 2017/2018 growing season. This presentation explores the effect of this new platform on Indigo's commercial acres with HRWW and the use of agricultural big data to develop a model that identifies potential causal factors for grain quality. Representative wheat samples were obtained from Indigo commercial fields at the time of harvest. Samples were analyzed for U.S. Grade and a panel of wheat grain, flour, and dough analyses conducted at leading third-party testing laboratories. Variables such as variety, location, weather data, management practices, and microbial treatment were evaluated for their utility in predicting yield and wheat quality. These data represent the first survey of commercial wheat production using this unique crop production platform. The breadth at which samples were taken across a diverse set of environmental conditions, management practices, and genetics combined with Indigo's microbial technology has resulted in a unique survey that can provide insight into the drivers of grain quality. For the 2018 HRWW harvest, fields planted with Indigo-treated seed had 12.7% greater yield compared to non-Indigo fields, despite 82-98% of the commercial fields being non-irrigated. Additionally, protein concentration improved from 12.7% to 13.8% (adjusted to 12% moisture basis) compared to untreated county averages. Amino acid analysis across a wide protein content diversity set of commercial samples indicate that both protein quality, as well as protein content was affected across the production platform. Indigo will apply machine learning methodologies to gain insights into grower and environmental factors that affect grain yield and commercially-relevant quality attributes on regional and global scales.

Plasma activated water (PAW) and its effects on the pasting profiles of starches from different botanical sources

I. L. KOUGBLENOU (1), G. A. Annor (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.

The use of Plasma Activated Water (PAW) for the modification of starch and for other food applications have been a subject of research interest in recent times. The production of PAW results in the formation of hydrogen peroxide, nitrates, nitrites, superoxide ion, radicals, singlet oxygen, hydroxyl radicals, and ozone amongst others. These reactive species then interact with surfaces or foods they come into contact with. This study investigated the effects of cooking starches from different botanical sources (normal and waxy rice; tapioca; normal, waxy and high amylose; normal and waxy potato) with PAW on their pasting profiles. PAW was prepared by discharging a plasma jet over distilled water under constant stirring for 10 min. The atmospheric plasma jet was produced with the Enercon Dyne-A-Mite IT LM4810-54 Atmospheric Air Plasma Surface Treater. The nozzle of the plasma treater was 25 cm above the surface of the water (2 L). Changes in pH, conductivity, and oxidative-reductive potential (ORP) of the PAW was monitored. The starches were then cooked with the Micro Visco Amylograph to 95°C and the cooled to 30°C. The peak viscosity, pasting temperature, final viscosity, breakdown and setback viscosities were measured. pH of water decreased from 7.29 to 3.10. Conductivity and ORP increased from 7.94 to 292 mS and from 272 to 554 mV respectively. Significant effects on all pasting parameters studied was observed except for pasting temperature. Slight increases in the pasting temperature were observed in tapioca, waxy corn, normal and waxy potato starches. The final viscosity of normal potato starch significantly decreased from 821 to 394 BU. However, there was no change in the final viscosity of normal corn starch. Except for

normal rice starch, decreases were observed in the final viscosity of all the starches. Breakdown of most of all the starches increased except in normal potato starch. Setback, which gives an indication of starch retrogradation reduced in all starches after PAW cooking. The effects observed in potato starch was more significant than that observed in the cereal starches. PAW cooking of starches significantly affected the pasting properties of starches and could be used as a possible starch modification technique.

Impact of processing on anti-nutritional factors in pulses

T. Der (1), C. CHIREMBA (2)

(1) Pulse Canada, Winnipeg, MB, Canada; (2) Saskatchewan Pulse Growers, Saskatoon, SK, Canada

As pulse use in commercial applications in the processed food sector continues to expand globally, there is need to understand the antinutrient levels in the raw seed and when they're exposed to various processing stages. A literature review was published in 2016 summarizing the presence and activities of a antinutrient factors (ANF) found in peas, lentils, chickpeas and beans. Conventional processing including soaking, dehulling, boiling, and pressure cooking as well as germination and fermentation have demonstrated reductions in the levels of phytate, protease inhibitors, phenolics, condensed tannins, lectins, and saponins in peas and other pulse types. While studies validate the effects of specific processing conditions on antinutrient levels, additional studies need to be conducted on a broader range of processing parameters relevant to commercial food operations, and to ensure that detection/quantification methods for each antinutrient are well established so that accurate comparisons can be made. This presentation will provide a benchmark of the current data on ANF in raw pulses and highlight more recent studies demonstrating impacts of ingredient processing.

Genome-wide association study on bran friability and water retention capacity traits

S. NAVROTSKYI (1)

(1) University of Nebraska–Lincoln, Lincoln, NE, U.S.A.

Whole grain and bran-containing foods remain an important part of the marketplace products with profound health benefits. Therefore, bran functionality should be constantly monitored in order to provide consumers with products of consistent quality. Genome-wide association studies (GWAS) provide an opportunity to map qualitative trait loci associated with bran quality traits of interest. Based on the previous research, bran friability (particle size distribution of bran after the milling) and water retention capacity (WRC) were selected as the traits with the most profound impact on the functionality of the whole grain flour. In the present study, 297 hard winter wheat lines commonly grown in the Great Plains region of the US were analyzed. GWAS analysis was performed utilizing TASSEL 5 software. Results suggested that two genes located on chromosome 5D were potentially involved in the controlling of bran friability: TraesCS5D02G001200 and TraesCS5D02G004300. According to the database search, TraesCS5D02G001200 purportedly encodes proteins responsible for transmembrane sucrose transfer. The functionality of protein encoded by TraesCS5D02G004300 has not been characterized yet. However, a blast search of the exon transcript showed highly similar coding sequence (%ID-55.3, E-val: 2.2E-40) to the genes encoding for the puroindoline proteins in wheat, which are involved in the control of kernel hardness. For WRC, two genes correlated with this trait were located on 4A chromosome: TraesCS4A02G251100 and TraesCS4A02G251300. However, functions of the proteins encoded by those genes have not been characterized so far. Therefore, potential candidate genes involved in bran friability and WRC may be utilized in wheat breeding programs aimed on the production of the lines with enhanced bran quality.

Degradation of arabinoxylans during mixing, fermentation and baking

Y. NISHITSUJI (1)

(1) Nisshin Flour Milling Inc., Tsukuba-city, Ibaraki, Japan

Arabinoxylans (AXs) are one of the main non-starch polysaccharides in wheat. They are composed of β -1,4-linked D-xylopyranosyl residues as a backbone, which is substituted with α -L-arabinofuranose units at the O-2 and/or O-3 position. AXs have unique properties; such as having high water holding-capacity, viscosity, and gelation properties. They are considered to play an important role in bread-making as proteins and starches do, but the effect of AXs on end-product quality has not been completely clarified. In this study, changes in AXs during bread-making process were investigated. Straight dough bread-making tests (AACC Approved Method 10-09.01) were performed with three flour samples from three different bread wheat varieties (Bolles, Glenn and Elgin-ND from 2015) and samples were collected at the end of the seven stages (flour, mixing, first fermentation, second fermentation, molding, final proofing, and baking) during the bread-making process. The samples were separated into water-extractable and water unextractable fractions, and the amount of water-extractable arabinoxylans (WEAXs), water unextractable arabinoxylans (WUAXs), and the arabinose to xylose ratio (A/X) of WEAXs and WUAXs were quantified. Extracted WEAXs were dissolved in D₂O and further analyzed by nuclear magnetic resonance (NMR) spectroscopy to investigate the changes in the structure of WEAXs. The purified WEAXs were also used for molecular weight analysis by SEC-MALS. The amount of WEAXs increased significantly at mixing and/or at the first fermentation stage, and decreased during the baking stage. On the other

hand, the amount of WUAXs displayed the opposite trend. In the ¹H-NMR analysis, the proportion of the peak areas originating from the unsubstituted xylose and disubstituted xylose increased significantly while mono-substituted xylose decreased at mixing or at the first fermentation stage. As molecular weight analysis, four peaks were obtained from wheat flour samples. Sugar composition was analyzed on each peak and it shows that the first peak was mainly AXs, and the rest of the peaks were mixture of AXs and arabinogalactans. The molecular weight of the AXs decreased until the first fermentation. This result indicates that the WEAXs are degraded in the early stage during baking process. Additionally, a new peak appeared after the mixing process. It is considered to be due to the solubilization of WUAXs. These results indicate that AXs in wheat flour changed dramatically at mixing and at the first fermentation stage, suggesting the WEAXs are degraded and WUAXs are solubilized, releasing WEAXs with more disubstituted xylose.

Understanding the physical and molecular changes in the mixtures of cellulose and corn starch during extrusion processing using FTIR

P. EK (1), B. J. Gu (1), G. M. Ganjyal (1)

(1) Washington State University, Pullman, WA, U.S.A.

Producing high-fiber direct expanded extruded products is still challenging. Fiber generally reduces the expansion of extrudates, resulting in an unacceptable texture for consumers. There is a lack of understanding of the physical and chemical changes of starch-fiber during extrusion. In this study, the molecular changes of selected starch and fiber mixtures during extrusion processing was explored using Fourier Transform Infrared Spectroscopy-Attenuated Total Reflectance (FTIR-ATR) technique. Corn starch with 50% amylose content (S50) were mixed with different levels of cellulose (0, 5, 15%). These mixtures were extruded by a twin-screw co-rotating extruder. The molecular changes of these starch-fiber mixtures and their extrudates were measured by using FTIR-ATR. Under the same extrusion conditions, the expansion of extrudates significantly reduced from 9.82 to 6.47 as the cellulose content increased. The density of extrudates were between 0.10 and 0.16. Torque, pressure and specific mechanical energy (SME) increased with increasing cellulose content. The comparison of FTIR spectra between raw mixtures and their extrudates showed notable changes at 1,078-930 cm⁻¹ region corresponding to C-OH bending of the glucose molecules. The intensity of the peak at 994 cm⁻¹ decreased while the one at 1,022 cm⁻¹ increased after extrusion. These changes explained the molecular degradation and re-association of starch and fiber during extrusion. For extrudates, increasing cellulose content reduced the peak intensity at 994 cm⁻¹ and increased the peak intensity at 1,022 cm⁻¹. The decreased intensity of the peak at 994 cm⁻¹ indicated that there was a reduction of intramolecular hydrogen bonds between glucose units at C-OH bonds, while the increased intensity of the peak at 1,022 cm⁻¹ meant that the ordered structure decreased. Therefore, it can be concluded that cellulose disrupted the ordered structure and the hydrogen bonding between the sub-units of starch during expansion process. In conclusion, cellulose could affect the molecular breakdown of starch during extrusion and interfere on how the sub-units of starch re-associate in extrudates.

Rapid tests to evaluate the baking potential of 25 edible dry bean powders

C. CAPP (1,2), J. D. Kelly (3), P. K. W. Ng (2)

(1) Department of Food, Environmental and Nutritional Sciences, University of Milan, Milan, Italy;

(2) Department of Food Science and Human Nutrition, Michigan State University, East Lansing, MI, U.S.A.;

(3) Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI, U.S.A.

The use of a baking test is a common method to evaluate suitability of wheat flours for production of high quality cookies, however the test is time consuming. The possibility of correlating target quality parameters of cookies with time-saving techniques utilized to evaluate wheat flour, but also suitable with non-wheat flours, is of great interest. The objective of this study was to investigate correlations among rapid test indices [i.e., water and lactic acid retention capacities, oil binding capacity, and Rapid Visco Analyzer (RVA) indices] of bean powder blends and nutritional, geometrical and textural properties of bean-cookies. Bean powders of 25 edible dry bean (*Phaseolus vulgaris L.*) varieties were investigated in order to understand the effects of bean genotype on cookie quality parameters. As powder particle size implicates a different surface contact area with the solvent, all dry beans were ground in order to be of similar particle size (≤ 0.5 mm). Baking potential varied greatly among bean genotype: cookie protein and resistant starch contents ranged from 7.7 to 10.2% and from 9.4 to 17.9%, respectively; cookie thickness and fracture strength ranged from 0.93 to 1.17 cm and from 87 to 226 kPa, respectively. Water retention capacity values were significantly ($p < 0.05$) correlated with cookie protein content and hardness ($r = 0.49$ and $r = 0.42$, respectively), while oil binding capacity values were correlated with rapidly digestible starch values ($r = 0.55$, $p < 0.005$). RVA-indices were not correlated with bean-cookie properties. Results of this research have demonstrated that some rapid test indices can be used to partially design bean cookie features and that bean genotype has a significant effect on cookie nutritional composition as well as geometrical and textural properties. Outcomes of this research can guide the making of value-added bean cookies.

Optimizing milling performance of intermediate wheatgrass (*Thinopyrum intermedium*), a novel perennial grain

R. BHARATHI (1), X. LI (1), C. Tyl (1), S. Held (1), Q. Deng (1), T. C. Schoenfuss (1), G. A. Annor (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Consumers and companies alike are interested in a wider range of products made of sustainably produced ingredients. The use of perennial grains such as intermediate wheatgrass (*Thinopyrum intermedium*, IWG) allows for achievement of such sustainability goals. Although this grain does not have a long history of human consumption, it has the potential to be incorporated into a wide range of food products. In previous studies, it was observed that the high bran (and consequently, high dietary fiber) contents present in whole IWG negatively affected bread quality, such as volume, firmness, and crumb cell structure, indicating a higher degree of refinement being beneficial for certain applications. Tempering is a critical first step in cereal processing aimed at improving the efficiency of flour extraction. The objective of this study was to determine optimum tempering conditions for IWG refinement, by using a $3 \times 3 \times 2$ factorial design and characterizing compositional and functional characteristics of the resulting flour. This is part of a wider-reaching effort to optimize IWG processing for baking and brewing applications. IWG was subjected to 4, 8 or 24 h of tempering at either 30 or 45°C. Kernels were either used at intrinsic moisture (i.e. no water added) as controls or tempered to 12 or 14% target moisture. Kernels were then milled, endosperm separated from the bran, and analyzed for ash, protein, color, and solvent retention capacity. Target moisture had the biggest impact on several flour characteristics, including ash content and color. In addition, after 24 h of tempering at 14% target moisture, the yields were significantly higher than after 4 or 8 h of tempering. Flour at intrinsic moisture displayed several inferior characteristics (significantly lower lightness and yellowness, and higher ash content) compared to flour tempered to 12 or 14% target moisture, especially when tempered for 24 h and at 45°C. Lightness was moderately, but significantly correlated with solvent retention capacity for water ($r = -0.662$, $p < 0.01$) as well as sodium carbonate ($r = -0.507$, $p < 0.05$). Overall, flour moisture after tempering significantly correlated with ash ($r = -0.722$, $p < 0.01$), lightness ($r = 0.621$, $p < 0.01$) and yellowness ($r = 0.782$, $p < 0.01$) of flour. Therefore, tempering may be a suitable processing strategy to produce refined IWG that is lighter, more yellow and has less starch damage, which may be beneficial for applications such as cookies or cakes.

Heat-induced fibrillation of wheat gluten proteins

M. MONGE MORERA (1), M. A. Lambrecht (1), L. J. Deleu (1), K. Brijs (1), F. Rousseau (2),
J. Schymkowitz (2), J. A. Delcour (1)

(1) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium; (2) VIB Switch Laboratory, KU Leuven, Leuven, Belgium

Protein structure and functionality are inseparable. Modifying protein structures into amyloid protein fibrils (APF) can enhance protein functionality and lead to new applications. APF are highly ordered nanofibers composed of cross β -strands, stacked perpendicularly along the fibril axis, which are stabilized by intermolecular hydrogen bonds. Amyloid-like protein structures have been derived from wheat gluten (WG) tryptic hydrolysates after prolonged drying at room temperature (Ridgley, Ebank and Barone, 2011). However, it remains unknown whether heating induces APF formation in WG under conditions relevant for food processing. Here, WG was heated at 78°C for 22 hours or boiled for 15 minutes, conditions that resemble slow cooking and pasta cooking, respectively. Potential APF were extracted after an enzymatic treatment with proteinase K and trypsin, considering that APF are less susceptible to enzymatic cleavage than amorphous protein aggregates. Thioflavin T (ThT) fluorescence, size exclusion chromatography, Fourier transform infrared spectroscopy, transmission electron microscopy and X-ray diffraction were used to analyze the presence of (cross) β -sheet structures and protein fibrils. The soluble fraction obtained after the enzymatic treatment had low levels of ThT fluorescence (<1.0%) and mainly contained amorphous protein structures. It was hypothesized that the pellet formed after the enzymatic treatment contained APF. Indeed, evidence for the presence of protein fibrils was found after extracting the pellet with 0.05 M sodium phosphate buffer (pH 7.0) without or with 1.0% (w/v) dithiothreitol (DTT). An increase in protein fibril extractability was observed when the medium contained DTT. Longer (>1 μm) and more straight protein fibrils were formed after boiling WG for 15 minutes than after heating at 78°C for 22 hours. These results suggest the presence of APF in heat-treated WG. Further research is needed to check the presence of APF in complex systems like bread and pasta.

Effect of different degree of rice milling on the characteristics of Chinese rice wine

S. CAI (1), F. Cai (1)

(1) Hubei Academy of Agricultural Sciences, Wuhan, China

Abstract: As one of the most ancient wine products, Chinese rice wine was a low-alcohol wine fermented by rice. And the quality of the wine was significantly affected by raw material properties and fermentation process. To study the effect of degree of rice milling on the characteristics of Chinese rice wine, five rice cultivars collected from Hubei province with four different degrees were prepared. The results showed that the moisture content

and starch content of five rice cultivars increased while ash content, total fat, protein content, crude fiber content and B group vitamins decreased as the degree of milling increasing. Starch content increased from 60% to 80%, total fat decreased from 7% to 2%, and crude fiber content decreased from 1.2% to 0.3%. During the fermentation process, alcohol content increased from 3% to 12%, amino acid-state nitrogen content increased from $0.02 \text{ g}\times\text{L}^{-1}$ to $0.4 \text{ g}\times\text{L}^{-1}$ with fermentation time, while the content of total sugar decreased from $25 \text{ g}\times\text{L}^{-1}$ to $2 \text{ g}\times\text{L}^{-1}$. The features of Chinese rice wine were enhanced by higher milling degree which improving the content of starch and reducing the content of crude fiber. Compared to high milling degree of rice, the alcohol content of Chinese rice wine using unpolished rice was low while the pH was high, which was not suitable for Chinese rice wine fermentation. In conclusion, the high milling degree of rice was more suited for Chinese rice wine fermentation.

WheatScan – Unraveling the causes for wheat sensitivities

D. PRONIN (1)

(1) Leibniz Institute for Food Systems Biology at the Technical University of Munich, Freising, Germany

The scientific literature contains evidences for an increased prevalence of celiac disease (CD) and non-celiac gluten sensitivity (NCGS). While CD is well studied the pathogenesis and the triggering factors of NCGS are still unclear. It is supposed that gluten might be a triggering factor because the intestinal and/or extraintestinal symptoms disappear on a gluten-free diet. Besides growing attention and improved diagnostic techniques, changes in the protein content and composition over the last 100 years due to breeding, are considered to be one reason for the increased number of patients who suffer from NCGS. This may result in higher immunostimulatory potential of modern cultivars (registered after 1950) compared to older cultivars (registered before 1950). The aim of this study was to investigate 60 German wheat cultivars, which were registered in the period of 1891 to 2010, for their protein content and distribution by Osborne fractionation and reversed-phase high performance liquid chromatography (RP-HPLC). In order to take environmental effects into account, samples from three different harvest years (2015-2017) were analyzed. The quantitation of the crude protein contents showed a slightly decreasing trend with highly variable contents depending on the cultivar and harvest year. The Osborne fractions showed changes in the protein composition with a decreasing trend for albumin/globulin and gliadin contents and an increasing trend for glutenin contents. Further there was a decrease within the gliadin/glutenin ratios from 1891 to 2010. In line with the assumption that the composition of the wheat proteins has changed over the past 100 years, the results showed that the contents of the fractions as well as crude protein followed a specific trend although the contents were highly variable over different cultivars. Principal component analysis (PCA) of all data showed a cluster formation for modern and old wheat cultivars, but with clear overlap in the middle of the biplot and several exceptions. On the other hand, the qualitative RP-HPLC profiles showed noticeable changes, especially for the gliadin fraction. The first change occurred in the decade 1941-1950 and then in the decade 1981-1990. Further work will focus on elucidating the immunoreactive potential of the wheat cultivars and how this can be traced back to the identified qualitative changes in protein composition.

How much is too much? Determining the effects of elevated alpha-amylase on end-product quality of wheat based foods

M. NEWBERRY (1), M. Sun (2), K. Ibrahim (2), J. Pritchard (1), S. N. Daneri-Castro (1), C. A. Howitt (1), J. P. F. Ral (1)

(1) CSIRO Agriculture and Food, Canberra, Australia; (2) CSIRO Agriculture and Food, Acton, Australia

Within the wheat growing, handling and processing supply chains grains high in α -amylase are seen as defects to be kept away from food processing and milling streams as high levels of α -amylase are seen as indicative of pre-harvest sprouting (PHS) or late maturity α -amylase (LMA) damage. The incidence of these environmentally triggered grain defects results in down grading of PHS and LMA affected wheat to feed grade with an associated loss of income to growers. This importance is recognised in Australian wheat breeding with LMA susceptible lines being automatically rejected, while, the presence of LMA prone cultivars has recently been detected in other wheat producing countries. Severely sprouted wheat is detrimental to baking quality and the instrumental screening tests for sprouted grain, such as the Falling Number test, essentially measure α -amylase content. Thus grading of grain based upon these measures is leading to the elimination of wheat with increased α -amylase levels, however, bakers have long added α -amylase, either in the form of malt flour or enzyme based improvers, to improve the baking quality of wheat. Which raise the question of how much α -amylase is too much in wheat? To address this question we have used novel transgenic wheat lines possessing elevated endogenous endosperm α -amylase levels to look at the effect of elevated α -amylase levels on bread baking and noodle making quality. Both bread and noodle quality was not adversely affected by the elevated α -amylase levels, indeed, with noodles poor noodle quality was only observed in noodles made from germinated wheat. These findings show that elevated α -amylase levels are insufficient to adversely affect end-product quality. Instead, the presence of other components such as proteases in germinated or PHS affected grain are necessary for detrimental impacts on quality. Further support for this idea arises from an investigation of tall wheat lines from a diverse wheat population that are constitutive LMA expressors which showed no relationship between Falling Number and

breadmaking quality. These findings show that although excessively sprouted wheat results in poor quality baked goods the avoidance of any wheat having elevated α -amylase levels may be selling farmers, wheat breeders and consumers short. Thus it is time for a more nuanced view of the appropriateness of wheat with elevated α -amylase content in food production.

CRISPR-mediated gene editing of lipase and lipoxygenase enzymes in rice (*Oryza sativa*) to reduce lipid oxidation and enhance storage life of brown rice

K. N. HAYDON (1), V. Srivastava (1), K. L. Korth (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

The short shelf life of brown rice as compared to milled white rice results from the formation of unpleasant odors caused by oxidation of free fatty acids in the bran layer. Lipase enzymes, of which there are over 100 in rice, release free fatty acids from lipids. Lipoxygenases act on such fatty acids to produce the compounds associated with the musty smell of brown rice stored for many months. Several lipases and lipoxygenases are expressed primarily in seed tissue and are thus ideal targets for gene editing to eliminate their contributions to brown rice quality reductions. These include lipoxygenase-3 (LOX3) and a lipase designated L2 by Tiwari et al. (2016). LOX3 has been mutated with TALEN-based gene editing and silenced by RNA interference (Ma et al. 2015, Xu et al. 2015). Targeting of LOX3 by CRISPR gene editing or of L2 via mutation or silencing has not been reported. LOX3 and L2 were individually targeted for mutation by CRISPR-Cas9 at two locations per gene in the model cultivar Nipponbare. Simultaneous editing of both genes is in progress and T₀ plants have been screened for mutations in the target areas. To date, no seed has been recovered from T₀ lines with mutations in the targeted regions of LOX3. Two fertile lines with homozygous or heterozygous mutations, including both insertions and deletions in the L2 gene, were obtained for further analysis. T₁ plants were screened for mutations and three distinct homozygotic lines were selected for grain production in the T₂ generation. Grain will be harvested at maturity and subjected to accelerated aging in rough rice and brown rice forms, and evaluated for lipoxygenase and lipase activities, free fatty acid content, conjugated diene formation, and seed longevity. Previous research has shown limited effects of LOX3 mutations on brown rice rancidity. With simultaneous knockout of L2, it is hoped that a synergistic effect will result in more drastic reductions in oxidation product formation.

A 100 g lab scale corn dry milling protocol for faster determination of coproduct yield and composition

P. SOMAVAT (1), Q. Li (2), D. Kumar (2), E. G. de Mejia (2), W. Liu (2), K. D. Rausch (2), J. A. Juvik (2), M. E. Tumbleson, emeritus (2), V. Singh (2)

(1) University of Texas at Rio Grande Valley, Edinburg, TX, U.S.A.; (2) University of Illinois at Urbana-Champaign, Urbana, IL, U.S.A.

A new 100 g lab scale corn dry milling protocol has been proposed for quick determination of coproduct yield and their composition analysis. Not only the proposed protocol facilitated reliable estimation of corn dry milling characteristics using only one tenth of the material used in the existing 1 kg protocol, it also generated commercial sized flaking grits. Ten corn cultivars including yellow dent, colored and white varieties were milled, producing six different coproducts. Compositional characteristics of corn kernels and generated coproducts were ascertained and compared with their corresponding commercial samples. The corn kernel moisture content was increased to 23.5% (wb) by tempering in a vessel and the tempered kernels were passed through a custom-made lab scale degerminator. Six coproducts (large, medium, and small grits, fines, germ and pericarp) were separated using a series of sieving and aspiration operations. The use of roller mill in the separation process was completely avoided, resulting in the recovery of true commercial sized flaking grits which wasn't possible in the existing 1 kg lab scale dry milling protocol. The coefficients of variability for coproducts generated from 12 milling runs were determined for large, medium and small grits (<3.62%), fines (9.64%), germ (3.60%) and pericarp (6.22%). The crude oil content of large and medium grits from hard endosperm varieties of yellow dent corn was <1.1% (db). The crude protein and crude oil content of colored corn varieties were higher compared to the yellow dent varieties. The variations in coproduct composition and yields were mainly due to hybrid effects. Absolute density ($r = 0.89$) and test weight ($r = 0.85$) were found to be positively correlated with overall large grits yield while crude protein and crude oil content were also found to be mutually correlated ($r = 0.79$). Using proposed protocol, coproduct yield was estimated with low standard deviation with respect to means. This new protocol will be helpful in ascertaining dry milling characteristics of corn cultivars in a shorter time frame with smaller sample sizes.

Analysis of amaranth leaves and seeds grown in Puerto Rico

E. VIDAL TORRES (1,2), E. Valencia (1), A. Linares (1), J. Dumas (1), S. Simsek (2)

(1) University of Puerto Rico – Mayaguez Campus Agroenvironmental Sciences, Mayaguez, PR, U.S.A.;

(2) North Dakota State University Department of Plant Science, Fargo, ND, U.S.A.

Amaranth seed has long been used in food products for human consumption in Central and South America, but information is lacking on the chemical composition of leaf and seed of *Amaranthus cruentus* L. or *Amaranthus viridis* L in Puerto Rico. The objective of this study was to develop an amino acids profile, and determine crude protein, dietary fiber, total fat, starch and mineral (calcium, magnesium, phosphorous, potassium, iron and zinc) concentrations on 3-wk old leaves and mature seeds of field grown *A. cruentus* (Juana, Aurelia, Elena) and *A. viridis* (Callaloo). Compositional analysis was completed using AOAC, AACC, and AOCS official methods. Harvested leaves were dried in a forced air oven at 65°C for 72 hours, and ground in a Wiley mill. Seeds at physiological maturity (15-wk) were harvested, dried and ground for analysis. Data was analyzed using SAS, Statistical program and when means were significant were separated using Tukey's test. Lysine content of both Amaranth species was high. There were significant differences ($p < 0.05$) in crude protein (CP) in leaves with Elena (23%) and Aurelia (21%) having higher percentage CP, but among amaranth seeds (19%) there was no significant differences. Among amaranth leaves, there were significant ($p < 0.05$) differences in IDF and TDF, while amaranth seeds differed significantly ($p < 0.05$) for IDF, SDF and TDF. While, total fat and starch in the seeds were not significantly ($p < 0.05$) different. Calcium, Mg, and P concentrations differed significantly ($p < 0.05$) in their leaves, but Fe, K and Zn, did not. Among amaranth seeds there were significant ($p < 0.05$) difference for Ca, Mg, Fe, and P. This study demonstrates that amaranth leaves and seeds are an excellent source of nutrients, with Elena and Aurelia having higher CP in their leaves.

Selecting a standard reference material for falling number

S. R. DELWICHE (1)

(1) USDA-ARS Food Quality Laboratory, Beltsville, MD, U.S.A.

Falling number (FN) is a decades-old method in wheat quality assessment that gauges the soundness of the seed endosperm, especially with respect to the integrity of the starch and the enzyme alpha-amylase that hydrolyzes starch. The method is a physical test that measures the viscosity of a heated meal-water mixture undergoing gelatinization and hydrolysis under tightly controlled conditions of mixture preparation, mixing, and heating. With good laboratory practice, FN repeatability precision, at relative standard deviations (RSD) of 2-3%, is excellent with respect to cereals analytical procedures. Less documented is the reproducibility precision, a measurement of agreement among laboratories. In anticipation of the eventual use of a standard material for monitoring FN operations (control charting) within a network of laboratories, we developed a study to determine a suitable material for long term monitoring. The criteria included the material 1) be of food-grade, 2) be directly operable with FN equipment, 3) produce repeatability precision comparable or better than wheat meal, and 4) have a 1-year minimum shelf life. Initial studies with mixtures of pure corn starch and barley malt amylase added to produce FNs equivalent to wheat meal resulted in excellent precision (RSD ~ 2%) in the short term (1-3 days), but the mixtures were not stable from one week to the next because of change in enzyme activity. Pure starch at masses less than the standard recommendation (7 g) were then decided upon. Four starches, wheat, corn, potato and rice, were obtained from a laboratory chemical supplier. Starch masses were adjusted to produce a nominal FN of 300 s at constant (25 mL) volume of water, with 6.0 g for corn and rice starches, 5.0 g for wheat starch, and 4.0 g for potato starch. Weekly runs were collected on all four starches (5 twin-tube runs for each) and on two FN instruments over a three-month period. Results indicated that while a slight bias occurred between instruments, the ranked order of the precision of the starches was consistent, with rice starch demonstrating the best intra-laboratory precision (RSD < 2%). The study's recommendation on starch type and mass will be implemented in an inter-laboratory collaborative study, whereupon, with acceptable performance (RSD_R < 5%), a protocol will be developed for network monitoring.

Morphological and particle-size based characterization of Canadian pulses as a tool for subsequent protein enrichment

B. JEGANATHAN (1), T. Vasanthan (1), F. Temelli (1)

(1) University of Alberta, Edmonton, AB, Canada

Alternative planet-friendly protein sources are increasingly acknowledged as a sustainable solution to feeding the growing population. Fava bean (*Vicia faba* L.) is a protein-rich pulse underutilized for human consumption mainly due to some negative impacts of non-nutritional compounds. An environmentally friendly approach is being developed by employing pearling, supercritical CO₂ extraction, air-current assisted particle separation (ACAPS) followed by wet-fractionation to scale-up the isolation of fava proteins, minimal in these compounds. As a first step, studying the distribution of the macro-nutrients and some of the non-nutritional factors throughout the grain by pearling can lead to efficient fractionation. However, unlike cereals, pulses have the tendency to split during pearling. The objective of this study was to morphologically characterize the outer and

naturally split surfaces of Canadian pulses as a tool for pearling and to develop a green approach to isolate fava proteins minimal in non-nutritional factors. The morphology of the outer and naturally split surfaces of fava beans (Snowbird (LT), Athena (HT)), chickpeas (Consul, Orion), field peas (Meadow, Striker) and lentils (Greenstar, Maxim) were examined under a scanning electron microscope [Zeiss Sigma 300, Germany] coupled to energy dispersive X-ray spectroscopy. The split surfaces of the pulses were protected by a cuticle layer, which showed morphological similarities to the outer surface, warranting the uniformity of the beans during pearling. Based on the extensive component distribution analyses of the derived fractions of pearling, a 60% pearling flour minimal in some of the negative factors but with 70% protein recovery was produced from fava beans. The dehulled and 60% pearling flours of both LT and HT fava bean varieties underwent traditional sieve analysis in comparison to ACAPS. With the increasing particle size (<75 μm to 500 μm), the protein percentage increased for both LT (26.23 ± 0.90 to $37.76 \pm 0.52\%$) and HT (30.26 ± 0.21 to $36.30 \pm 0.07\%$). Dietary fibre content showed a similar trend, whereas starch showed an inverse trend. ACAPS using a 250 μm sieve separated a fine fraction with a protein recovery of 77% for LT and 75% for HT. But 60% pearling flour under similar conditions resulted in a protein and dietary fiber rich coarse fraction. The subsequent wet fractionation approach resulted in protein isolates. These data suggest that inclusion of pearling/ACAPS as upstream processing steps in fava bean fractionation can generate novel food ingredients for subsequent processing. The morphological characterization permits the application of these technological advances for the value-added utilisation of other pulses.

Walter Bushuk Graduate Research Presentation

S. GEISLITZ (1), K. Scherf (1), P. Koehler (2)

(1) Leibniz-Institute for Food Systems Biology at the TUM, Freising, Germany; (2) Biotask AG, Esslingen am Neckar, Germany

The ancient wheat species einkorn, emmer and spelt are cultivated in very low amounts in comparison to modern common wheat due to low yields, unfavorable agronomic characteristics and poor baking properties. The baking quality is not only influenced by high gluten content, but primarily by the composition of gluten, which consists of gliadins (GLIA) and glutenins (GLUT). The aim of the study was to select ancient wheat cultivars with good baking performance by analyzing the gluten protein composition and help intensify the use of ancient wheats. The contents of GLIA and GLUT were quantitated in 40 flours by modified Osborne fractionation followed by reversed-phase high-performance liquid chromatography (RP-HPLC) and correlated to baking experiments. The GLUT content and the ratio of GLIA and GLUT (GLIA/GLUT) were good predictors for the bread volume of ancient and modern wheats. Thus, GLIA and GLUT were quantitated in 300 samples (15 cultivars of five wheat species grown at four locations in Germany) by the fast and easy Bradford assay. The comparison of RP-HPLC and Bradford assay data showed that the photometric assay is not only suitable for common wheat, but also for ancient wheats. The lowest GLIA content was present in common wheat, but there was no difference in the GLIA content of spelt, emmer and einkorn. The highest GLUT content was obtained for spelt and the lowest for emmer and einkorn with common wheat in between. These differences in the GLIA and GLUT contents resulted in very high ratios of GLIA/GLUT for emmer and einkorn and explained why emmer and einkorn form weak and soft doughs and low volume breads. The influence of the location and the environment on the GLIA and GLUT contents and on GLIA/GLUT was very low compared to the influence of the wheat species. It was possible to identify ancient wheat cultivars with predicted good baking properties independent of the growing location. These cultivars (spelt, 'Filderstolz'; emmer 'CC1E-04059/04'; einkorn, 'Monlis') had higher GLUT contents and lower GLIA/GLUT ratios compared to other cultivars within the respective wheat species. The results of this study may help to increase the number of licensed ancient wheat cultivars and the creation of innovative products made from ancient wheats.

Effect of polyphenols on functional and rheological properties of black bean protein isolates

S. S. FERNANDO (1), F. A. Manthey (1)

(1) North Dakota State University, Fargo, ND, U.S.A.

Polyphenols have a significant binding affinity for proteins and are known to form complexes with proteins which causes to changes in the structural, functional and nutritional properties of both compounds. The objective of this study was to evaluate the effect of polyphenols on functional and rheological properties of black bean protein isolates from the whole bean and cotyledon. The seeds were manually cleaned to remove all foreign matter and dehulled to obtain cotyledons. Both the seeds and cotyledons were milled using a hammer mill. One portion of both seed and cotyledon flour were subjected to phenolic extraction resulting in whole bean flour with polyphenols (WBWP); whole bean flour free of polyphenols (WBFP); cotyledon flour with polyphenols (CBWP); and cotyledon flour free of polyphenols (CBFP). Four protein isolates were prepared from the four portions of black bean flour described above. Contents of moisture, ash, protein, crude fiber, total fat, total phenol and available lysine were determined for proximate analysis. Color, wettability, solubility, emulsification properties, foaming properties, water holding capacity, oil holding capacity and gelation dynamics were determined for the physical and rheological properties. The experimental design was a randomized complete block with split-plot arrangement where whole-plot was flour with or without seed coat and the sub-plot was presence of polyphenols.

Protein isolates from CBFP had significantly low ($P < 0.05$) ash, phenolic content and significantly high ($P < 0.05$) protein levels. The color of protein isolates from WBWP and CBWP improved considerably after removal of polyphenols. Protein isolates from CBFP had significantly high ($P < 0.05$) foaming capacity, foaming stability, emulsion capacity, emulsion stability and oil holding capacity. Water binding capacity was significantly higher ($P < 0.05$) for protein isolates with high phenolic content. Polyphenols in protein isolates decreased both the storage modulus and loss modulus of protein dispersions and formed more viscous and less elastic gels. Removal of polyphenols from the black bean protein isolates improved the functional and rheological properties.

Effects of glyphosate application on malting barley quality

M. S. IZYDORCZYK (1)

(1) Canadian Grain Commission, Grain Research Laboratory, Winnipeg, MB, Canada

A pre-harvest application of glyphosate on malting barley can assist in the management of perennial weed growth prior to harvest and serves as a harvest aid by drying down the crop. However, maltsters are reluctant to accept grain treated with glyphosate due to possible negative effects on seed germination and quality. The main objective of this study was to assess the benefits and risks associated with using a pre-harvest glyphosate application as a dry-down on malting barley. Field experiments were conducted for four years (2013-2017) at five locations in western Canada (Beaverlodge, Lacombe and Lethbridge, AB; Scott and Indian Head, SK). A factorial combination of timing of glyphosate application (soft dough, hard dough and maturity) at two rates (900 and 1,125 g ae/ha) on an early (AC Metcalfe) and late maturing (CDC Meredith) malting barley varieties and two non-treated controls was randomized in a complete block design with four replicates in the field. The effects of the glyphosate application on barley yield were variable among locations and years. Detectable levels of glyphosate residue were found on grains treated with glyphosate at both application levels and all three application times. Early applications of glyphosate resulted in slightly lower kernel weight compared to the untreated control. Barley grain with up to 40 mg/kg of glyphosate residue exhibited adequate germination energy normally required for malting purposes; however, the glyphosate residue on barley appeared to negatively affect the growth of roots during the malting process. The percentage of roots decreased with increasing level of glyphosate residue in barley. The levels of α -amylase in malt decreased with increasing levels of glyphosate residue in barley. Other malt and wort parameters, including malt extract, diastatic power, and wort viscosity, were generally not affected by the glyphosate application on barley.

Enriching the nutritional values of the traditional meals in KwaZulu-Natal, South Africa, by incorporating provitamin A-biofortified maize and orange sweet potatoes

M. SIWELA (1), L. Govender (1), K. Pillay (1), T. Mabhaudhi (1,2), A. Modi (1,2)

(1) University of KwaZulu-Natal, Pietermaritzburg, South Africa; (2) Centre for Transformative Agricultural and Food Systems, Pietermaritzburg, South Africa

Micronutrient malnutrition, especially vitamin A deficiency, is a major health concern in South Africa (SA). Biofortification of crops could be a more effective and sustainable approach for improving the nutritional status of vulnerable groups. However, due to their undesirable sensory properties, most biofortified foods, especially maize, have been found less acceptable compared to non-PVA-biofortified counterparts. Consumer acceptability and nutritional composition of PVA-biofortified foods could be improved by complementing them with other commonly consumed food items to produce modified traditional dishes. The study objective was to determine the effect of replacing commonly consumed white maize and cream-fleshed sweet potato (CFSP) with PVA-biofortified maize and orange fleshed sweet potato (OFSP), on the nutritional composition of traditional dishes in KwaZulu-Natal, SA. The dishes studied were *phutu* (crumbly maize porridge) prepared with PVA-biofortified maize meal and served with either curried chicken, cabbage or bambara groundnut, and boiled orange-fleshed sweet potato (OFSP). The nutritional composition of uncooked and cooked foods samples were determined using the Association of Official Agricultural Chemists (AOAC) method, van Soest method and the central analytical facilities (CAF) HCl hydrolysis method. Before nutritional analysis, uncooked and cooked food samples with a high moisture content were freeze-dried. Two replicates of each sample were analysed. Nutritional analysis results showed significant ($p < 0.05$) differences in mean PVA content across the dishes containing PVA maize and each sample had a higher mean PVA content than its control. Generally, amino acid and mineral content varied significantly across the food samples containing PVA-biofortified maize. The samples containing PVA *phutu* combined with either curried chicken or cabbage had a lower mean content of the essential amino acid lysine when compared with their controls. The mean total mineral (ash) content was higher in samples containing PVA-maize relative to their controls ($p < 0.05$). The OFSP had a low protein content (4.51 g/100 g) compared to the CFSP (6.38 g/100 g) but had higher fat and mineral content. PVA content (55.84 $\mu\text{g/g DW}$) was higher in OFSP than in the control (CFSP) (0.77 $\mu\text{g/g DW}$). OFSP and PVA-maize *phutu* when combined with other foods, such as curried cabbage, chicken or bambara groundnut, have the potential for improving nutrient intake and dietary diversity of rural communities in KwaZulu-Natal.

Modifying tuber and cereal waxy starches with radio frequency cold plasma

G. A. ANNOR (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.

The electrons, ions, free radicals and large numbers of unionized neutral molecules produced as part of the cold plasma generation process interacts with surfaces they come into contact with. In addition to being used for applications such as inactivation of microbes, enzymatic inactivation, enhancement of seed germination time and aflatoxin destruction, cold plasma is actively being explored as a starch modification technique. This study investigated radio-frequency generated cold plasma effects on the morphological, pasting, thermal properties, resistant starch, starch damage, unit and internal chain profiles of waxy rice, maize and potato starches. Cold plasma significantly increased the resistant starch of waxy potato starch (44.3 to 66.5%) and significantly affected the pasting profiles of both waxy cereal and tuber starches. Plasma treatment resulted in a 5.5% decrease in crystallinity of potato starch. There were not significant differences in the unit and internal chain profiles of the plasma and non-plasma treated samples. Results indicated that radio frequency generated cold plasma treatment had more effects on tuber waxy starches but not that of cereals, possibly due to differences in the starch properties of these different starch types.

Processing suitability of sucrose alternatives for potential sugar reduction in muffin

E. J. Lee (1), Y. Moon (1), M. KWEON (1), Y. Zhao (1), S. Kim (1), X. Wang (1)

(1) Pusan National University, Busan, South Korea

Consumer interest in healthier baked goods is increasing, including expectations for prebiotic nutritional benefits and reduced glycemic impact. Recently WHO recommended a reduction in sugar consumption as a primary calorie source. As a result, various sugar alternatives have been developed and marketed. Sucrose is a major ingredient for confectionery goods such as cookies and cakes which formulated with high sucrose concentration. However, those products resulted in a negative effect on the processing and product quality when sucrose is replaced. It is necessary to select an appropriate sucrose alternative for producing satisfactory products. The present study explored the effects of allulose, Mylose, and isomaltulose as sucrose alternatives on the starch gelatinization characteristics of flour by differential scanning calorimetry (DSC), and the quality characteristics such as moisture content, volume, crumb color, and firmness of the muffins formulated with replacement of sucrose with those sucrose alternatives at 25, 50, 75 and 100%. DSC results showed retardation of starch gelatinization in the order: water<allulose<Mylose≤sucrose=isomaltulose. The muffins formulated with sucrose and sucrose alternatives did not show any differences in weight and moisture content even with increasing replacement ratio. However, there were significant differences in volume and firmness of the muffins that depends on sucrose alternatives. In particular, the muffins replaced with allulose showed smaller volume and larger firmness than those with Mylose and isomaltulose. With increasing replacement ratio, the color of the muffins with Mylose was not significantly different from that with sucrose, but those with allulose and isomaltulose showed a decrease in L* (whiteness) and an increase in a* (redness) values significantly. When the muffins with 25 and 75% replacement with sucrose alternatives were stored at 4°C for 4 days, their firmness increased in all samples. In particular, the muffins formulated with 75% of allulose replacement showed a much more significant increase in firmness, compared with other samples, which suggests increased staling by an increased degree of starch gelatinization due to lowered starch gelatinization temperature by allulose. In terms of product quality based on appearance, shape, color, and hardness of muffins, Mylose could be considered as the most suitable sucrose alternative for producing muffins. Isomaltulose would also be the suitable sucrose alternative for producing low glycemic muffins enable to improve health benefit.

Not wasted: An international perspective

C. BAKER (1)

(1) Campden BRI, Chipping Campden, U.K.

According to the United Nations' World Population Prospects 2019: Highlights published earlier this year, the world population is expected to reach 9.7 billion in 2050. If current lifestyles remain the same, the World Resources Report [1] has estimated that food production will have to increase by more than 50%. The challenges around feeding the growing population sustainably are clear; the potential solutions are complex and require a multi-angle approach including: Producing food more sustainably; Maximising the use of the food produced to reduce the need for increased production. The ideas of reducing food waste and of valorising by-products as well as waste produced have gathered momentum over the past few years. Reducing the amount of waste going to landfills alone is unlikely to provide a viable solution to reducing the food gap when used to produce energy rather than food. Research and trials have been carried out in repurposing waste as ingredients in different products where they can also have a positive impact on their nutritional profile. Although some have made it to market, their development and commercialisation present several hurdles. The valorisation of waste and by-product needs to be safe for the consumer, economically viable for the businesses involved and environmentally sustainable. The presentation will give an overview of some of the options that have been trialled with focus on

specific examples and will consider some of the challenges. [1] World Resources Report – Creating a sustainable food future (Dec 2018).

Characteristics of Korean rice varieties and their potential end-uses

M. A. PAGANI (1), A. Marti (1), S. Feccia (2), J. H. Cho (3), J. Y. Lee (3)

(1) Department of Food, Environmental and Nutritional Sciences, University of Milan, Milan, Italy; (2) Ente Nazionale Risi, Laboratorio Chimico Merceologico, Castello d'Agogna, Italy; (3) Department of Southern Area Crop Science, National Institute of Crop Science, Miryang, Korea

As Korean consumers are increasingly attracted by Western foods as substitutes for their conventional diets, the Rural Development Administration (RDA) of the Korean National Institute of Crop Science is involved in enhancing and developing alternative rice-based foods, presently hard to find) on the Korean market. Traditionally in Oriental countries, milled rice is consumed after boiling in water and combined with other courses. Therefore, to re-vitalize this sector, the RDA is planning the production of added-value foods, such as dried pasta and “risotto”, two well-known Italian-style products. Rice from four Korean *O. sativa* varieties (two subsp. *japonica*—Dodamssad and Mylang 344—and two subsp. *indica*—Saemimyeon and Shingil) were characterized and compared to four Italian varieties, all from subsp. *japonica* (Carnaroli, Volano, Vialone Nano—indicated for risotto preparation—and one subsp. *tropical japonica*—Gladio—preferred for the parboiling process). In addition to the characteristics of the starch fraction (amylose content, alkali test, pasting properties), the cooking behavior (i.e. rice hardness and stickiness) was considered. The three Italian *cvs* recommended for risotto belong to different commercial classes according to their biometric characteristics and their amylose content (Italian law n. 131/2017). Nevertheless, they are all characterized by long gelatinization times (16-17 min), high alkali index (5-7) and good texture after cooking (i.e. surface stickiness as well as good grain consistency). Among the Korean varieties, Saemimyeon *cv* makes the best risotto, even if its alkali test value is very low and its grain hardness is quite high, traits indicating low starch swelling during cooking. Concerning rice-pasta production, the literature suggests that high amylose (>25%) varieties are preferable as they are more suitable in forming a strong and regular starch network during thermal treatments carried out during the extrusion process. With the exception of Dodamssad *cv*, whose amylose content (41.7%) is too high to obtain (according to its pasting property indications) sufficient starch swelling, Saemimyeon and Shingil *cvs* seem to have the right traits for assuring good results in rice-pasta processing. In conclusion, none of the Korean rice varieties tested so far seems to guarantee cooking performances for risotto similar to those observed for Italian varieties. On the contrary, the former exhibit promising characteristics for rice pasta-making. Further investigations will focus on starch digestibility, which might be strongly affected by the amylose content and may lower the Glycemic Index of the cooked product.

Improving wheat quality for processing and health in an international breeding program

C. GUZMAN (1)

(1) University of Cordoba, Cordoba, Spain

At the International Maize and Wheat Improvement Center (CIMMYT) wheat breeding draws on a large, genetically wide, gene pool to develop germplasm, which is widely distributed among breeding programs of wheat-producing countries. The priority of the wheat breeding program is to develop high-yielding, disease-resistant varieties that can tolerate drought, heat stresses, and produce high grain quality. The latter is essential in wheat varieties to be accepted by industry, local food manufacturers and consumers. But the integration of quality traits in a breeding program remains a challenge. The focus is often on traits with more direct importance for farmers such as grain yield or disease resistance. Additionally, high costs and time limitations restrict the use of traditional quality tests conducted with the mixograph, farinograph, alveograph, or end-use quality tests in large breeding programs where thousands of genotypes are evaluated annually. The development of high-throughput methodologies and protocols is essential to overtake those limitations. Traditionally, wheat quality improvement at CIMMYT has been focused in industrial quality. In bread wheat, the most important parameters affecting processing and end-use quality is probably gluten quality (strength and extensibility), which is analyzed extensively with diverse methodology. In durum wheat, the yellow color of semolina and gluten quality are the priorities. Thousands of breeding lines are analyzed every year for those traits. The phenotypic data obtained is complemented with molecular markers analysis. Besides, new approaches as Genomic Selection are being tested to increase the efficiency of the breeding process. In the last years, nutritional quality and health related aspects have emerged as other important priorities of breeding programmes. In this regard, CIMMYT, with the funding from the HarvestPlus Challenge Program, is leading a global effort to develop and disseminate to partners in South Asia high-yielding wheat varieties that contain high levels of grain Zn concentration. The first biofortified varieties are already available for farmers in India and Pakistan. The objective for the next years is to include in the breeding process more traits related to nutrition and health.

Quantitative assessment of the effectiveness of intervention strategies to reduce the risk of *E. coli* O157:H7 infection due to consumption of uncooked ready-to-bake cookie dough

L. Sabillón Galeas (1), A. BIANCHINI (1), J. Stratton (1), B. Wang (1),
(1) University of Nebraska–Lincoln, Lincoln, NE, U.S.A.

In recent years, wheat flour-based foods have been involved in several food safety outbreaks due to Shiga toxin-producing *E. coli* contamination. A stochastic, quantitative microbiological risk assessment (QMRA) model was developed to evaluate the public health risk associated with consumption of ready-to-bake but raw cookie dough contaminated with *E. coli* O157:H7. The cookie dough production chain was modeled from milling of wheat grain to consumption at home. The effectiveness of several potential intervention strategies (i.e., acidic saline tempering solutions and high-pressure processing) to mitigate public health risks was evaluated using the QMRA model. Monte Carlo simulation coupled with Latin Hypercube sampling method was used to assess the variability and uncertainty of the model parameters. All intervention strategies evaluated significantly reduced the estimated probability of illness per serving and the number of illness cases per year among 100,000 individuals when compared with the baseline model prediction (i.e., no interventions). For instance, tempering wheat grain with lactic acid-NaCl solutions and using the resulting flour in the manufacture of ready-to-bake cookie dough reduced the average probability of illness per serving by 38%, while the estimated number of illness cases per year declined by 36% compared to the baseline scenario. Combinations of interventions applied at different stages of the production chain resulted in the greatest relative risk reductions. Tempering wheat kernels with lactic acid-NaCl solution at the beginning of the flour-production chain and subsequently treating the pre-packaged cookie dough with high pressure before it is shipped to the market reduced the probability of illness per serving by 67%, when compared to the baseline scenario. The initial concentration of *E. coli* in wheat grain and the potential reduction in contamination caused by the milling process were identified as the main sources of uncertainty and the most important factors affecting the risk estimates. The risk to public health posed by wheat grain contaminated with *E. coli* O157:H7 at levels of up to 2 log CFU/g was substantially mitigated by the application of the interventions. The developed QMRA provides a modeling framework for the processing chain of grain-based foods to evaluate potential intervention strategies applied at different points of this chain.

Effects of Glu-D1 and Gpc-1 on soft durum quality

A. M. KISZONAS (1), M. I. Ibba (2), J. D. Boehm, Jr. (2), C. F. Morris (3)

(1) USDA-ARS WWQL, Pullman, WA, U.S.A.; (2) Washington State University, Pullman, WA, U.S.A.;
(3) USDA – Western Wheat Quality Lab, Pullman, WA, U.S.A.

Soft durum is an emerging new grain ingredient used as a novel product. Unlike traditional durum, soft durum can be milled on any mill that handles soft and hard wheat; no special, dedicated mill is necessary. Because of its ease of milling, soft durum has shown extensive potential to be used in traditionally soft wheat products, bread, and pasta. Several objectives continue to be explored: translocation of Glu-D1 genes for better bread potential, introgression of the Gpc-B1 gene for added grain protein, and studying the agronomics of soft durum to provide greater value to the growers. Glu-D1 alleles were translocated into two populations of Soft Svevo in place of the Glu-A1 allele. These two Glu-D1 alleles were Dx5+Dy10, typically associated with stronger gluten properties, and Dx2+Dy12, typically associated with weaker gluten. Following a bread bake of 60 lines containing these translocations, the Soft Svevo with Dx2+Dy12 resulted in greater bread loaf volumes and better dough handling properties. The dough from Soft Svevo containing Dx5+Dy10 was overly strong and did not have sufficient oven spring. The Gpc-B1 allele was crossed into Soft Svevo using the variety Desert King High Protein. Following three environments of evaluation, 30 lines with and without Gpc-B1 did not show any bread quality differences, though there was a protein content increase of 0.9% when Gpc-B1 was present. Soft durum was grown in several locations across several crop years to evaluate various agronomic properties. Soft Svevo and several varieties developed from Soft Svevo were evaluated for resistance to aluminum toxicity, Hessian Fly, stripe rust, stem rust, dwarf bunt, and cereal cyst nematode. A seeding rate study was also completed at two locations to evaluate the optimum seeding rate for maximum yield. Soft durum exhibited moderate resistance to strong resistance to stripe rust, stem rust, cereal cyst nematode, and mixed results to Hessian Fly. No aluminum toxicity resistance was observed. The seeding rate found to maximize yield was 161 seeds/m² in dry locations (<28 cm precipitation/year), and 237 seeds/m² in a higher rainfall area (~48 cm precipitation/year). The more knowledge gained about soft durum, its dough behaviors, and agronomics, the greater potential for its cultivation and utilization.

Effect of egg white, sugar, and oil on gluten-free batter properties and bread quality

Y. ZHANG (1), Y. Li (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

There has been a strong demand for gluten-free bakery products due to increased incidence in celiac disease and gluten-sensitivity, as well as consumer's need of diverse food choices. Egg, sugar, and oil are commonly added into wheat-based bakeries to improve dough/batter rheology and product quality; however, less is known about

their effects in gluten-free systems. The objective of this study was to investigate the effect of different levels (low, medium, and high) of egg white (EW, 4, 8, and 12%), sugar (5, 7.5, and 10%), and oil (4, 8, and 12%) on gluten-free batter properties and bread quality. Commercial gluten-free flour comprising of potato starch, tapioca flour, sorghum flour, and bean flours was used as the base flour. Batter properties were characterized using a rapid visco analyzer (RVA) and oscillation rheometer. Bread quality attributes including baking loss, specific volume, color, moisture content, crumb structure, texture, and staling were determined. Effects of bread formulation on the formation of melanoidins and bread antioxidant capacity were characterized using a spectrophotometer. Adding EW, sugar, and oil decreased batter RVA viscosities and altered batter viscoelasticity. Increasing the amount of EG and sugar greatly increased bread specific volume. Larger number of cells and much even crumb cell structures were achieved with EG, sugar, and oils. Although adding sugar, oil, and EG did not affect the amount of starch retrogradation, the retrogradation peak temperature was slightly increased based on DSC results. Bread melanoidin content and antioxidant capacity were also affected by bread formulations. This study will benefit the development of better quality gluten-free bakery products.

Another break in the wall: Plant structural integrity and nutrients digestibility

E. CAPUANO (1)

(1) Università Di Napoli Federico II, Portici, Italy

So far nutrition science has poorly considered that the bioavailability of a nutrient is intrinsically coupled to the specific food matrix it occurs in. During digestion, the food matrix, and in particular the structure of food, modulates the extent and kinetics to which nutrients and bioactive compounds make themselves available for absorption. This is especially relevant for plant-based foods, which are characterized by a continuous network of cell walls. Cell walls are constituted of dietary fibre (DF) which is resistant to digestion in the small intestine. When cellular integrity is retained, nutrients are “encapsulated” within cell walls and the cytoplasmic environment which shields them from digestive enzymes and modulates their bioavailability. In this presentation I will provide some examples of how structural integrity affects nutrients bioavailability in plant foods, with special attention to pulses and legumes. This comprises bioavailability of macronutrients in the small intestine but also modulation of the utilization of undigested nutrients by the gut microbiota. Considering the structure rather than just the composition of foods opens up possibilities for the design of healthier foods where extent and kinetics of nutrients digestion/absorption is optimized.

Using plant-derived ingredients as tertiary butyl hydroquinone (TBHQ) alternatives in whole-grain breakfast biscuits

K. ROBBINS (1)

(1) Kemin Food Technologies, Des Moines, IA, U.S.A.

Whole-grain (wheat, buckwheat, rye, oats) breakfast biscuits treated with 0.200% rosemary extract (RE), 0.100% rosemary and ascorbic acid (RA), 0.0800% mixed tocopherols (MT), 0.0188% tertiary butyl hydroquinone (TBHQ), and no treatment, were evaluated using chemical (peroxide values (PV) and hexanal) and sensory analyses under ambient storage conditions (22°C) over 48 weeks. The objective was to evaluate the efficacy of the plant extracts and plant-derived ingredients compared to the synthetic antioxidant in delaying rancidity and flavor changes. The chemical analyses showed that the RE, RA, and TBHQ had the lowest primary and secondary oxidation markers. From week 4 onward, the MT biscuits had higher ($p < 0.05$) PVs than the other treatments and the untreated control. At weeks 36, 44, and 48, TBHQ had lower ($p < 0.05$) PV than the RE; however, the RA biscuits were not significantly different than either the TBHQ or the RE. The untreated control and MT had higher ($p < 0.05$) levels of hexanal than the RE, RA, and TBHQ from week 24 onward. Starting at week 12, the acceptance scores for the untreated and MT were lower than RE, RA, and TBHQ. This trend continued through week 48. From a sensory standpoint, the panelists deemed the untreated control unacceptable (score < 5.0) at week 32, whereas MT was unacceptable starting at week 40. The three treatments (RE, RA, TBHQ) which distinguished themselves as the best had similar acceptance scores at week 40 and 48, and they remained above the acceptability threshold for the entire study. Statistical analysis of the correlation between the instrumental and sensory testing revealed a strong negative correlation ($r = -0.9122$) between sensory scores and PV, and also between sensory scores and hexanal levels ($r = -0.8199$). Treatments with higher quantities of oxidative byproducts had lower acceptance scores. Using only panelists who were trained and screened for their aptitude at discriminating between fresh, moderately fresh, moderately oxidized, and extremely oxidized breakfast biscuits was key to generating sensory data that was nearly as predictive as the chemical data. Additionally, there was a strong ($r = 0.8323$) positive correlation between the peroxide values and the hexanal levels. As the biscuit category continues to use alternative grains and healthier oils to align with industry trends, there is a growing need for consumer-friendly solutions to maintain quality and acceptance during shelf life. This study showed that RE and RA were effective options for label-friendly shelf life extension of whole-grain breakfast biscuits.

Arabinoxylan and endoxylanases in the animal gastrointestinal tract

A. Bautil (1), M. R. Bedford (2), C. M. COURTIN (1)

(1) KU Leuven, Leuven, Belgium; (2) AB Vista Feed Ingredients, Marlborough, U.K.

The dietary fibre fraction of cereal-based diets for animals like pigs and chickens (with a monogastric and avian digestive system, respectively) largely consists of non-starch carbohydrates (NSC), mainly arabinoxylans (AX). As these animals lack the metabolic capacity to produce carbohydrate active enzymes to degrade the NSC of cereal cell walls, they rely on their intestinal microbiome to hydrolyze and ferment the dietary fibre fraction of the feed. To overcome the anti-nutritional effects of the dietary NSC substrates, endoxylanases are frequently added to the animal diets. But addition of these enzymes also improves fibre digestion, due to the modification of both the structural and physicochemical characteristics of the NSC substrates, thereby making them better available for microbial fermentation. In this talk we discuss the fate of AX and impact of endoxylanases in the animal gastrointestinal tract by demonstrating the importance of broiler age and the age-related microbial development on the capacity of broilers to degrade dietary AX. Furthermore, we show that supplementation with prehydrolyzed AX can kick start the fibre solubilizing and fermentation capacity of the intestinal microbiota at young broiler ages. Nutritional intervention strategies should take the age-related and diet-adapted fibre degrading potential of the intestinal microbiota into account. Depending on dietary ingredients and broiler age, microbiota will contribute differently to fibre digestion.

Understanding possible gluten contamination in lentils

N. RAMACHANDRAN (1), L. Malcolmson (1), T. Heal (1), M. Hughes (2)

(1) Avena Foods Limited, Portage la Prairie, MB, Canada; (2) Avena Foods Limited, Regina, SK, Canada

Though naturally gluten-free, supplying gluten-free pulses (peas, beans, lentils and chickpeas) and pulse ingredients (flours, grits) can pose a challenge due to the possible risk of contamination with either gluten containing grains or grain dust. Gluten contamination of pulses is possible at several stages including harvesting, transportation and processing. Incoming pulse samples are visually assessed and the requirements for cleaning are determined. Regardless of the level of foreign material, several stages of cleaning are used including the use of mechanical separators and aspirators. More rigorous cleaning will be done to obtain gluten-free pulses. The removal of gluten containing grains from lentils is especially challenging due to the size and shape of the seed compared to other pulse types. To better understand the possible contamination of lentils with gluten containing grains and grain dust, a series of laboratory scale experiments were conducted. In the first experiment, the influence of granulation size (flour and grit) on the detection of gluten was examined. Lentils (1 kg) which had been visually inspected for the presence of gluten containing grains and tested for gluten using ELISA-R5 was spiked with two kernels of wheat and milled into grit and flour and re-tested for the presence of gluten. Flour samples tested positive for gluten whereas gluten was not detected in the grit samples. A second spiking experiment was carried out to examine the effect of grain dust on gluten contamination. Lentils (1 kg) were spiked with wheat flour at levels of 0.1 and 0.2%. All of the samples were above the allowable EU/Codex Alimentarius limit of 20 ppm. However, after the lentils underwent bench scale aspiration and vacuum sifting the level of gluten was reduced to well within the acceptable limit. A third experiment was undertaken to examine if the deliveries made by farmers varied substantially in terms of gluten contamination. Lentil samples collected from different farmers were visually examined for foreign material including gluten containing grains. After removing the visual contaminants, the lentils were tested for gluten. Further cleaning of lentils using bench scale mechanical and aspiration techniques was then carried out and the samples re-tested for gluten. Differences were found among the various samples. Our findings suggest there are a number of factors which influence gluten contamination in lentils. Understanding these factors is critical in ensuring the supply of safe gluten-free pulses and pulse ingredients.

Nutritional benefits of germinated wheat

E. LEMMENS (1), N. De Brier (1), L. J. Deleu (2), K. Spiers (3), P. Goos (1), E. Smolders (1), J. A. Delcour (2)

(1) KU Leuven, Leuven, Belgium; (2) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium; (3) Photon Science, Deutsches-Elektronen Synchrotron DESY, Hamburg, Germany

Wheat whole grains are a good source of dietary fiber and an array of bio-actives including minerals such as iron (Fe) and zinc (Zn). However, only 5 to 10% of Fe and Zn ions are bio-accessible as these minerals are both physically and chemically entrapped. The physical barrier is set by the rigid cell walls which withstand conventional milling and human digestion enzymes. Phytic acid, the main storage form of phosphorus (P), chelates divalent cations like Fe and Zn. During germination hydrolytic enzymes are activated and *de novo* synthesized to fuel seedling growth. Endoxylanases alter the cell wall by hydrolyzing and solubilizing arabinoxylan into water extractable arabinoxylan (WEAX). At the same time, the increase in phytase activity makes minerals available. Both the opening of aleurone cells and breakdown of phytate by germination may result in a greater mineral accessibility in the human gastro-intestinal tract. To explore the potential of steeping and germination of wheat optimal conditions were selected from a multifactor experiment based on phytate and

WEAX content. Steeping for 36 h at 15°C and germinating for 120 h at 26°C decreased phytate content from 0.96% to 0.64% of initial dry matter and increased WEAX content from 0.48% to 1.34% of initial dry matter. While the Fe and Zn bio-accessibility in the grains was 5% and 3%, respectively, that in the germinated grains was 6% and 8% when the cellular matrix was preserved, and 22% and 21% when it was mechanically disrupted by milling. This revealed that controlled germination of wheat improves mineral bio-accessibility when the cell walls are substantially broken down. Moreover, high-definition μ -X-ray fluorescence microscopy was here for the first time used to map changes in distribution of Fe and Zn between and within wheat tissues during germination. While Zn and Fe are clearly confined to the aleurone cells in regular wheat, co-localizing with P globoids, Zn was translocated to the pericarp, coleoptile and radicle during germination. This proves that it is more available in the seedling than in the aleurone, where it is used for different biological functions, such as protein synthesis.

Significance of particle and environmental conditions on the flow properties of hard and soft wheat flours

J. D. R. RIVERA (1), A. Owonikoko (2), J. C. Zhao (2), K. Siliveru (1)

(1) Grain Science and Industry, Kansas State University, Manhattan, KS, U.S.A.; (2) Biological and Agricultural Engineering, Kansas State University, Manhattan, KS, U.S.A.

Powder flowability is affected by environmental factors such as temperature and relative humidity as well as particle morphological characteristics. Knowing the flow properties of powders is essential in establishing efficient powder processing steps. The study will also help in determining the particle mechanics that are responsible for the resistance to flow in the hard red winter (HRW) and soft red winter (SRW) flours. The objective of this study is to determine the effect of temperature, relative humidity (RH), and particle size on the flow properties of HRW and SRW wheat flours. Physical, chemical, and morphological analysis of the HRW and SRW flour samples were conducted. In evaluating the effects of particle size, flour samples (HRW and SRW) were sieved into three size fractions (<53, 53-106, and >106 microns). Size classes from each flour sample were exposed to different temperatures (15, 25, and 35°C) and RH (50-55, 60-65, and 70-75%) to account for the variations in the ambient conditions in different seasons. The tapped and bulk densities of each fraction were then measured to calculate the Hausner ratio (HR). The Malvern particle morphology system was used to further define the particle morphology of each size fraction while the Freeman FT4 rheometer was used for measuring the flow properties (dynamic, bulk, and shear properties). HR calculations indicate that SRW flours are more cohesive (HR = 1.24) and exhibit poorer flowability compared to HRW flour (HR = 1). It was also observed that, the smaller size (<53 microns) particles for both the wheat classes have poor flowability when compared to other particle sizes. The shear cell measurements indicate that SRW flour has a lower (1.55) flow function (FF_c) compared to HRW flour (3.73) indicating poorer flowability nature. The compressibility measurements indicate that SRW flour is more compressible than HRW flour for all the sizes. Wall friction angle (WFA) measurements indicate that HRW flour have higher flow resistance compared to SRW flour when tested on a steel wall container. A highly significant correlation ($R^2 = 0.9$) was observed for the relationship of particle size with WFA, compressibility, FF_c, cohesion, specific energy and flow rate index which indicates a good relationship between particle size and the flow measurements. The same relationship was observed for both flour classes at different humidities. The smaller particle sized flours are more likely to exhibit poorer flow compared to larger particle sized flours.

Physical properties of prolamin simple coacervates and applications in food technology

R. DE VRIES (1)

(1) Wageningen University & Research, Wageningen, Netherlands

Traditionally, complex coacervates of oppositely charged biopolymers have been used to form coatings around oil droplets for encapsulation of oil-soluble active ingredients, such as in the classic gelatin-gum Arabic system. However, many proteins can form coacervates by themselves, under certain conditions. Well known examples that have been studied in the past are for example lens crystallins and zein in mixed water/ethanol solvents, or seed globulins at low temperatures and low salt. Such “simple” protein coacervates are currently raising much attention in biophysics with the discovery that living cells use droplets of such simple protein coacervates as dynamic microcompartments. Here we revisit the well known simple coacervates of prolamins such as zein in mixed solvents, to explore whether they can be used for plant-based encapsulation systems. We show that for zein in mixed solvents, we can encapsulate oil droplets, but only under specific conditions. We show that this is due to the very different physical properties of the simple zein coacervates as compared to those of classic polysaccharide/protein complex coacervates. In particular we show that wetting of the coacervate at the oil-water interface is generally thermodynamically favored, but the kinetics of coacervate droplet deposition and the interactions between coacervate droplets are highly pH dependent, leading to a sharp pH optimum (around pH 8) for capsule formation.

Milling process and cultivars impact pea flour functionality and flavor profile

H. JIANG (1), J. Rao (1)

(1) North Dakota State University, Fargo, ND, U.S.A.

There is a growing interest in utilizing pulse ingredient in food due to health benefits, such as allergen-free and gluten-free claim that can be made on foods. Nevertheless, beany flavor, sensory problems, and some functionality are continuing impediments to popularizing pulses as functional food ingredients. This study aimed to study how yellow pea varieties and ultracentrifugal milling parameters could potentially impact functionality and flavor profile of flours. The particle size of yellow pea flours detected by dynamic light scattering instrument was around 49 to 72 nm and all pea flour presented bimodal particle size distribution. The range of moisture content, ash content, protein content, lipid content, and total starch content of eight pea flours was around 7-11%, 2.0-2.8%, 20-25%, 1-3%, and 39-44%, respectively. The pasting properties of eight pea starches showed significant differences in terms of breakdown and final viscosity value using rapid visco analysis (RVA). Hexanal, 1-pentanol, 3-methyl-1-butanol, and 1-hexanol were selected as beany flavor markers. From the GC-MS measurement, one variety of pea flour, Meadow, showed singular and lowest beany flavor among all selected yellow pea varieties. This study indicated that yellow pea varieties had an essential impact on flavor profile and pasting property of pea flour. The accomplishment of this research will provide useful information not only to pulse growers to grow the varieties with premium characteristics, but also to pulse ingredient manufacturers and consumer companies to select raw materials with greater functionality.

A novel soluble crosslinked corn bran arabinoxylan matrix supports a shift to butyrogenic gut bacteria and forms a gel at low pH

X. ZHANG (1), B. R. Hamaker (1)

(1) Department of Food Science, Purdue University, West Lafayette, IN, U.S.A.

Insoluble fermentable cell wall matrix fibers have been shown to support beneficial butyrogenic *Clostridia*, but have restricted use in food products. Here, a soluble fiber matrix was developed that exhibited a similar effect. Low arabinose/xylose ratio corn bran arabinoxylan (CAX) was extracted with two concentrations of sodium hydroxide to give soluble polymers with relatively low and high residual ferulic acid (CAX-LFA and CAX-HFA). After laccase treatment to make diferulate crosslinks, soluble matrices were formed with average 3.5 to 4.5 mer. *In vitro* human fecal fermentation of CAX-LFA, CAX-HFA, soluble crosslinked ~3.5 mer CAX-LFA (SCCAX-LFA), and ~4.5 mer SCCAX-HFA revealed that the SCCAX matrices had slower fermentation property and higher butyrate proportion in SCCAX-HFA. 16S rRNA gene sequencing showed that SCCAX-HFA promoted OTUs associated with butyrate production including Unassigned *Ruminococcaceae*, Unassigned *Blautia*, *Fecalibacterium prausnitzii*, and Unassigned *Clostridium*. Moreover, SCCAXs exhibited interesting gel forming property on simple pH reduction, which is similar in gelling property to low acyl gellan gum, though is readily soluble in water. Both of the SCCAXs formed gels at pH 2, with SCCAX-HFA forming the stronger gel. Gels showed shear-thinning behavior and a thermal and pH reversible property. A gel forming mechanism was proposed involving noncovalent crosslinking including hydrogen bonds and hydrophobic interaction among the SCCAX complexes. This mechanism was supported by structural characterization of SCCAX complexes using a Zeta-sizer and FT-IR spectroscopy. SCCAX-HFA could be used in low sugar gels and promotes butyrogenic bacteria in the gut.

Use of pre-germination combined with infrared heating to improve the functional characteristics and nutritional value of lentil flours

S. LIU (1), H. Yin (1), M. D. Pickard (2), Y. Ai (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada; (2) InfraReady Products (1998) Ltd., Saskatoon, SK, Canada

Lentils are an important member of the nutritious *Leguminous* crops. To improve the functional and nutritional properties of lentil flours, a combined modification method of pre-germination and infrared heating was employed. Lentil seeds of three varieties, including CDC Greenstar (large green), CDC Invincible (small green) and CDC Maxim (small red), were tempered at 25% moisture for 24 h, subjected to pre-germination at the same moisture for 0, 24, 48 and 72 h, and then infrared heated to a surface temperature of 130 and 150°C, respectively. Variations were found in the starch and protein contents of the three lentil varieties, but the treatment did not cause significant changes in the chemical compositions. A longer pre-germination period followed by infrared heating generally led to a larger percentage of damaged starch, which was attributed to a greater extent of starch gelatinization. The protein solubility was largely reduced after the treatment. The damaged-starch contents of the lentil flours after 130°C treatment was largely higher than those of the counterparts modified at 150°C, which could be related to faster water evaporation from the lentil seeds at the higher temperature. Greenstar showed a lower damaged-starch content compared with Invincible and Maxim after the same treatment because Greenstar had a larger seed size (*i.e.*, less specific surface area exposed to infrared heat). With an increased level of starch gelatinization, the modified lentil flours in general showed remarkably greater water-holding capacity and higher

initial pasting viscosities, but exhibited smaller particle sizes, lower peak and final viscosities, and weaker gelling ability when compared with their respective raw flours. Moreover, both uncooked and cooked modified lentil flours showed a higher amount of rapidly digestible starch but a lower amount of resistant starch compared with their respective raw flours. The digestibility of protein was also enhanced in the modified lentil flours because of the weaker association between starch and protein. Additionally, the impacts of pre-germination time and infrared heating temperature on the contents of bioactive compounds, such as vitamin B complex and γ -amino butyric acid were investigated. The modification method of combining pre-germination and infrared heating has shown promise in enhancing the functional characteristics and nutritional quality of lentil flours. The treatment can also be utilized to modify other pulses and cereal grains to generate new food ingredients for wider food applications.

Composition and properties of black bean flour processed by excess steam jet-cooking at different pH levels

F. C. FELKER (1), J. A. Kenar (1), M. Singh (1), J. K. Winkler-Moser (1), S. X. Liu (1)
(1) USDA-ARS-NCAUR, Peoria, IL, U.S.A.

Pulse consumption is rapidly increasing due to the growing recognition of the many health benefits that their inclusion in the diet can confer. One approach for improving pulse flour properties is pretreatment by excess steam jet-cooking, and since black beans are of particular interest due to their conspicuous anthocyanin content and high antioxidant levels, the effects of jet-cooking black bean flour at different pH levels from 3.0 to 8.0 were examined. As the pH of jet-cooking increased, water absorption, protein solubility, initial viscosity on pasting, and degradation of phenolics increased. Antioxidant levels were not affected by jet-cooking at pH levels of 3 and 4.5, but decreased 34% and 55% by jet-cooking at pH 6 and pH 8, respectively. At pH 3, raffinose family oligosaccharides were partially degraded and insoluble fiber was reduced. The microstructure of freeze-dried flours when placed in water varied consistently with differences in water absorption and protein solubility. Flours exhibited characteristic bright pink and violet colors when jet-cooked at pH 3 and 4.5, respectively. The results of jet-cooking at two different temperatures and at different pH levels suggest that further processing modifications and combinations would enable further flour improvement leading to increased utilization in food applications.

Impacts of flour quality and drying condition on quality of Korean style dried white-salted noodles

Y. Moon (1), M. KWEON (1), S. Kim (1), Y. Zhao (1), X. Wang (1)
(1) Pusan National University, Busan, South Korea

The most substantial consumption of flour in Korea is used for making dried noodles. Numerous studies on the fresh noodle making performance have reported, but scientific reports on dried white-salted noodles focused on drying condition are very scarce. The present study explored how flour quality and drying conditions affect the quality of Korean style dried white-salted noodles. One commercial all-purpose flour (A) and two commercial Korean domestic flours (B and C) were used in the study. Flour quality was analyzed with solvent retention capacity (SRC) and Rapid ViscoAnalyzer (RVA). Dried noodles were prepared by drying at different temperatures of 30, 40, 50, and 60°C with or without applying air circulation. Quality of the noodles was analyzed with cracks and breaking force for dried noodles, and cooking and textural properties for cooked noodles. Ash and protein contents of the flours were ranged from 0.37-0.65% and 9.0-10.2%, respectively. SRC results showed much higher lactic acid SRC value and gluten performance index for the flour A than for the flour B and C. RVA results showed a significantly lower peak, final and setback viscosity of the flour A than those of the flour B and C. A significant increase in cracks and a resulted decrease in breaking force were observed for the noodles with all flours dried at 50 and 60°C without air circulation during drying. The noodles with all flours applied air circulation during drying also exhibited an increase in cracks and a decrease in breaking force. For the analysis of the cooking property, the noodles with all flours dried at 30°C without air circulation showed only completely intact noodle strands during cooking, and those at 40°C showed a slight breakage of cooked noodle strands. However, those at 50 and 60°C showed dramatic and severe breakage of cooked noodles. The noodles with all flours dried even at 30°C with air circulation showed a slight breakage of cooked noodle strands, which was a similar trend to those at 40°C without air blowing. However, those at 40, 50 and 60°C with air circulation showed apparent and severe breakage in cooked noodle strands. Although flour quality showed a relationship with the firmness of cooked noodles, drying temperature and air circulation gave more dominant effects on the quality of dried white-salted noodles. For producing excellent quality of dried white-salted noodles, drying at high temperature and with air circulation for shortening drying time would not be desirable.

Variation in appearance and properties of milled rices from different regions

Y. J. WANG (1)

(1) Department of Food Science, University of Arkansas, Fayetteville, AR, U.S.A.

Rice quality is mainly determined by its milling, physical, chemical, cooking, and eating properties, and is governed by genetic background, environments, and farming practices. In the U.S., rice is commonly classified into long-, medium-, and short-grain classes according to grain dimensions. Long-grain rice accounts for more

than 70% of U.S. production and is grown almost entirely in the South. Medium-grain is grown in both California and the South, and short-grain rice is grown exclusively in California. Being a major rice exporter, the U.S. also imports about 9% of its total supply of rice, predominantly jasmine from Thailand. Different rice classes have different chemical compositions and properties; therefore, they are used in different applications. Diversification of rice cultivars is necessary because of their variation in adaptation to various locations, thus processing characteristics and eating quality of rice become less predictable. Among chemical components, starch is a key determinant of rice quality because starch constitutes 90% of milled rice dry weight. Starch properties are affected by its composition and structure, which are strongly influenced by the production environment. Environmental factors affecting starch properties include geographic location (latitude and altitude), climate (temperature, solar radiation, rainfall distribution, day length, winds, and relative humidity), land and soil (topography, type, and fertility), water supply, and farming practices. Therefore, rice from different regions displays different properties that reflect influences from environments and genetic makeup and their interactions. In this presentation, the kernel appearance, chemical composition, and starch fine structure of milled rice from different grain types and different regions will be discussed.

Micro- and macromolecule composition of quinoa leaf and grain of three genotypes grown in Puerto Rico

E. VIDAL TORRES (1,2), E. Valencia (1), A. Linares (1), J. Dumas (1), S. Simsek (2)

(1) University of Puerto Rico – Mayaguez Campus Agroenvironmental Sciences, Mayaguez, PR, U.S.A.;

(2) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Quinoa (*Chenopodium quinoa* Willd.) grain has attracted scientific research because of its broad genetic diversity and high nutritional value. In the tropics, little is known about quinoa grain chemical composition or the potential use of its young succulent leaves as edible greens. This research developed an amino acid profile, determined crude protein, dietary fiber, total fat, starch and mineral (calcium, magnesium, phosphorous, potassium, iron and zinc) concentrations for leaves (3-weeks old) and grains from heat-tolerant quinoa genotypes [Ames 13746 (Pison), Ames 13748 Copacabana) and Ames 13745 (Kaslaea)]. Compositional analysis was completed using AOAC, AACC, and AOCS official methods. Leaf samples were dried in a forced air oven at 65°C for 72 hours, ground in a Wiley mill. Grains at physiological maturity (15-weeks) were harvested, dried and ground for analysis. Data was analyzed using SAS, Statistical program and when means were significant were separated using Tukey's test. Lysine content was higher than most other staple grains. There was no significant ($p > 0.05$) difference between Pison, Copacabana and Kaslaea for crude protein of leaves and grains, with mean percentages of 33.3 and 16.6%, respectively. Insoluble dietary fiber (IDF), total dietary fiber (TDF) percentage in the leaves differed significantly ($p > 0.05$) among quinoa, whereas soluble dietary fiber (SDF) was similar. Quinoa grains did not differ significantly ($p > 0.05$) in percentage IDF, SDF and TDF, nor in total fat and total starch. Calcium (Ca) and phosphorous (P) concentrations of leaves were different ($p < 0.05$) among accessions, but magnesium (Mg), iron (Fe), potassium (K) and zinc (Zn) were not different in leaves. Among quinoa grains there was no significant ($p > 0.05$) difference in mineral contents. This result show high crude protein and minerals of quinoa genotypes, with Kaslaea exhibiting higher TDF in their leaves. Sensory evaluations should assess potential use of leaves for human consumption.

Optimization of de-hulling and milling of chickpeas using roller mills

R. MARTIN (1), J. C. Zhao (2), K. Siliveru (1), S. Alavi (1)

(1) Grain Science and Industry, Kansas State University, Manhattan, KS, U.S.A.; (2) Biological and Agricultural Engineering, Kansas State University, Manhattan, KS, U.S.A.

Chickpeas and other pulses are gaining popularity because of their nutritional quality and sustainability. Chickpea flour is commonly prepared using hammer mills and de-hulling typically involves higher water usage. Roller milling can be more beneficial than hammer milling with greater hull separation and lower water usage. The focus of this research was to optimize the use of roller mills in processing chickpeas into flour and a larger particle meal. Milling characteristics of two varieties were studied, Kabuli and Desi. These varieties are commonly used and differ in size and composition. Kabuli seeds were larger with thinner hulls and Desi seeds were smaller with thicker hulls. Lab-scale roller mills were used for initial process design. Flow sheets were designed for each variety; one for flour (≤ 150 microns) and one for meal (300-750 microns). Independent variables included the number of rollers, roller gap size, roller characteristics, sieve separation, and tempering methods. Results were analyzed on flour yield, chemical composition, particle size, starch damage and functionality of in baking crackers. Compositional tests included ash, protein, lipid, fiber, and total starch. Extent of damage to starch and water interactions were measured using Rapid Visco Analysis (RVA). Cold tempering to 11% was found to be optimum, with flour yields up to 92%. Proximate analysis of flour showed reduction in crude fiber as compared to the whole chickpea from 3.8% to 0.92%, and an increase in total starch from 39.9% to 46.6%. Flow sheets designed for meal produced an average of 20% flour as by-product. RVA peak viscosity for chickpea meal was very low (191-248 cP). For flour, higher peak viscosities were observed for Desi (1,050-1,100 cP) as compared to Kabuli (850-900 cP), and also lower breakdown for Kabuli (80-105 cP versus 77-123 cP). Pasting temperatures were similar for both flours (70-75°C). These data suggested greater amount of damaged starch in Kabuli flour.

Crackers baked from these raw flours were consistent with this inference, as crackers from Kabuli flour had a smoother appearance than the ones from Desi. Both had undesirable flavors compared with crackers baked from commercial chickpea flour that was precooked. The commercial flour had very low peak viscosity (80-90 cP) showing the impact of thermal treatment. Future work will include scaling-up the milling process to a pilot-scale roller mill, and thermo-mechanical pretreatment of flours using pilot-scale twin screw extrusion to get rid of off flavors as opposed to the currently used thermal treatment.

Optimization of poly(lactic acid)/poly(butylene co-adipate-terephthalate)/thermoplastic starch nanocomposite films for barrier and mechanical properties

P. H. MANEPALLI (1), X. Sun (1), S. Narayan-Sarathy (2), S. Alavi (1)

(1) Kansas State University, Department of Grain Science and Industry, Manhattan, KS, U.S.A.; (2) PepsiCo Global Snacks Packaging R&D – Discovery, Plano, TX, U.S.A.

Poly(lactic acid) (PLA) is the most common bio-based and compostable polymer available commercially that is cost competitive and combines a range of desirable properties like melt processability, high strength and modulus. The films made from this aliphatic polyester tend to be brittle which can be overcome by blending PLA with another bio-based polymer with high flexibility poly(butylene adipate-co-terephthalate) (PBAT), but the resultant blend is only biodegradable in composting conditions. Thermoplastic starch (TPS) was incorporated in PLA/PBAT blends to increase the rate of biodegradability and decrease the cost. 0.5% Joncryl was used as a compatibilizer. Mixture response surface methods were used to investigate the effect of PLA, PBAT, TPS and nanofiller nanocrystalline cellulose (NCC) on the responses water vapor permeability (WVP), tensile strength (TS), elongation at break (EB). All factors including levels of PLA, PBAT, TPS, NCC influenced the mechanical and barrier properties of the films. Quadratic models with good predicted R^2 (between 84.3% and 97.59%) were developed for all the responses. Addition of PBAT improved the EB of the films while NCC and TPS addition decreased the EB. TPS addition decreased the mechanical properties and increased the WVP; but addition of NCC increased the tensile strength of the PLA/PBAT/TPS blends and decreased the WVP. Optimization study was done that could yield films with optimum properties comparable to commercial plastics and maximizing the level of TPS. Films with optimum properties (TS = 29.5 MPa, EB = 12%, WVP = 1.99 g.mm/kPa.h.m²) were predicted at levels of 64.3% PLA, 14.5% PBAT, 18% TPS and 2.6% NCC along with 0.5% Joncryl. The improved mechanical and barrier performance suggested that PLA/PBAT/TPS/NCC nanocomposites have potential use in food packaging applications.

2019 Alsberg-French-Schoch Memorial Award Presentation – A 39-year retrospective on Slade/Levine’s ‘food polymer science’ approach to the practice of industrial R&D, leading to U.S. patent estates based on fundamental starch science and technology

L. Slade (1), H. LEVINE (1)

(1) Food Polymer Science Consultancy, Morris Plains, NJ, U.S.A.

This award lecture presents a 39-year retrospective on the applications of Slade/Levine’s ‘Food Polymer Science’ approach to the practice of industrial R&D, leading to U.S. patent estates based on fundamental starch science and technology. The areas of patents and patented technologies reviewed here include: a) soft-from-the freezer ice creams and freezer-storage-stable frozen bread dough products, based on ‘cryostabilization technology’ of frozen foods, utilizing commercial starch hydrolysis products (SHPs); b) glassy-matrix encapsulation technology for flavors and other volatiles, based on structure-function relationships for commercial SHPs; c) production of stabilized whole-grain wheat flours for biscuit products, based on the application of ‘solvent retention capacity’ technology to develop flours with reduced damaged starch; d) production of improved-quality, low-moisture cookies and crackers, based on pentosanase enzyme technology; e) production of ‘baked-not-fried’, chip-like, starch-based snack products, based on the use of commercial modified-starch ingredients with selected functionality; f) accelerated staling of a starch-based food product from baked bread crumb, based on the kinetics of starch retrogradation, treated as a crystallization process for a partially crystalline glassy polymer system; and g) a process for producing an enzyme resistant starch, for use as a reduced-calorie flour replacer in a wide range of grain-based food products, including cookies, extruded expanded snacks, and breakfast cereals.

Individual effects of enzymes and vital wheat gluten on qualities and staling characteristics of bread made from whole grain wheat flour

L. Tebben (1), Y. LI (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

Compared to white bread, whole wheat bread has a small loaf volume and hard crumb texture, creating unique challenges for the baking industry and for consumer acceptability. Enzymes have been widely studied in white pan bread, but less information has been published on their use in whole wheat bread. The objective of this research was to determine effects of five enzymes on whole wheat bread properties, with a focus on loaf volume, bread texture, and staling. Bread was prepared from whole wheat flour following AACC Approved Method

10-10.03. Enzymes (α -amylase, cellulase, glucose oxidase, maltogenic amylase, and xylanase) were added at three levels based on the minimum, maximum, and 50% greater than the maximum recommendations provided by the manufacturer. Vital wheat gluten (VWG) was added as an additional, separate treatment at 2.5% (fwb). Dough rheological properties were determined by farinograph and mixograph. Specific volume was measured for fresh bread, and moisture content, texture profile analysis (TPA), and crumb structure were analyzed the following day. Moisture content and TPA were measured again after 3 and 7 days of storage at 22°C to determine changes associated with staling. Effect on starch retrogradation was quantified by differential scanning calorimetry (DSC) after the 7 days. Enzymes had minimal effect on water absorption and mixing time for whole wheat dough. Each enzyme increased specific loaf volume for at least one of the usage levels tested ($P < 0.01$). Among the enzyme treatments, the greatest loaf volume was seen for xylanase at the medium and high levels. No enzyme was as effective as VWG at increasing loaf volume. Enzymes did not significantly change cell structure, except for a slight increase in cell wall thickness ($P < 0.05$) and cell diameter ($P < 0.01$) for the high level of maltogenic amylase. The greatest reduction in fresh bread hardness was obtained for the high level of xylanase. VWG, maltogenic amylase, and xylanase reduced the rate of bread firming over 7 days. α -Amylase, cellulase, and maltogenic amylase decreased starch retrogradation at day 7 as measured by DSC ($P < 0.01$). Maltogenic amylase nearly eliminated the endothermic peak for recrystallized amylopectin, showing this enzyme's strong ability to reduce retrogradation in bread. This study demonstrated the specific application of enzymes in whole wheat bread to increase loaf volume and decrease initial crumb hardness and bread staling, which may help improve the sensory appeal of whole wheat bread and ultimately increase whole grain consumption.

Effect of insect-sorghum meal blend on the proximate composition and protein quality of cookies

M. SIWELA (1), K. Pillay (1), T. D. Awobusuyi (1)

(1) University of KwaZulu-Natal, Pietermaritzburg, South Africa

Protein-energy malnutrition and micronutrient deficiencies are chronic health problems in the sub-Saharan African region, where a large proportion of the population, especially the rural communities are poor and food insecure. Cookies could be a vehicle for alleviating protein-energy malnutrition among vulnerable groups because they are ready-to-eat and widely popular snacks. However, the cereal grain of choice for baking food products is wheat, which is limited in several micronutrients, including protein, and it is also inaccessible as it is imported at a very high cost. On the other hand, sorghum is a gluten-free, cheap, and easily accessible grain that grows well on marginal land and stressful environmental conditions, which are prevalent in large parts of the sub-Saharan African region. Furthermore, because there is a growing demand for meat, there is an urgent need to find alternative protein sources. Insect species are generally high in several nutrients, especially protein and minerals. Unfortunately, insects are underutilized as a food source. Partial substitution of wheat flour with a blend of sorghum and insects in baked foods such as cookies could contribute to the alleviation of these challenges. This study determined the effect of sorghum and insect addition on the nutritional quality of the resultant cookies. Whole grain sorghum and insect flour were substituted at ratio 3:1 (w/w sorghum: insect). To determine the maximum concentration that could be incorporated to produce acceptable cookies, wheat flour was substituted with the sorghum-insect blend at 20%, 40% and 60% (w/w), respectively. The nutritional composition of the cookies was analysed using the Association of Official Agricultural Chemists (AOAC) standard methods. Increasing the concentration of the sorghum-insect meal blend from 0% (control) to 60% significantly improved the nutritional composition of the cookies. Protein content increased by 300%; fibre, 119%; fat, 97% and ash, 147%. Similarly, the concentration of essential amino acids, especially lysine, which is limiting in cereal grains, increased by 300%. The concentration of several mineral elements increased including zinc and iron, by 92% and 91%, respectively. The *in vitro* protein digestibility of the cookies increased by 24% due to incorporation of the insect-sorghum blend. There is potential for incorporating sorghum and insects to produce cookies that could be used to increase the intake of several nutrients, including protein and minerals, by target communities that are chronically vulnerable to nutrient deficiencies.

Biodegradable starch biofilms with modified starch for utilization in biomedical industry

M. OVANDO-MARTINEZ (1), M. Leon-Bejarano (1), S. Simsek (1)

(1) University of Sonora, Sonora, ND, Mexico

Non-biodegradable petroleum-based film materials used by different industries such as biomedical have been associated with environmental problems. For this reason, the production of biodegradable film materials, based on biopolymers, was proposed. Among those polymers, starch represents an option because it is cheap and non-toxic. Native starch does not always have good physicochemical and mechanical properties. Starch can be chemically modified to octenyl succinate starch (OSA starch) in order to create biodegradable films with better properties. Besides this, the main medical problems are the high incidence of wound infections and infections associated with medical devices. Both infections cause microbial development which could be treated with antibiotics. However, nowadays the resistance to antibiotics has been increased. An alternative to antibiotics is the use of bioactive compounds such as polyphenols extracted from by-products generated by the agroindustry. The problem is that such polyphenols are sensible to light, temperature, and oxygen. Therefore, the use of OSA

starch as material to protect these polyphenols is a good option to produce biodegradable films with antimicrobial properties. The objective of this research was to evaluate the physicochemical, biodegradability and antimicrobial properties of films prepared with a mix of OSA starch and polyphenols extracted from pecan nutshell and hazelnut skin. The microbial properties were evaluated using *Staphylococcus aureus* and *S. epidermis*. In both pecan nutshell and hazelnut skin films, the interaction among polyphenols-OSA starch is mainly by hydrogen bonds, and the films' surfaces were homogeneous. Additionally, the extract increased the thickness of both films compared to the control film with only OSA starch, but the water permeability was not affected. The addition of the extract changed the film's color, this being more evident in the hazelnut skin film; however, both films had the ability to block UV-light. With respect to the microbial properties, the zone of inhibition was not observed. However, compared to the control film, the pecan nutshell and hazelnut skin films did not allow the growth of bacterial colonies under the film. Overall, results indicate that films produced with OSA starch and polyphenols from pecan nutshell and hazelnut skin could have potential applications as a wound dressing, patches for catheter insertion areas, or other applications where microbial contamination of packaging is a concern.

The effects of commercially available natural sweeteners, used as substitutes for sucrose, on wheat starch gelatinization and pasting

T. J. WOODBURY (1)

(1) Purdue University, West Lafayette, IN, U.S.A.

Natural sweeteners are increasing in popularity for replacing sucrose in intermediate-moisture sweet baked goods. Sucrose is known to influence product texture by altering starch thermal properties. To guide more informed choices on which alternative sweeteners have the most similar effects to sucrose on starch thermal properties, the objectives of this study were to determine the effects of natural sweeteners and sucrose, at varying concentrations, on the gelatinization temperature, RVA (Rapid Visco Analyzer) profiles, and granule swelling of wheat starch. The natural sweeteners studied were: Truvia, Splenda, Swerve, coconut palm sugar, monk fruit, erythritol, blue agave syrup, yacon syrup, Sukrin syrup, and date sugar syrup. Wheat starch was combined with sweetener solutions (10-60% w/w db in a 1:2 ratio), generating slurries that were then analyzed by differential scanning calorimetry (DSC), RVA, polarized light microscopy, and particle size analysis. For determining gelatinization temperatures by DSC, samples were heated from 30°C – 120°C at 10°C/min, and the gelatinization onset temperature (T_o) was identified by the onset of the baseline shift using the “peak calculation function” in Pyris software. T_o was significantly affected by sweetener type and concentration. Overall, as the concentration of sweetener increased, the T_o of wheat starch significantly increased ($p < 0.05$) compared to the T_o of the negative control (wheat starch and water). The T_o significantly increased compared to the positive control (wheat starch and sucrose) in yacon syrup (30% w/w db) and Sukrin syrup (60% w/w db). At the same concentrations, coconut palm sugar and date sugar syrup resulted in no significant differences in T_o compared to sucrose. Sweeteners containing erythritol (erythritol, Truvia, Swerve, and monk fruit) and blue agave syrup did not increase the T_o as much as sucrose. Sweeteners that had similar effects on T_o as sucrose, at the same concentrations, are potential candidates for 1:1 replacement of sucrose in baked goods. However, these sweeteners did not consistently have the same effects as sucrose on RVA profiles and granule swelling. Different trends were seen for RVA profiles and granule swelling, based on sweetener type and concentration. Although intermolecular hydrogen bond density has been used to describe and predict the effects of sweeteners on T_o , based on the different trends found in starch swelling and pasting, it appears that sweeteners influence starch properties in a more complex manner. The data generated provide a foundation for developing sucrose replacement strategies, based on sweetener effects on starch gelatinization, pasting, and swelling.

The contribution of texturizing and protein ingredients in alternative meat products

Y. BIAN (1)

(1) Ingredient Inc., Englewood, CO, U.S.A.

Meat alternatives are quickly becoming mainstream in both foodservice and retail with vegan burgers, nuggets, tacos, and sausages available at multiple fast food restaurants and supermarkets. Because 86% of consumers buying plant-based products are meat eaters, meat alternative products are required to deliver an eating experience equivalent to animal-based products in taste and texture. The food industry is challenged to develop competitively advantaged ingredient and technology solutions for the growing market of meat alternatives. Vegan meat alternatives formulations are unique but many are made primarily from soy, wheat gluten, and/or pulse proteins. To give the alternative meat a similar texture and taste to its animal-based counterpart, plant-based meats often rely on various ingredients such as texturized vegetable proteins, starches, hydrocolloids, solid fats, liquid oils, and minor ingredients such as colors and flavors. Innovation in this area includes creation of plant-based meat ingredients that retain shape, texture and flavor through freezing, thawing, and cooking across a broad range of prepared products. To successfully formulate an alternative product, we must understand the functional contribution of each ingredient, leverage interactions between plant-based proteins and texturizing agents, and identify key sensory attributes we hope to achieve. This presentation will help guide development of a

functional ingredient system using protein, fat, texturizing components, colors and flavors to deliver appealing finished product quality.

Mixing dynamics of gliadins, HMW-glutenins, and LMW-glutenins analyzed by fluorescent co-localization and protein network quantification

J. C. BONILLA (1), J. L. Kokini (1), A. K. Bhunia (1), J. Schaber (2)

(1) Department of Food Science, College of Agriculture, Purdue University, West Lafayette, IN, U.S.A.;

(2) Bindley Bioscience Center, Purdue University, West Lafayette, IN, U.S.A.

The impact of gluten in affecting the texture and rheology of wheat products is well-known. While, visualization of the distribution of gluten in dough and its linkage with dough physical properties has been done, this is not the case for all its subunits, gliadins, low molecular weight (LMW) glutenins, and high molecular weight (HMW) glutenins. In this research, specific antibodies-quantum dots complexes are used as highly-specific labeling tools to visualize gliadins, HMW-glutenins, and LMW-glutenins in wheat dough. The objective of this research is to link qualitative observations and quantitative data acquired through image processing from the spatial distribution of gliadins, LMW-glutenins, and HMW-glutenins to dough physical characteristics during dough mixing. To do so, the fluorescent detection using Confocal Laser Scanning Microscopy of the gluten subunits are being analyzed at arrival time, peak time, departure time, and 10 min after departure during mixing in a Brabender farinograph following AACC Approved Method 54-21.02 for dough physical test. The images are processed in order to obtain quantitative data regarding the degree of co-localization of the different gluten subunits in the same dough area, and the protein network analysis (PNA) which, is a method for quantification of the network branches from each gluten subunit. It has been found that, gliadins, which are more mobile proteins stay distributed in the dough matrix throughout dough mixing. Aggregates of HMW-glutenins and LMW-glutenins are found at arrival times, then, the co-localization of HMW-glutenins and LMW-glutenins with gliadins increases due to the formation of the strong gluten network at peak time. After continuous mixing, at departure time, the co-localization of LMW-glutenins with gliadins decreases, while HMW-glutenins does not reduce their co-localization with gliadins until 10 min after departure time, forming aggregates between LMW-glutenins and HMW-glutenins again. These results indicate that LWM-glutenins dissociate from the network first, followed by a later dissociation of HMW-glutenins. The results from the individual PNA of each protein subunits corroborate the co-localization results, confirming that the HMW-glutenins and LMW-glutenins interact differently with gliadin during dough mixing. These visualization of the distribution and interactions of the different gluten subunits during mixing makes real the imagination of gluten network formation and aggregation during dough mixing. These results are helping us advance our understanding of the mechanism of dough development and will improve the state of knowledge in cereal science, which will eventually lead to an improvement in the quality wheat products.

Use of marker assisted selection for improvement of cereal crops

J. A. ANDERSON (1), P. Bajgain (1), E. Adeyemo (1), E. Conley (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.

Many of the key genes responsible for adaptation, disease resistance, and end-use quality of cereal crop traits have been known for decades. Breeders may select for such genes based on phenotype (i.e. the trait per se), DNA markers linked to the causal genes, or predictive methodologies such as genomic selection. The University of Minnesota's spring wheat breeding program has been using marker-assisted selection for more than 20 years to more efficiently select for genes conditioning disease resistance and improved end-use quality traits. Marker-assisted selection can be applied at any stage of plant growth or generation rather than waiting for phenotypic evaluations that require near-homozygous lines and/or large amounts of grain for analysis, as is the case with most end-use quality traits. Good markers exist for the high molecular weight glutenin subunits (*Glu-1*), the cloned genes *Lr34/Yr18* for leaf/stripe rust resistance, *Fhb1*, a major QTL for Fusarium head blight (FHB) resistance, and many other important genes. More recently, we have been exploring the use of genomic selection to predictively select for Fusarium head blight resistance in wheat. Our objective is to predict the resistance level of a large set (~3,000) of genotyped breeding lines, based on a training population of a few hundred lines that is phenotyped and genotyped. The Genotyping-By-Sequencing (GBS) platform we use for genotyping currently costs approximately \$6 per sample for standardization and sequencing. With the assistance of the USDA-ARS Genotyping Center in Fargo, ND, we are able to genotype 3,000 lines every year using GBS and obtain single marker data for 10-20 known genes. We typically observe cross-validation prediction accuracies of approximately 0.5 using genomic selection for FHB and based on this success plan to explore its use to predict end-use quality and lodging as well. Genomic selection is already a key component of our 8-year-old Intermediate wheatgrass (*Kernza*[®]) breeding program.

Commercial DON test kits show cross reactivity towards other DON-like compounds

S. TITTEMIER (1), K. Pleskach (1), T. Zirdum (1), R. Blagden (2), J. Chan (1)

(1) Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, Canada; (2) Canadian Grain Commission, Winnipeg, MB, Canada

Many cereals are susceptible to infection by *Fusarium graminearum*, a fungus which can produce deoxynivalenol (DON), and related compounds such as 3- and 15-acetyl deoxynivalenol (3-ADON and 15-ADON) and nivalenol (NIV). Deoxynivalenol-3-glucoside (DON3G) is also produced *in planta* as a defense mechanism to the fungal production of DON. Cereal grains are frequently analyzed for DON since many jurisdictions have maximum limits or specifications for DON. This work studied commercially available immuno-based assays marketed for DON testing and evaluated their cross reactivity towards DON-like compounds. This was performed to assess the impact of the presence of these DON-like compounds on the DON concentrations reported by these test kits. Individual standards and mixtures were used to estimate the cross reactivity of 3-ADON, 15-ADON, DON3G, and NIV. All four DON-like compounds studied showed some cross reactivity amongst the test kits studied. In general, 3-ADON showed the highest cross reactivity in solvent, producing responses ranging from 120-460% of those from an equimolar concentration of DON. NIV showed the lowest cross reactivity in solvent, producing responses ranging from 0-97% of those from an equimolar concentration of DON. The degree of cross reactivity for each DON-like compound varied amongst test kits, but was consistent between solutions in solvent and wheat matrix extract. A set of wheat samples that had known amounts of DON and DON-like compounds previously determined by liquid chromatography tandem mass spectrometry were also analyzed by each test kit. For most test kits, reported DON concentrations greater than 2 mg/kg were higher than those determined by instrumental analysis. This positive bias of the immuno-based methods did not appear to be due to the presence of DON-like compounds in the samples, even though the cross reactivity studies demonstrated that DON-like compounds have the ability to increase the apparent DON concentration reported by the test kits.

Interest in choline chloride for salt reduction in bread: Structure-properties relations and societal acceptability

P. LE-BAIL (1,2), C. Crucean (3,4), D. G. Debuquet (5), A. M. Le Bail (4,6)

(1) SFR-IBSM 4202, Nantes, France; (2) INRA-BIA, Nantes, France; (3) ONIRIS, Nantes, France; (4) SFR-IBSM 4402, Nantes, France; (5) Audencia, Nantes, France; (6) GEPEA-UMR CNRS 6144, Nantes, France

Reducing salt in foods is a public health concern. This project was supported by a PhD which was defended in April 2019; it aimed at reducing salt by 50% in a bread with the adding of 25% of choline-chloride (based on 1.8 g of sodium-chloride as reference). Choline-chloride (CC), which is also vitamin B4. In the food ingredients nomenclature, choline is E1001 and is identified as an emulsifier; choline holds also three European Health-Claims. It is used under different salts, such as choline-chloride(E1001iii), which is temperature resistant (melting temperature 247°C) and is GRAS by the FDA. From a sensorial point of view, CC provides a salty taste and can be used as an efficient substitute even though it is not as salty as sodium-chloride. Another new and unexplored advantage of CC as far as we know, lies on its interaction with starch and bread staling. In aqueous solution, CC behaves like an ionic liquid and causes a reorganization of the internal structure of the starch grain. The staling study highlighted the positive effect of CC on bread texture (softening) and on the retrogradation of starch. Indeed, the CC restricts the recrystallisation of amylopectin due to less availability of water in the medium, and decreases the staling kinetics of the bread. An in-depth investigation has been done using calorimetry and X-rays diffraction over a wide range of CC concentration and playing also with the order of presentation of the ingredients (CC solubilized of as a dry ingredient) using original mixing cells in isothermal calorimetry conditions. A full phase diagram has been established on a model system (water-cc-flour). The consumers acceptance has been investigated in three focus groups targeting different categories; health-oriented young people, young parents and consumers sensitive to nutritional information. Among consumers who are very sensitive to the traditional values associated with bread, the “functionalization” or “nutritionalisation” of this food constitutes a major obstacle to its consumption. Appropriate wording should accompany the marketing of such salt substitute. As a conclusion, CC is a relevant alternative to salt that combines technological and sensory benefits, its success will depend on the consideration of issues related to societal acceptability.

Pasting and thermal properties of red and white sorghum flour produced in Kansas

J. Guazzelli Pezzali (1), K. Lema Almeida (1), C. G. ALDRICH (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

Sorghum is the fifth most important cereal crop grown in the world and the third most important in the United States. It has a great potential for the gluten-free market and as a healthy alternative ingredient. Sorghum can be milled into flour which can be used as a major ingredient for many food applications. Flour quality characterization may aid in understanding the functionalities of the raw material and provide meaningful information to the industry regarding process optimization. Thus, the objective of this study was to evaluate the

nutritional, thermal, and pasting profile of red sorghum flour (RSF) and white sorghum flour (WSF). Red and white sorghum were milled at Hal Ross Flour Mill in three days to achieve replication. RSF and WSF samples were collected in each replicate, and were evaluated for proximate analysis, total starch, and damaged starch. Flour pasting and thermal properties were determined using a Rapid Visco Analyser and a Differential Scanning Calorimeter, respectively. Data were analyzed using the GLIMMIX procedure of SAS (SAS 9.4 Inst. Inc., Cary, NC). A greater concentration ($P < 0.05$) of crude protein (9.95 vs. 8.22%) was observed for WSF compared to RSF, respectively. Total potassium and copper concentration were greater for WSF ($P > 0.05$). No differences were observed for the other nutritional parameters. Pasting variables were not significantly different between WSF and RSF ($P > 0.05$). On the other hand, temperatures of gelatinization were different between WSF and RSF. The results revealed a 3.22°C and a 1.47°C increase ($P < 0.05$) in initial and peak temperature of gelatinization, respectively, for RSF while final temperature of gelatinization and enthalpy of gelatinization were not different between flours. Our results suggest that RSF and WSF present different thermal profile characteristic which may impact their use as raw material for different processes.

Claims that can be made for protein – An overview in key markets globally

K. MUSA-VELOSO (1)

(1) Intertek Scientific & Regulatory Consultancy, Mississauga, Canada

Protein is a macronutrient that is in great demand by consumers. According to a consumer research study conducted by Nielson in 2018, 55% of U.S. respondents indicated that protein is an important attribute to consider when buying food for their households, and 6% of households have at least one person who is following a high protein diet (see www.nielson.com/us/en/insights/article/2018/protein-consumers-want-it-but-dont-understand-it). Claims about protein that are made in the labeling and/or advertising of foods represent a means of highlighting the attributes of the food and possibly impacting the purchase intent of consumers. However, in several markets globally, there are regulations that dictate the types of claims that can be made for protein, as well as the requirements for making such claims. In this presentation, the types of claims that are permissible for protein, as well as the requirements for making such claims, will be reviewed for the U.S. and Canada, as well as other key markets globally. The concept of protein quality will be introduced, and its application in the determination of the eligibility of a food for a protein claim also will be discussed. Finally, various protein claims will be presented, and their acceptability/unacceptability will be scrutinized so that the audience can understand, based on case studies, how to formulate appropriate claim wording for protein.

Developing food quality standards for distiller's dried grains – Evaluating composition, quality and safety

T. Deshpande (1), P. KRISHNAN (1)

(1) South Dakota State University, Brookings, SD, U.S.A.

Introduction: Distillers grains represent a major co-product of corn ethanol production. At the production rate of 44 million tons/year and a price of \$95/ton, this co-product has potential as a food ingredient (solvent-treated dried products) owing to its high protein content (38%) and high fiber content (40%TDF). The aim of the research was to determine the composition, quality and safety of several initial moisture types of distiller's grains-distiller's grains without solubles (DG) and distiller's grains with solubles (DGS) in wet and freeze-dried form (FrD) from 2017 and 2018. **Method:** Processing methods were optimized for raw DG and DGS by employing food grade solvents namely: a) Ethanol b) Ethyl acetate+Ethanol and c) Hexane+Ethanol on the wet and FrD raw material to reduce pigments, odor, and oils to improve compositional quality and shelf stability. The resulting solvent-treated dried product was ground to 0.5mm and heat-sterilized. Linear models were generated, and analysis of variance was used to compare proximate composition, total phenolic content (TPC) and mycotoxin content of raw DG and DGS-wet, FrD form and their corresponding solvent-treated dried products. The mycotoxins were determined through controlled spiking studies and using rapid mycotoxin detection test kits and LC-MS technique. Particle size distribution (PSD) was determined using a series of stacked sieves (40, 60, 80, 100 and 200 mesh) and correlated with solvent-treated dried product color (L, a, b) parameters. **Results:** Raw DG and DGS - wet and FrD from 2017 and 2018 were significantly different from each other in terms of composition. Use of defatting solvents-Hexane and ethyl acetate reduced the fat content from ~11% to ≤1% for finished products. Maximum retention with 150-180 µm particle size (PS) range was seen for finished products obtained using wet and FrD DG whereas 250-400 µm PS range was seen for finished products obtained using wet and FrD DGS. The mycotoxin content was found to be below the FDA guidance levels of 20 ppb (aflatoxins) and 2 ppm (fumonisins) for solvent-treated dried products. Solvent treatment of wet and FrD DG and DGS yielded TPC ranges of 250-400 mg GAE/100 g and 30-250 mg GAE/100 g, respectively. **Significance:** Processing treatments enhanced the food functionality traits of finished products in order to be odorless, tasteless, color neutral, gluten-free with minimal oil content and consistent PS. A material specification sheet was developed to highlight the characteristics of a food grade distillers dried grains product.

Structural aspects of corn arabinoxylans related to functionality

B. R. HAMAKER (1)

(1) Whistler Center for Carbohydrate Research, Department of Food Science, Purdue University, West Lafayette, IN, U.S.A.

Corn bran arabinoxylans are a structural type that has a highly branched, or substituted, xylan backbone. As such, compared to less branched arabinoxylans like water-soluble wheat arabinoxylans, the functional properties of corn arabinoxylan are somewhat unique. In its soluble form, after extraction in an alkaline solution, it takes on an elongated bush-like conformation and tends to not form entanglements or aggregates. Accordingly, it can be added at a fairly high TDF level of 25% w/w and still achieve high expansion of an extruded product. Also, corn arabinoxylan branched structures are fairly complex in terms of sugar and linkage types, and therefore require utilizing gut bacteria to have encoded many enzymes to digest them to sugars for energy. We found that the corn arabinoxylan structure is composed of repeating nestled subunits of high branch complexity alternating with more simple regions of the xylan backbone. This heterogeneous polymer structure in the gut leads to different utilizing bacteria having different competitive abilities to various parts of the arabinoxylan, leading to feeding of various bacteria. Corn arabinoxylan is a good model polysaccharide to understand structure-function relationships in foods and the body.

Evaluating a qualitative method of determining added iron in a variety of flour matrices

P. KRISHNAN (1)

(1) South Dakota State University, Brookings, SD, U.S.A.

Rapid and robust chemical tests to determine iron enrichment are still needed in developing countries for decision making in food processing. Simple qualitative indicators still have an important role in nutrition programs as they are inexpensive and easy to implement without error. Existing methods in the AACC *Approved Methods* manual will need to be evaluated to determine their effectiveness in view of newer raw materials being employed. The objective of this study was to evaluate AACC Approved Method 40-40.01, a qualitative test for added forms of iron, in relation to newer forms of enrichment iron. A variety of real world flour matrices including wheat and corn were acquired from commercial sources. The enrichment forms of iron included ferric orthophosphate, ferric pyrophosphate, ferric sodium EDTA WS-80549, ferrous fumarate, and electrolytic iron food enrichment powder WS-80825. Reagents employed in the slick test include hydrochloric acid, potassium thiocyanate and 3% hydrogen peroxide solution. To test the different forms of iron, untreated and enriched flour were slicked side-by-side via method 14-10.01. Then, 1 mL of thiocyanate reagent was added at the junction of the two flours. An area about 1 inch in diameter was wetted and allowed to stand undisturbed for at least 10 minutes. When ferric compounds were present, a deeper red color appeared in treated flour compared to the untreated flour. Small local areas that appeared after 20 minutes indicated individual iron particles and lack of uniformity in mixing. When testing for ferrous iron, the same technique was used, except that an additional 1 mL of 3% hydrogen peroxide was dropped over the same area that was wetted by the thiocyanate reagent. The ferrous iron was oxidized to the ferric state by the excess hydrogen peroxide, so the same red color test can be used. The paper will present pictorial information showing the outcome of the qualitative tests relative the five forms of iron and at least two types of flour (wheat flour and corn meal). Both enriched and unenriched flours were tested to determine the robustness of AACC Approved Method 40-40.01. Purified forms of enrichment media were spiked at 20 mg for pound of flour to compare with the unenriched flour counterpart. This research was sponsored by the Vitamins, Minerals and Lipids Technical Committee. Funding was received from the Cereals & Grains Association Graduate Research Leadership Program.

In situ fortification of vitamin B₁₂ in wheat bran by co-fermentation with *Propionibacterium freudenreichii* and *Lactobacillus brevis*

C. XIE (1), R. Coda (1), B. Chamlagain (1), P. Varmanen (1), V. Piironen (1), K. K. Katina (1)

(1) University of Helsinki, Helsinki, Finland

Vitamin B₁₂ is an essential micronutrient naturally existing in animal products. A growing interest and need to replace animal protein with plant protein sources have resulted in increased attention to developing vitamin B₁₂-fortified plant-based food. *In situ* fortification by food-grade microorganisms with the ability to synthesize active vitamin B₁₂ is a promising alternative to chemical fortification. The present study investigated the effect of a co-culture fermentation with *Propionibacterium freudenreichii* DSM 20271 and *Lactobacillus brevis* ATCC 14869 on vitamin B₁₂ fortification in wheat bran. *P. freudenreichii* was used as the producer of vitamin while *L. brevis* was selected to ensure the microbial safety of the bran dough. Fermentation trials were conducted in bioreactors to monitor and adjust the pH of the ferments. Vitamin B₁₂ level in the dough reached 357 ± 8 ng/g dry weight (dw) after one day of pH-controlled fermentation with *P. freudenreichii*. In co-fermentation with *L. brevis*, slightly less B₁₂ (255 ± 31 ng/g dw) was produced in one day and an effective inhibition of the growth of total *Enterobacteriaceae* and *Bacillus cereus* was obtained. Fermentation with *P. freudenreichii* for three days did not further increase vitamin B₁₂ yield whereas in three day co-fermentation the yield increased up to

332 ± 44 ng/g dw. On the other hand, without a pH control, co-fermentation resulted in a stronger inhibition of *Enterobacteriaceae* and *B. cereus* growth but a lower level of vitamin B₁₂ was reached (183 ± 5 ng/g dw on day 3). These results demonstrated that wheat bran fermented with *P. freudenreichii* and *L. brevis* can be a promising way to produce vitamin B₁₂ fortified plant-origin food ingredients, which could reduce cereal waste streams and contribute to a more resilient food chain.

Significance of tempering methods on white sorghum flour and baking properties

M. YOGANANDAN (1), K. Siliveru (2), S. Bean (3), R. A. Miller (1), D. Hulya (2)

(1) Kansas State University, Manhattan, KS, U.S.A.; (2) Grain Science and Industry, Kansas State University, Manhattan, KS, U.S.A.; (3) USDA ARS, Manhattan, KS, U.S.A.

Sorghum is a substitute cereal for celiac and gluten sensitive people. The current sorghum milling industry is medium scale and uses hammer mills to produce whole grain flour. This results in milling losses, bran contamination, and inconsistent flour quality. Appropriate tempering methods prior to roller milling could produce white sorghum flour and also improves the milling yields and flour characteristics. In this study, the effect of tempering process on flour quality and dough properties were studied. In this study, three sets of tempering methods were carried out on sorghum kernels: (i) cold (at 24°C for 24 h) at 16 and 18% moisture content (m.c.) (wet basis w.b.); (ii) hot (at 60°C for 12, 18, and 24 h) at 16 and 18% m.c. (w.b.); and (iii) steam (at 25 psi for 5, 10, and 15 s). Physical, chemical, and quality properties of flour and dough were evaluated as an effect of tempering process. The bulk and tapped density of white sorghum flour decreased significantly with increasing moisture content when treated with cold water. However, the opposite trend was observed when treated with hot water in both 16 and 18% m.c. (w.b.). The protein content of white sorghum flour did not have any significant differences when treated with cold or hot water. However, the protein content of flour produced from steam tempered kernels were significantly lower than the other treatments. Flour produced from all treatments had high brightness (L = 81.34) value. This showed that there was less bran contamination or less whole grain flour. No significant differences was observed in brightness values when the kernels were treated with cold or hot water or steam. All the flour values had close to neutral a values (a = 2.14). They did not have dominance of either red or green color. However, flour from all treatments showed high positive values (b = 12.50) demonstrating a greater yellow than blue color. A significant trend was not observed between different treatments and moisture contents in both a and b values. The maximum amount as well as good quality (low damaged starch and good protein quality) flour from the designed flow sheet was produced from white sorghum kernels treated with hot water (16% m.c) at 60°C for 18 h than the other treatments. The bread quality parameters will be evaluated in the future research.

Genetic and genomic applications to improving food grade corn

C. HIRSCH (1)

(1) Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN, U.S.A.

Food grade corn represents a small fraction of the commercial acreage in the United States, and as such, research and development for traits specific to food grade corn have been limited. There are many different points in which a commercial hybrid may fail in the process of making a chip, or other masa based products. Two main areas that we are focusing on is water uptake during the nixtamalization (soaking process used to remove the pericarp from the seed) and the amount of acrylamide that is present following frying. We are using a set of 500 diverse maize lines to determine desirable compositional attributes for these two attributes and subsequently working to identify the genetic landscape that controls trait variation for these traits. Food grade corn represents a niche market where research in the public sector can have a substantial direct influence of commercial breeding programs. We have identified two key areas that limit the utility of a commercial hybrid for chip processing in corn. Using genetic, genomic, and machine learning approaches we are working to gain knowledge on the compositional attributes of importance, the range of variation that exists in natural populations for these traits, the range of acceptable variation that can be tolerated for these traits to meet industry needs, and the genetic architecture that underlies these important properties.

Influence of carbon dioxide-argon radio frequency plasma on structural and functional properties of cereal and tuber waxy starches

A. Y. OKYERE (1), E. Bertoft (2), G. A. Annor (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.; (2) Bertoft Solutions, Turku, Finland

Modification of native starch is necessary due to its insoluble and unreactive nature. Physical methods of modification such as cold plasma is highly desirable because it is devoid of chemical waste generation. Thus, the effect of radio frequency cold plasma on the crystallinity, changes in short range molecular order (NMR), resistant starch, starch damage and iodine affinity of waxy rice, maize and potato was investigated. Starches (15 g) were treated for 60 minutes in a plasma chamber filled with carbon dioxide and argon gas at a flow rate of 25 and 10 sccm respectively and a plasma power of 0 (gas treatment) and 120 W. X-ray diffraction, NMR,

resistant starch, starch damage and iodine affinity of the samples were studied. A 5.5% and 2.8% decrease in crystallinity was seen in waxy potato after plasma and gas treatment respectively; however, maize and rice were unaffected after treatment. The presence of V-type single helices could be seen in waxy maize and rice but not in potato after treatment as indicated by peaks around 101.1 and 103 ppm. Peaks at 104.2 to 105.3 ppm, visible in potato only, have been associated with the junction zones of the double helices in amylopectin and increases in their areas were noted after both treatments. Resistant starch contents increased significantly in waxy potato (44.31-66.48%) and maize (0.84-1.21%) after plasma treatment with rice increasing only after gas treatment (0.12-1.33%). Similar increases were observed in damaged starches after plasma treatment in potato (0.74%-1.09%), maize (2.20%-2.33%) and gas treatment in rice (5.33% -5.56%). There were no statistical differences in the λ_{\max} values of treated and untreated waxy rice and maize starch; potato however increased significantly after plasma treatment (554.5-557.5). The peak values of waxy maize were unaffected by plasma treatment but increased significantly in potato (0.84-1.00) and rice (0.37-0.48). Gas treatment also caused significant increases in waxy rice (0.37-0.59) whilst a decrease was observed in potato (0.84-0.62). In conclusion, plasma treatment significantly increased the resistant starch and starch damage content of maize and potato but not rice. The iodine affinity of potato significantly increased after plasma treatment. Plasma or gas treatment resulted in no decreases in crystallinity in maize and rice, but however induced the formation of V-type single helices.

Mechanisms of 3-deoxyanthocyanin-polysaccharide interactions and effect on aqueous colloidal stability

J. F. BRANTSEN (1)

(1) Texas A&M University, Soil & Crop Sciences, TX, U.S.A.

3-Deoxyanthocyanins (3-DXA) from sorghum have promising potential as natural food colorants. They are uniquely stable to food processing conditions, unlike the more common anthocyanins, but are poorly water soluble. Amphiphilic polysaccharides have been shown to interact with and stabilize anthocyanins. We hypothesize that amphiphilic polysaccharides can effectively stabilize 3-DXA in aqueous solutions. This work investigated the stabilizing effect of polysaccharides on 3-DXA, the interaction mechanisms, and the effect in a model beverage system. UV-Vis spectroscopy was used to monitor 3-DXA extract precipitation over time in solution with pectin of varying DE. Binding affinity of apigeninidin and luteolinidin to gum Arabic were measured with fluorescence quenching. 3-DXA stability by polysaccharides was assessed in a beverage model after heat treatment and storage. Pectin (DE 54%) at 0.1 g/L effectively stabilized 3-DXA with greater proportion of apigeninidin (more hydrophobic) than luteolinidin (more hydrophilic) (85% to 41%, respectively). Fluorescence quenching with gum Arabic indicated the binding mechanism is due to complex formation between the polysaccharide and 3-DXA. The binding affinity of apigeninidin ($43.16 \times 10^4/M$) was greater compared to luteolinidin ($0.79 \times 10^4/M$) at pH 3. Both greater stability of apigeninidin-dominant extracts with pectin and greater binding affinity of apigeninidin to gum arabic suggest hydrophobic interactions as a mechanism of interaction. Polysaccharides effectively stabilized 3-DXA in solution after heating (60°C for 10-30 min) and during storage (4°C-40°C for 7 days). At 25°C, gum arabic and pectin (DE 54%) stabilized 47-71% of 3-DXA in solution compared to <30% without polysaccharides. Polysaccharides enhance aqueous stability of 3-DXA; this expands the functionality of these pigments as a natural colorant for beverages.

Disentangling starch digestibility, passage rate and fermentation effects of grain-based diets on feed intake and weight gain in pigs

V. Ratanpaul (1), B. Williams (1), J. Black (2), M. GIDLEY (1)

(1) University of Queensland, St. Lucia, Australia; (2) John L Black Consulting, Warrimoo, Australia

Background – Diets high in whole grains and cereal fibre are associated with beneficial human health outcomes, but underlying contributory mechanisms are incompletely understood. Pigs represent the best model for in vivo studies, as anatomy and physiology are similar to humans, and grain-based diets with controlled composition and processing can be studied. Objectives – 1. To test the hypothesis that feed intake is driven by gastric residence time and ileocolonic brake effects and can be predicted from hydration capacity and fermentability for fibre-containing grain-based diets. 2. To test the hypothesis that weight gain can be predicted from in vitro starch digestibility and is reflected in faecal pH from fermentation of resistant starch in grain-based diets. Methods – 1. Five levels of wheat-bran (WB) or oat-hulls (OH) were added to a highly digestible starch-based diet fed to pigs ad-libitum for 21 days. Average-daily-feed-intake (ADFI) and faecal short-chain-fatty-acids (SCFA) were determined weekly, and diet hydration capacity was measured in vitro. A linear mixed model was fitted to FI and fermentation parameters. 2. Pigs were fed ad libitum for 28 days four grain-based diets containing milled or steam-flaked wheat or sorghum. Intrinsic starch digestibility was assessed by amylase diffusion coefficient. FI, average-daily-weight-gain (ADG), faecal SCFA-concentration and pH were measured weekly. Linear-mixed-models were fitted to determine significance of treatment differences. Results – 1. WB diets showed a dose-dependent decrease in ADFI and increase in faecal SCFA. OH diets increased ADFI at low (5%) inclusion and decreased ADFI at higher concentrations, but did not influence faecal SCFA. Greater diet HC correlated with reduced FI across WB and OH and could be a useful screening tool. 2. Grain digestibility did not affect FI, but slower digested sorghum reduced ADG and produced more faecal SCFA than wheat. ADG correlated with faecal

SCFA and pH, providing an indirect assay for in vivo resistant starch. Conclusions – 1. Three mechanisms control the effects of cereal fibre on FI: increase in passage rate and FI at low concentrations of non-swelling fibres; a depression in FI from high fibre bulk; and reduced FI from stimulation of ileal and colonic brakes. 2. Low intrinsic starch digestibility may not affect FI, but increases fermentation in the colon, resulting in less energy for metabolism. Consuming whole grains with low intrinsic digestibility could help reduce body weight without changing energy intake.

Cereals and grains global and emerging trends

M. CWIKOWSKI (1)

(1) All Food Consulting, Saive, Belgium

The presentation will discuss the global macro forces and trends affecting the future of food and how these forces and trends are influencing the way food is being produced, distributed, sold, bought and consumed around the globe. It will consider why staying ahead of the curve is key and will invite and engage the audience in defining collectively what key challenges/opportunities/topics/technologies will have to be addressed by the Cereals & Grains Association in the future.

Drying methods affect physicochemical and functional properties of quinoa proteins

Y. SHEN (1), Y. Li (1)

(1) Kansas State University, Manhattan, KS, U.S.A.

Quinoa as an emerging ancient grain is becoming more attractive for various food uses, and this is partially attributed to its high protein content, great amino acid profiles especially rich in lysine and histidine that are deficient in most cereals, wide range of minerals and vitamins, and good proportion of omega-6 fatty acids. Quinoa protein could also be a potential food ingredient with broad applications. The objective of this study was to investigate the effect of different drying methods, namely freeze drying, spray drying, and vacuum drying on physicochemical and functional properties of quinoa protein isolates. Quinoa protein was extracted from flour through alkaline extraction (pH 10) and acid precipitation (pH 4), neutralized, and dried with different methods. Critical protein functional properties including solubility, water/fat binding, gelation, emulsification and foaming properties were tested. Protein physicochemical characteristics including amino acid composition, surface hydrophobicity, sulfhydryl/disulfide content, SDS-PAGE profile, secondary structure, thermal stability, and AFM morphology were also evaluated. Freeze dried protein exhibited the highest emulsification capacity and stability and oil binding capacity due to its higher surface hydrophobicity, while spray dried sample had the highest solubility and water binding capacity at pH 7. Freeze dried and spray dried proteins demonstrated better foaming stability than vacuum dried sample. The color, protein content, and particle size of freeze and vacuum dried proteins were similar, while spray dried sample had significantly smaller particle size and lower protein content. Freeze dried protein had the highest denaturation temperature but lowest enthalpy, which may be caused by its higher percent of random coil and lower percent of alpha-helix and beta-sheet structures. In addition, gels (8%) prepared with freeze dried proteins had higher elastic and viscous modulus than that from spray and vacuum dried samples. Overall, quinoa protein demonstrated good functional properties, which could be further manipulated through drying methods.

Promoting whole grain intake through health and economics

K. MILLER (1)

(1) General Mills, Plymouth, MN, U.S.A.

In the US, Dietary Guidance recommends that one-half of all grains consumed be whole grains. However, dietary guidances from around the world may not even acknowledge whole grains as a potential contributor to public health. The objective of this working group is to assess the cost savings associated with reducing the incidence of disease. These data may be useful in promoting whole grains not only to consumers, but to governments to influence policy that helps relieve financially overburdened healthcare systems.

Development of an enhanced beta (β) glucan beverage – Evaluating satiety, nutrition and shelf stability

B. S. Manu (1), P. KRISHNAN (1), M. Caffè (1)

(1) South Dakota State University, Brookings, SD, U.S.A.

Oat and barley are good sources of dietary fiber, especially β -glucans. Currently, dietary fiber intake among adults in the United States average about 15 grams a day, which is significantly lower than the recommended 25 to 30 grams a day. This makes dietary fiber a shortfall nutrient and as such, a nutrient of public health concern in older adults. A limited variety of non-alcoholic high moisture products have been made from oats and barley though they are widely grown in the United States. Studies have shown that the addition of β -glucans to beverages or high moisture products impairs their sensory qualities (relatively high viscosity) despite improving other rheological properties. Thus, the development of β -glucan fortified foods remains to be highly challenging. Partial enzyme and acid hydrolyses were employed to reduce the unappealing problem of high viscosity while

maintaining its satiety increasing functionality and nutritional content. The effects of partial enzyme hydrolysis and partial acid hydrolysis on the viscosity, β -glucan content and hunger suppressing functionality of the beverage containing a blend of GMI423 oat flour and barley flour were studied. Hydrolyses were performed at 50% moisture content at 50°C. Partial enzyme hydrolysis using β -glucanase in a 1% substrate concentration with constant stirring and a 1min deactivation at 80°C, resulted in reducing the viscosity 153-185 centipoises(Cp) to 45-57 centipoises (Cp). Also the β -glucan content of the beverage decreased from 6.52 to 6.23% and it was shown to increase fullness, reduce hunger, reduce desire to eat and prospective intake. Partial acid hydrolysis was carried out with an addition of ascorbic acid (10 mM) in the presence of iron sulphate, with the viscosity decrease inhibited by introducing a OH⁻ scavenger (glucose) in the solution. This resulted in a slight viscosity decrease from 153-185 centipoises(Cp) to 127-155 centipoises(Cp). Also there was almost no significant difference observed in the β -glucan content of the beverage. Partial acid hydrolyzed beverage was not preferred in the sensory tests and hence not evaluated on its hunger suppressing functionality. Partial enzyme hydrolysis was therefore shown to be an effective method to reduce beverage viscosity, maintain β -glucan content, improve sensory parameters and increase satiety. Thus helping to add value to oats and barley by developing a variety of products beyond the breakfast cereal aisle.

How rice varieties have evolved since the 30's in the southern U.S.

K. A. K. MOLDENHAUER (1), D. K. A. Wisdom (1), J. T. Hardke (1)

(1) University of Arkansas Rice Research & Extension Center, Stuttgart, AR, U.S.A.

There have been many changes in rice cultivars and management practices since the first rice breeders were placed in the Southern U.S. by the United States Department of Agriculture with the mission/goal to improve the rice varieties. Rough rice grain yields have increased dramatically from 43.5 bushels/acre (Arkansas, Louisiana, Mississippi, Missouri, and Texas) in 1934 to 166.6 bushels/acre in 2018. Until the 1930's medium grain varieties were the prevalent cultivars in the Southern U.S. During the 1940's long-grain cultivars increased, by the mid 1950's Bluebonnet became the predominate variety, and by the 1960's medium grains were grown on 20% or less of the Southern rice acreage, where they have remained. In the 2000's variety preference shifted to Clearfield cultivars and later hybrids so that by 2010 these proprietary materials were on approximately 60% of the Southern rice acreage. Other trends which have occurred include: 1) A decrease in maturity of the rice cultivars, planting and harvest dates are earlier all which can effect the amount of chalk in the kernels and the head rice yields. 2) Height has decreased and there is less lodging which can improve rice quality. 3) Clearfield cultivars have reduced the red rice in producers fields and therefore in the harvested rice at the mills. 4) Market demands have largely influenced the production of rice, moving toward larger kernel long-grains, and specialty rice in the Southern United States and 5) Cultural changes are occurring with advent of requests for identity preservation and tracking food from farm-to-market so consumers know where their food comes from.

Simple and fast methods for the assessment of wheat grain pre-harvest sprouting

B. K. BAIK (1), T. Donelson (1)

(1) USDA-ARS-CSWQRU Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.

Pre-harvest sprouting (PHS) of grain is one of the major concerns in wheat production and adversely affects grain quality, marketability and price. While the falling number (FN) test is accepted and widely used as a standard method for the assessment of wheat grain PHS, it is a low throughput and expensive test, requiring the grinding of grain prior to the test, a FN test instrument and an experienced technician, making it unsuitable for the evaluation of a large number of breeding lines in the development of PHS-resistant wheat varieties by breeding programs, and for the rapid screening of wheat grain in truck loads at the grain elevator for segregation. We explored simple and fast alternatives to the FN test for the determination of wheat grain PHS damage. Three approaches, including 1) electrical resistance of wheat grain soaking water using a portable electrical multi-meter, 2) absorbance of alpha-amylase dye tablet solution of wheat grain grits using a spectrophotometer, and 3) hot paste flow viscosity of wheat grain meal using a Bostwick Consistometer, were examined for the assessment of wheat grain PHS. The test procedures and conditions were established and evaluated considering their capacity to differentiate the grains of three wheat varieties showing low, medium and high degrees of PHS as indicated by their FNs. All three approaches clearly differentiated the wheat grains of different FNs, proving their potential for the assessment of wheat grain PHS. The three approaches were further examined for their performance using the grains of fifteen soft winter wheat varieties with a wide range of PHS and FN. The electrical resistance, spectroscopy absorbance and flow viscosity all showed strong relationships with FN and alpha-amylase activity, and yielded r-squares ranging from 0.93 to 0.97 for the former and 0.82 to 0.87 for the latter, proving that all three approaches could be developed as methods to more simply and quickly assess wheat grain PHS than the FN test. Electrical resistance of wheat grain soaking water was the simplest and fastest test with no need for grinding grain, while hot paste flow viscosity of wheat grain meal yielded the best prediction of FN.

The effects of radio-frequency cold plasma on dough functional properties of hard red wheat, soft wheat, and intermediate wheatgrass flours

S. HELD (1), C. Tyl (1), G. A. Annor (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.

Cold plasma has been proposed as a way to affect functional properties as well as safety of food. This technique has the potential to kill surface microorganisms with minimal loss of nutrients or change to sensory properties. Recent studies on cereals have shown that cold plasma may modify secondary structures and solubility of flour proteins. The objective of this study was to compare the effects of cold plasma treatment on hard red wheat (HRW), soft wheat (SW) and intermediate wheatgrass (*Thinopyrum intermedium*, IWG), a novel perennial grain. While IWG's cultivation offers environmental benefits attractive to consumers, its protein composition varies from that of wheat, which introduces challenges in its dough functionality. HRW and SW differ in protein content and profile and are therefore suitable for different products. The effects of cold plasma on protein and dough functionality of the three flours were assessed through the following tests: total protein content and solubility, solvent retention capacity, starch damage, Farinograph analysis, dough extensibility and resistance to extension, protein secondary structures, and GlutoPeak analysis. Plasma treatment resulted in moisture loss but did not affect the protein content or solubility. Solvent retention capacity increased for water and sodium carbonate after plasma treatment, indicating that levels of starch damage may have been affected differently across samples. This was supported by starch damage analysis, which indicated that HRW and SW experienced greater starch damage due to plasma treatment (3.34% to 3.53% and 6.03% to 6.62% respectively) whereas the same was not observed for IWG. Protein secondary structure was also affected differently across samples. SW dough experienced an increase in beta-turns and a decrease in beta-sheets while HRW and IWG showed no significant changes. Farinograph water absorption increased for all samples (56-61.1% to 71.0-81.6%) because of moisture loss and starch damage. Dough development time increased for SW, decreased for HRW, and did not change for IWG after plasma treatment. The extensibility of SW dough decreased after plasma treatment. GlutoPeak tests after plasma treatment revealed that protein aggregation did not change for HRW, resulted in no aggregation for SW, and aggregation energy significantly increased for IWG (32 to 39.5 GlutoPeak Units). In summary, plasma treatment had different effects depending on the flour type, and functional properties were affected due to starch damage. More work should be done to further explore the molecular mechanisms driving these differences and the effect on product characteristics made of plasma-treated flours.

Effect of nitrogen levels on the nutrient quality of corn under organic management

E. GULKIRPIK (1), M. Toc (1), G. Bogran (2), C. Katrakis (1), C. M. Ugarte (1), J. E. Andrade (1)

(1) Urbana, IL, U.S.A.; (2) San Antonio de Oriente, Honduras

Approximately 95% of the crop varieties grown under organic management were bred specifically for high input conventional production systems. These varieties, however, lack the resilience and stability in agronomic performances necessary for low input organic production. Moreover, most varieties are mostly screened for starch content and no other nutrients such as protein and oil for niche markets. This study aimed at selecting corn cultivars adapted for organic production through a participatory breeding approach with Midwest organic farmers. A core set of corn hybrids developed at the University of Illinois and the Mandaamin Institute Wisconsin were selected based on agronomic performance and grain processing characterization in past experiments under conventional and organic management respectively. During the first year of experiment in 2018, the hybrids were evaluated in a controlled experiment in two locations (Pana and Macomb, IL). The controlled experiment was established in experimental plot size (52 × 177 m) under randomized complete block design with split-split plot arrangement. Three rates of nitrogen (N) application (0, 112 and 224 kg N/ha) delivered as pelletized poultry manure were evaluated based on their influence on the nutrient composition (i.e., protein, oil, and starch) of 10 hybrids (ORG1, ORG2, CONV1, CONV2, CONV3, CONV4, CONV5, CONV6, CONV7, CONV8). An NIR grain analyzer (Inframatic 9500) was used to assess the nutritional composition. A linear regression analysis was conducted to evaluate the effect of increasing N levels on protein, oil, and starch contents. Nutrient content were correlated using Pearson. The protein, oil and starch contents of hybrids were between 7.5–11.0% (db), 3.40–5.02% (db), and 68.3–72.7% (db), respectively. Regardless of the hybrid, protein ($y_{(\%)}$ = 0.0037N + 8.4176; R^2 = 0.98) and oil ($y_{(\%)}$ = 0.0003N + 3.8422; R^2 = 0.96) levels increased while starch content decreased ($y_{(\%)}$ = -0.0031N + 71.457; R^2 = 0.99) as a result of increased N levels. Accumulation of protein and oil in whole grain was positively associated (r = 0.594, p < 0.01), whereas accumulation of starch was negatively associated with protein (r = -0.892, p < 0.01) and oil (r = -0.874, p < 0.01). ORG-2, CONV-6, CONV-2 and CONV-8 showed the highest performance in oil and protein accumulation and highest reduction in starch content as the N level was increasing. As part of this project, further characterization of the grain quality characteristics of these hybrids will include evaluations of the amino acid profile, and carotenoids, phenolics, minerals, and fatty acids contents. Results will improve our understanding on the response of maize to different management treatments and will add value to germplasm selection for organic grain production systems.

Young Scientist Award Presentation: Bubbles in foods and how they affect food quality

F. KOKSEL (1)

(1) Food and Human Nutrition, Winnipeg, MB, Canada

Bubbles are integral 'ingredients' in many cereal and pulse-based foods, e.g., baked goods, puffed snacks, etc. Understanding the changes in these underappreciated ingredients during processes like mixing and extrusion often requires a multi-disciplinary approach, from food engineering to food chemistry and food physics. For various baked goods such as bread, the first step of processing is mixing, during which bubble nuclei are occluded into the dough from the headspace of the mixer. During the rest of the breadmaking process, the changes in size and number of bubbles have a direct impact on loaf volume, structure, texture. Therefore, non-destructively monitoring the bubble population within the dough can be the basis for predicting final product quality before bread is manufactured. For foods such as expanded snacks and breakfast cereals, if bubbles are not manipulated properly during processing, physical quality of the end-product may be impaired. Especially at elevated protein and fiber contents, lower expansion, higher density and harder texture are some common quality issues. The use of physical blowing agents (carbon dioxide gas, nitrogen gas, etc.) can help to overcome these challenges by providing additional bubble nucleation sites during extrusion cooking. Physical blowing agents also alter techno-functional properties of extrudates so that they can be used as functionalized ingredients fit for different foods.

Evaluation of glutopeak as a tool for screening North Dakota hard red spring wheat breeding lines

K. PETERSON (1), A. Green (1), S. Simsek (2)

(1) North Dakota State University, Fargo, ND, U.S.A.; (2) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Evaluation of wheat breeding lines with good quality traits, for the release of new varieties of hard red spring wheat (HRS), is key to meet industry needs. The glutopeak has potential to be a fast, effective way to screen breeding lines with acceptable protein quality, in order to decide which lines to advance to further trials. This research evaluated the ability of data from the glutopeak to select lines with good protein quality from breeding program trials compared to current methods. Eighteen wheat varieties were grown at NDSU Research Extension Centers located at Dickinson, Langdon and Minot North Dakota in 2017. Protein content, dough rheology and baking were conducted according to AACC methods. Whole wheat protein ranged from 14.4 to 17.4% and gluten index ranged from 84.5 to 98.5. The glutopeak peak maximum time (PMT) ranged from 121 to 249 seconds. Maximum torque (MT) ranged from 51 to 63 glutopeak units (GPU). Aggregation energy ranged from 1,398 to 1,716 cm². MT had very highly significant ($p < 0.001$) correlations with protein content (0.74), lactic acid solvent retention capacity (SRC, 0.50), and wet gluten content (0.76). PMT had very highly significant ($p < 0.001$) correlations with gluten index (0.44) and mixograph peak time (0.56). Glutopeak results were also consistent across growing locations. When comparing to other screening tools, the glutopeak values had similar or better relationships with flour quality compared to mixograph parameters, gluten index and lactic acid SRC. Among mixograph parameters, only peak time had very highly significant ($p < 0.001$) correlation with gluten index (0.53). These results show that the glutopeak can be used to differentiate poor and good quality HRS wheat breeding lines. Therefore, the glutopeak has good potential to aid in the selection of more desirable quality HRS lines.

Improving dietary quality of carbohydrates through proanthocyanidins–starch complex formation

D. B. AMOAKO (1)

(1) PepsiCo, Plano, TX, U.S.A.

Excess calorie intake and related conditions such as obesity and diabetes are global public health problems. Starch is a major component of dietary carbohydrates, which accounts for approximately 52% of daily calorie intake. Reducing starch digestibility can significantly benefit efforts to combat obesity and associated chronic conditions. Polymeric proanthocyanidins (PA) interact with amylose in cooked starch to increase resistant starch (RS). To investigate the effect of complexing granular starch with PA, sorghum derived PA was complexed with normal and waxy maize starch in 30% (30E) and 50% (50E) ethanol solutions at 70°C/20 min. The complexes formed were analyzed for in vitro digestibility and structural properties. Starch-PA complexes increased slowly digestible starch (SDS) from 96.7 mg/g to 274 mg/g and RS from 148 mg/g to 299 mg/g in 30E normal starch. The 50E treatments produced almost non-digestible starch (approximately 90% RS). Molecular weight (MW) distribution data from gel permeation chromatography showed that after 2 h of digestion, control samples had no large ($DP \geq 78.8 \times 10^4$) and medium ($DP \leq 21.2 - 0.6 \times 10^4$) MW starch left; all starch molecules (100%) were of low MW sizes ($DP \leq 0.6 \times 10^4$). In corresponding PA-treated starches however, the proportion of high and medium MW starch were 16% and 18%, respectively. To elucidate the mechanisms of starch-PA complex formation, high MW PA was complexed with amylose, amylopectin, and granular maize starches in regular and deuterated solvents. Based on iodine binding, X-ray diffraction patterns, crystallinity, and thermal properties, we demonstrated, for the first time, that type II semi-crystalline V-complexes are formed between amylose and PA. Furthermore, suppression of H-bonding led to amorphous complexes, suggesting extensive H-bonding facilitate and/or

stabilize the V-complexes. We speculate that the complexation involves inclusion of B-rings of the PA units into the amylose helical cavity. The V-complex formation significantly increased resistant starch in gelatinized normal starch and pure amylose (by 35–45%), indicating likely physiological benefits. High MW PA can be used to produce new starch-based ingredients and foods with improved dietary carbohydrate quality.

Wheat flour as a model system to study process effects of sonic agglomeration – A new food compression technique

A. H. BARRETT (1), R. Capodiecì (2)

(1) CCDC Soldier Center, Natick, MA, U.S.A.; (2) Creative Resonance Inc., Scottsdale, AZ, U.S.A.

Sonic agglomeration is a densification process newly applied to food products through the adaptation of sonic welding technology. The process, which can yield energy-dense compact bars, is advantageous over standard uniaxial compression because the application of sonic energy serves to momentarily plasticize particle surfaces due to localized vibrational heating during compression, thus yielding permanent interparticle junctions and products of superior quality. Cereal/grain based bars formed through uniaxial compression, relying on static pressure only, require a high proportion of non-nutritive syrups or binders for bar cohesion. By contrast, compression employing sonic energy (in which the compressing crosshead is a sonic horn), can yield firmly compacted products without the incorporation of such less-nutritious ingredients. The military has employed sonic compression to produce a range of calorically dense meal-replacement bars that are of high sensory acceptance (>8 on a 9-point hedonic scale), and is now pursuing fundamental research using model systems concerning the relationships among process parameters, energy developed in the bars and the resultant bar characteristics. In moistened (10% added water) wheat flour systems, using a modified Branson ultrasonic welder with a 1.5 inch by 1.75 inch rectangular horn and receptacle, it was determined that: developed energy (joules) was a linear function of sonication time and percent maximum vibrational amplitude; that product temperature and moisture loss were linearly related to developed energy; and, that developed energy was an exponential function of specimen weight. Such findings are the basis of understanding the sonic agglomeration process and for predicting the behavior of formulations during development of compressed products.

Glyphosate benefits, uses, and safety

W. REEVES (1)

(1) Bayer, St. Louis, MO, U.S.A.

Weed control is an essential part of agriculture and can play an important role in protecting public health. Glyphosate has been central to many weed control strategies because of its broad activity spectrum, systemic uptake by weeds, and favorable safety profile. In cereal crops, glyphosate can prevent harvests from being contaminated with weed seeds and mycotoxins. Unfortunately, glyphosate is often the focus of criticism based on unjustified safety concerns. This presentation will review the reasons for glyphosate's widespread adoption, its importance to reliable weed control, and its ability to prevent hazardous weeds from contaminating harvests. Perhaps most importantly, this presentation will present the scientific facts underlying glyphosate's favorable safety profile and resources for those needing to answer questions about this once in a century herbicide.

Bomb calorimetry for measurement of calories and impact of product dehydration methods on caloric determination in military ration items

A. WRIGHT (1)

(1) U.S. Army CCDC-SC, Natick, MA, U.S.A.

Nutritional analysis for military rations has historically utilized the calculation method to determine calories in foods due to instrumentation limitations that made it technically challenging to capture all heat released in bomb calorimetry measures. However, new instrumentation and methods now provide consistent and rapid measures of calories in foods. Use of the bomb calorimeter is desirable to objectively assess caloric content in foods. It also allows nutrient analysis to be performed wherein total carbohydrate and ash may be calculated when the fat, protein, and moisture contents are known. Bomb calorimetry thus provides another means of performing nutrient analysis that can help laboratories capture nutrient data with minimal testing and more rapid techniques. However, since bomb calorimetry requires reduced moisture content in order to combust foods, some ration items are too wet and must therefore be dried prior to caloric assessment. In this study, various samples were dehydrated fully or to a standard moisture content using various methods to assess the impact of the drying technique on the caloric results. Dehydration methods using various food types were compared in order to determine the extent to which a dehydration method impacted final caloric results. Freeze-dried, ambient dried, 70°C vacuum-oven dried, 120°C IR dried products such as protein shakes, puddings, meats, dairy products, pasta-based entrées, and other high water content foods were tested. Some products appear more impacted by drying methods than others. Results reported show the measured impact of drying techniques on actual caloric measures.

A multi-linear regression approach for simulation of a traditional (95°C) starch pasting profile using a high altitude (91°C) heating regimen

C. S. HENRIKSEN (1), K. C. Huber (1), D. Palmer (1), C. Kauffman (2)

(1) Brigham Young University-Idaho, Rexburg, ID, U.S.A.; (2) Perten Instruments, Springfield, IL, U.S.A.

The Rapid Visco Analyzer (RVA) is utilized for evaluating the rheological properties of starch-based materials. A traditional RVA test monitors the viscosity of a stirred starch suspension as it is incrementally heated to 95°C, held isothermally for a set time, and gradually cooled to 50°C. At high altitudes, the target temperature of 95°C is unachievable due to boiling point depression; thus, an alternative 91°C profile is recommended for such locations. However, pasting profile outputs obtained via the 91°C profile do not match those of the traditional 95°C test condition, due to differential temperature regimens. The research objective was to utilize a multi-linear regression approach to vary the run parameters of a 91°C heating regimen to match the output of a traditional 95°C pasting profile using native potato starch. Pasting profile targets for the 95°C heating regimen were generated using the RVA standard profile (2.000 g starch; stir rate = 160 rpm; heating, hold, and cooling times = 222, 120, and 228 seconds [s], respectively). Independent variables (3 levels each) investigated for adapting 91°C profile run parameters included: starch weight (1.900, 2.000, or 2.100 g, dry basis), stir rate (120, 160, or 200 rpm), heating time (132, 222, or 312 s), hold time (60, 150, or 240 s), and cooling time (138, 228, 318 s). Measured pasting profile dependent variables/outputs were: peak, trough, breakdown, and final viscosities. A Box-Behnken design was used to fit second-order linear regression models for each individual dependent variable to predict a combination of 91°C run parameters that matched target 95°C pasting viscosity outputs using contour plots. Model predictions were validated by RVA runs and further adjusted to yield a set of 91°C run parameters (1.998 g starch, stir rate = 163 rpm; heating, hold, and cooling times = 222, 152, and 245 s, respectively) that successfully matched 95°C pasting profile target outputs. Regarding main effects, increased amounts of starch increased all pasting viscosity attributes ($p < 0.0001$). Conversely, peak, trough, and final viscosities all decreased as stir rate increased, while an increase in hold time similarly decreased trough and final viscosities, and increased breakdown ($p < 0.0001$). High stir rates or extended stirring at high temperatures likely caused greater destruction of swollen granules, decreasing paste viscosity. Stir rate exhibited significant two-way interactions with starch weight, heating time, and hold time, with the impact of these latter run parameters becoming attenuated as stir rate increased.

Creation and testing of wheat with improved product quality via mutagenesis

M. J. GIROUX (1), J. M. Martin (1), E. Jobson (1), M. Brown (1), A. C. Hogg (1)

(1) Montana State University, Bozeman, MT, U.S.A.

Wheat quality is impacted by many genes but those that control starch or storage protein type or abundance have the greatest impact. Our studies have focused on creating and testing new *Starch Synthase II (SSII)* and *Reduced height (Rht)* alleles. The new alleles are being created using EMS mutagenesis and identified by either direct seed phenotyping or DNA sequencing. *SSII* mutations are valuable since they can be combined to decrease seed amylopectin while increasing amylose, resistant starch, and dietary fiber. There is a single *SSII* gene on each of the wheat genomes, so impacting seed amylose requires combining two *SSII* mutations in durum and three in bread wheat. In both durum and bread wheat we have created new *SSII* alleles that we have combined by crossing to create specific amylose levels, from small to large increases relative to standard wheat. The key to creating specific amylose levels with *SSII* alleles is combine *SSII* null alleles with *SSII* alleles having some residual activity. The resultant varying amylose levels are useful to modify pasta and bread product and nutritional quality with intermediate amylose levels resulting in firmer pasta with higher fiber content. Wheat quality is also impacted by genes that control seed protein content with one such gene being *Rht*. The most commonly used semi-dwarfing alleles are *Rht-B1b* and *Rht-D1b*, which while increasing agronomic yield also decrease seed size and protein content. As with *SSII*, we have identified *Rht* alleles varying in gene function that may allow us to increase seed size and protein content while still increasing agronomic yield. As with *SSII*, we have combined the alleles by crossing and are testing the impact of different *Rht* allelic combinations upon wheat quality traits. Our project's goal is to create new allelic variation in genes impacting wheat quality and to incorporate them into new wheat varieties.

Financial feasibility of safer maize storage technologies for smallholder farmers in developing nations:

A case study in Guatemala

A. Bianchini (1), J. R. MENDOZA JIMENEZ (1), F. Mattos (1)

(1) University of Nebraska-Lincoln, Lincoln, NE, U.S.A.

Several maize pests including fungi, rodents and birds thrive in warm, humid areas, boosted by poor post-harvest practices such as inadequate storage. This in turn causes significant safety, quality, and trade problems between producers and consumers. Increasing agricultural productivity is closely associated with improved storage to ensure food supply in developing countries. However, while improved storage options have become available in the market, few studies have focused on the financial capability of growers to acquire them. The goal of this study

was to investigate the financial feasibility of new technologies compared to traditional storage practices. The ability to safely store grain for longer periods allow farmers to wait and sell when prices are higher. Likewise, farmers who need to buy grain can do so in larger quantities when prices are lower. This research surveyed ($n_1 = 280$, $n_{2,3} = 225$) farmers from two townships in Huehuetenango, Guatemala. Further, local NGOs, banks and governmental entities were contacted for supplementary information to strengthen the financial model. Realistic scenarios faced by producers were simulated with Monte Carlo methods according to farm size (producers and consumers = Chain 1), maize consumption (strictly consumers = Chain 2), storage technologies (metallic silos, plastic silos, and plastic drums), and loan period (1, 2, or 3 years). The model provides a comprehensive cost-benefit analysis of storage technologies, which enables producers to identify the option best suited to their needs and preferences. For example, if farmers (Chain 1) choose storage capacity based on their yield history, plastic silos are not a financially feasible alternative due to their higher cost and fixed capacity. As far as metal silos, they seem to be a more feasible option after a loan period of 2 years for larger-sized farms, and after three years for medium- and smaller-sized farms. The opposite pattern was observed with plastic drums, likely due to their small capacity. Further, if Chain 2 farmers choose storage capacity based on historical 4-month consumption, all new storage technologies would be financially more feasible compared to traditional practices. The choice of storage capacity is crucial because, if a farmer selects a storage capacity larger than needed, unused space represents an extra monetary cost. The developed platform can be easily adapted to other storage technologies or commodities, and expanded to include other regions of the country, or other developing nations to obtain safer grain products with extended shelf life.

Added fiber and dietary fiber: The FDA rulings

D. T. GORDON (1,2)

(1) PIC&PC, Cathlamet, WA, U.S.A.; (2) emeritus, NDSU, Cathlamet, WA, U.S.A.

After approximately 25-plus years, the legal deliberations on the definitions of dietary fiber (DF) may have come to conclusion. The Institute of Medicine (IOM) defined DF as the nondigestible carbohydrates (NDC) mainly in plant foods. The IOM also coined the term Added Fiber (AF) for any NDC extracted from a food or synthesized. However, to be included under the umbrella term DF, an AF must have demonstrated a “beneficial physiological effect for human health” (BPEFHH). During the period of 2016-2018, the FDA first approved 6 AF, cellulose, guar gum, pectin, locus bean gum and hydroxypropylmethylcellulose. Beta-glucan and psyllium husk were reaffirmed as DF having previously been granted health claims to lower cholesterol. The FDA approved, “mixed plant cell wall fibers (intrinsic and intact)” as an encompassing term of great importance in cereal science, and the food-baking industries. Also advanced from AF to DF status were arabinoxylan, alginate, inulin and inulin-type fructans, high amylose starch (resistant starch 2 – RS2) galactiooligosaccharide, polydextrose, and restraint maltodextrin/dextrin, and most recently, resistant starch 4 (RS4). Among the 15 AF, only one, cellulose had the ability to improve laxation as determined with stool markers that were used to demonstrate reduced transit times. One primary goal of this paper is to champion the fact increased fecal weight and frequency and not necessarily just decreased transit times should be considered as a BPEFHH for other NDC-AF. Six AF demonstrated the ability to attenuate cholesterol levels and their levels of efficacy compared to beta-glucan and psyllium husk will be compared. The FDA has indicated a “completion of [their] such a rulemaking, to consider enforcement discretion for declaring their amount” on food labels will be forthcoming; an additional objective of this paper. Three AF were approved that attenuate blood glucose levels and one was approved to improve insulin sensitivity. Three fermentable AF demonstrated increased calcium (Ca) availability and or retention. While other reports have indicated some of these 3 AF could promote absorption of Fe, Cu, and or M, these elements were not mentioned. The mechanisms to explain the increased absorption/retention of Ca will presented as will the significance of these findings to public health. Polydextrose was approved to both lower energy intake and have and energy value of one (1) kcal/g. In summary, review of the BPEFHH effects and the levels to achieve these BPEFHH effect for the 15 AF will be summarized.

Understanding the behavior of wheat gliadin based nanoparticles upon adsorption at air-water interfaces

A. G. B. WOUTERS (1), I. J. Joye (2), J. A. Delcour (3)

(1) KU Leuven, Heverlee, Belgium; (2) University of Guelph, Guelph, ON, Canada; (3) Laboratory of Food Chemistry and Biochemistry, University of Leuven, Heverlee, Belgium

Wheat gluten proteins have low solubility in aqueous systems. This limits their use in applications requiring stabilization of air-water interfaces (foams). Traditionally, animal proteins such as those of egg white or milk have been used for this purpose. However, the production of plant protein, such as wheat gluten protein, has a lower environmental impact and is cheaper than that of animal protein. Novel strategies to improve the functionality of these proteins in aqueous systems are welcomed. In recent years, interest in protein based nano-aggregated structures for interfacial stabilization has increased. It has long been known that inert, rigid nanoparticles adsorb almost irreversibly at interfaces thereby providing them with high stability. It largely remains to be investigated to what extent and if so, by which mechanism protein based nanoparticles exert a similar effect. Here, a gliadin fraction was extracted from commercial wheat gluten with aqueous ethanol

(70.0% v/v). Via anti-solvent precipitation, a homogeneously dispersed suspension of nano-sized aggregates, hereafter referred to as gliadin nanoparticles (GNPs) was obtained. A GNP suspension (0.1% w_{protein}/v) at pH 6.0, which is close to the GNP's point-of-zero-charge, in a standardized whipping test displays excellent foam stability, with stable foam remaining even after 24 hours. In contrast, the same GNPs at pH 4.0 had very low foam stability. Surface dilatational rheology measurements revealed that protein films with high dilatational moduli were obtained at pH 6.0 but not at pH 4.0. This implies strong lateral protein-protein interactions at the interface. Indeed, cryo-SEM imaging of GNP-stabilized foams suggested that adsorbed GNPs at pH 4.0 retain their particulate nature, while at pH 6.0, a more smooth interfacial film was observed. To further assess GNP properties after adsorption at an air-water interface, foam was isolated fifteen minutes after whipping. Extraction with media containing sodium dodecyl sulfate (SDS) and both SDS and dithiothreitol and subsequent quantification of the protein content in these extracts suggested that intermolecular disulfide bonds had formed upon interfacial adsorption of GNPs at pH 6.0, but much less so at pH 4.0. As gliadins do not contain free thiol groups, other protein species present in the gliadin extracts possibly trigger thiol group-disulfide exchange reactions upon adsorption at the interface. Further investigation into the behavior of pure gliadins in this context is necessary. Overall, it seems that to efficiently stabilize air-water interfaces, GNP constituents need to spread out, mutually react and form an adsorbed protein film with high E values.

Best practices for sanitary dry bulk transport

R. GALLE (1)

(1) Miller Milling Company, Minneapolis, MN, U.S.A.

A recently published manual, *Bulk Trailer Sanitary Transport Best Practices*, was created for the International Association of Operative Millers (IAOM) membership by the IAOM Food Protection Committee in response to the new sanitary transport regulations by FDA. Its purpose is to compile a document that would combine best practices to achieve compliance with FDA regulations and the quality expectations of milling industry customers. The manual was written by members of IAOM's Food Protection Committee who are practical experts in food safety, quality and transportation, with additional input from independent bulk transportation companies. Although this manual focuses on the transport of milled grain products, which are non-ready to eat, this manual has applicability to other dry bulk food ingredients. This presentation will cover all areas of this manual including: Trailer design; Trailer maintenance; Trailer wash station and wash requirements; Prior load and return to service; Inspection and loading; Product handling and delivery.

Starch nanoparticle formation from high amylose rice starches using ultrasonic treatment

J. NO (1), M. Shin (2)

(1) Songwon University, Gwangju, South Korea; (2) Division of Food and Nutrition, Chonnam National University, Gwangju, Korea

Ultrasonic treatment is possible to break into the nanoparticles from starch granules instead of acid hydrolysis. Korean high amylose rice varieties, Goami, Singil Goami, and Dodamssal, were used after purification of starch granules. Starch suspensions (1%) were sonicated at 45% power output for 30 min and stood at 5°C for 18 h to separate into the dispersed and precipitated particles. Morphology, particle size distribution, X-ray diffraction, FT-IR, thermal properties and zeta potential of ultrasonicated rice starches were investigated. The particle size of dispersed nanoparticle was ranged from 69.1 to 251.9 nm, but that of the precipitated particle was ranged 728.4-1,224.1 nm. The nanoparticle size of Goami2 was the smallest (69.1 nm) among them. The starch nanoparticles showed amorphous without any peaks, but precipitated particles showed the same crystalline types, A type of Goami and Singil and B type of Goami2 and Dodamssal starches. From FT-IR, nanoparticles were formed a new band at $1,559\text{ cm}^{-1}$, regardless of crystalline type of starch. The gelatinization enthalpy of native and nanoparticle decreased from 6.96-8.58 J/g to 0.17-1.70 J/g, respectively. Zeta potential was not affected particles size and was ranged -36.98 - 16.16 mV, except Singil nanoparticle. It is confirmed that the ultrasonic treatment should be prepared nanoparticles from high amylose rice starches and all nanoparticles changed into amorphous type polymers.

Designing a vacuum dough expansion system to predict bread loaf volume

B. RAJPUROHIT (1), P. Krishnan (1), K. D. Glover (1), S. K. Sehgal (1), D. L. Brabec (2), B. Berzonsky (3)

(1) South Dakota State University, Brookings, SD, U.S.A.; (2) USDA ARS, Manhattan, KS, U.S.A.; (3) BASF, Beaver Crossing, NE, U.S.A.

Predicting bread loaf volume is the holy grail of the bread industry. Loaf volume is a significant economic factor in the baking industry. Numerous flour and dough quality tests exist, however, none of these tests accurately predict bread loaf volume. The most reliable method to determine baking potential of wheat flours is a standard baking experiment, which is time consuming. Vacuum Dough Expansion System (VDES) was designed to expand optimally developed dough prepared from flour and water. Dough expansion was carried out in a chamber and maximum height of the expanding dough was recorded. This rheological test was paired with a

chemical test, the hybrid SDS-SRC sedimentation test that measures gluten proteins that precipitate on the addition of solvents and detergents. Routine flour tests, dough quality tests and baking experiments were also done in parallel. Dough expansion height was significantly correlated with corresponding baked loaf volume for flour blends (gluten concentration from 7.3-14.7%) prepared by spiking vital wheat gluten of a low protein flour ($R^2 = 0.94$). The dough expansion behavior in a weak flour provided evidence of the applicability of VDES for testing effects of dough enhancers and baking ingredients. In a validation study performed on 24 hard red winter (HRW) varieties, specific loaf volume (SLV, Loaf volume/weight) showed significant correlation with dough expansion height ($r = 0.47$) and weight value (obtained from the hybrid SDS-SRC sedimentation test, $r = 0.54$). The best predictor of SLV in this sample set was the Mixolab stability ($r = 0.61$). In another validation sample set performed using 33 hard red spring (HRS) varieties each grown at three locations, loaf volume was found to be significantly correlated with dough expansion height ($r = 0.42$). However, the best predictor of loaf volume in this sample set was good wet gluten from the Glutomatic test ($r = 0.69$). The research established a proof of concept for dough expansion and its potential applicability in measuring baking quality of wheat. The VDES provided linkage between true baking test and other chemical indicators of wheat and dough quality. Inclusion of the VDES in predictive models involving other conventional tests may prove to be effective in predicting bread quality. The results will serve as stepping stone for the larger goal of improving the wheat quality by providing robust, rapid analytical tools to wheat breeders, flour millers and bakers.

Arabinoxylan actions in (models for) the digestive tract

M. GIDLEY (1)

(1) University of Queensland, St. Lucia, Australia

Background and Objectives - Arabinoxylan (AX) is the largest single component of wheat grain cell walls and thus represents a major source of dietary fibre, but is not as well studied as other fibres in (models for) the digestive tract. A minor fraction of AX is classified as soluble dietary fibre, with the majority being insoluble due to associations with other cell wall components such as mixed linkage β -glucan and cellulose. Soluble dietary fibres are expected to have positive nutritional effects in e.g. reducing the rate of macronutrient (starch, protein, triglyceride) digestion and lowering circulating cholesterol. Insoluble fibres may also contribute through binding of digestive enzymes, reducing the efficiency of macronutrient hydrolysis. Both soluble and insoluble fibres are expected to have benefits through promoting large intestinal fermentation. **Methods** - We have used an arabinoxylan-rich stream from a gluten fractionation plant as a source of soluble material for pig trials (as a model for humans) and have demonstrated a diverse range of positive nutritional effects. These in vivo data have been backed up by in vitro studies to identify the underlying mechanisms involved in starch digestion, bile acid interactions, lipid digestion, and microbial fermentation. **Results** - The addition of wheat AX to pig diets results in multiple beneficial effects, including: (i) Reduced protein digestion in the small intestine, linked with an increase in the rate of passage of digesta, (ii) Reduced circulating triglycerides linked to slower triglyceride digestion rates and reduced bile levels, and (iii) Enhancement of microbial health biomarkers in the large intestine, even in the presence of dietary red meat. In vitro studies are consistent with the in vivo data and show that soluble wheat AX is as effective as more widely studied soluble fibres (pectin, mixed linkage β -glucan) in retarding starch or triglyceride hydrolysis, binding to bile acids and promoting a healthy gut microflora and fermentation end-products. **Conclusions and relevance** - Wheat AX is a promising nutritional component, particularly if solubility can be improved.

Composition and interfacial properties of whole wheat dough liquor as affected by pentosanase and glucose oxidase

L. LIU (1), S. Zhou (1), L. Tong (2), L. Wang (1), X. Zhou (1)

(1) IFST, Chinese Academy of Agricultural Sciences, Beijing, China; (2) Chinese Academy of Agricultural Sciences, Beijing, China

Pentosanase (Pn) and glucose oxidase (Gox) are effective in improving the quality of whole wheat buns, forming higher loaf volume and better crumb structure. The discontinuities of liquid lamellae structure formed from the aqueous phase of dough, known as dough liquor (DL), play a critical role in gas cell stabilization and finally influence crumb structure. However, the effects of Pn or Gox on the composition and physicochemical properties of DL (rheological behavior, foam properties, etc.) extracted from whole wheat buns dough are remaining unclear. In the present study, DL was separated from Pn or Gox treated dough of whole wheat buns through ultracentrifugation method. Their composition and physicochemical properties, especially the foam properties were investigated. The results indicated that either Pn or Gox could increase the DL yield and changed its composition. Pn promoted the increase of water extractable arabinoxylan and Gox enhanced protein level in DL. Additionally, Gox catalyzed the formation of large protein aggregates, as well as protein-polysaccharide conjugates linked through disulfide and/or non-disulfide. As a result, the size of foams prepared with DL and their stability were significantly modified by Pn and Gox, especially at 60°C, which can be assigned to the enhanced ability to resist thermal stress, probably through retarding their coarsening and/or coalescence. The smaller bubbles size and higher stability were supposed to be good for forming fine crumb structure and higher loaf

volume of the products. This study extended knowledge of the relative contribution of Pn and Gox to the texture of whole wheat products by improving the foaming properties of DL during processing.

Impact of alternative irrigation practices on rice quality

S. G. ACQUAAH (1), T. Siebenmorgen (1), M. Reba (2)

(1) University of Arkansas, Fayetteville, AR, U.S.A.; (2) USDA-ARS, Delta Water Management Research Unit, Jonesboro, AR, U.S.A.

Current global concerns about water scarcity present a need to investigate more water-efficient rice production methods. Alternate wetting and drying (AWD) is fast emerging as a water-saving irrigation practice, but its effects on rice quality are largely unknown. To ascertain the impact of water-saving irrigation practices on rice quality, three irrigation treatments, namely: continuous flooding with cascade delivery (4 fields); continuous flooding with multiple-inlet delivery (4 fields); and AWD with multiple-inlet delivery (4 fields) were established on 12 production-sized (16.2 ha) fields in 2017. Results of rice quality evaluations showed that irrigation treatment had a significant ($P < 0.05$) effect on chalkiness. Samples harvested from the AWD fields had slightly greater mean chalkiness (5.6%) than samples harvested from the two continuously flooded fields (5.1 to 5.2%). Milling yields were not affected ($P > 0.05$) by irrigation treatments. The average milled rice and head rice yields across irrigation treatments were 73% and 59% respectively. Regarding pasting properties, while peak and breakdown viscosities were not affected ($P > 0.05$) by the irrigation treatments, setback viscosity, which is often linked with cooked rice texture, was impacted. Among the irrigation treatments, mean SB was least for the AWD treatment (146 cP) while the mean SB for the continuously-flooded fields were similar at 168 to 169 cP. In summary, the use of AWD with multiple-inlet delivery did not impact milling yields of rice relative to the conventional practices of continuous flooding. However, rice harvested from the AWD treatment fields had slightly greater chalkiness and lesser SB.

Effects of thermal treatment, bran content, and storage on development of flavor in intermediate wheatgrass flour and tortilla

M. LUU (1), L. Inamdar (1), G. A. Reineccius (1), Z. Vickers (1), B. Ismail (1)

(1) University of Minnesota, St. Paul, MN, U.S.A.

Intermediate wheatgrass (IWG, *Thinopyrum intermedium*) is a perennial crop that has garnered attention for its environmental and nutritional benefits. Grains, including wheat, are typically processed into flour and stored until use. Grains are stable up to 8-12 years; however, flour has a significantly lower shelf-life. Thermal treatment may increase grain shelf life by inactivating enzymes that are involved in rancidity, which is a major pathway for the formation of volatile organic compounds (VOC). Reducing the bran content may also increase shelf life by reducing the amount of fat and enzymes available for rancidity. Our objective was to evaluate the effect of steam treatment and level of refinement on the flavor development of stored IWG flour. IWG groats were subjected to steam treatment, milled into refined, partially refined, and whole flour, and then stored at room temperature at 43% relative humidity along with a hard red wheat (HRW) control. VOC were extracted from flour following a dynamic headspace purge and trap protocol and analyzed by gas chromatography-olfactory-mass spectrometry. A descriptive analysis sensory test was conducted with eight trained panelists to evaluate the extent of difference in on 36 attributes describing aroma, flavor, and aftertaste of tortilla made from the stored flour. Lipid oxidation compounds nonenal, 1-octen-3-ol, octanal, and decanal were detected in IWG with higher intensity in whole-flour sample over storage. Steam-treated samples had lower intensity of off-flavor compounds compared to non-steamed samples, attributed to a reduction in enzyme activity. IWG was described as grassier and earthier compared to HRW, due to the presence of alkyl aldehydes and 1-octen-3-ol. Descriptive analysis showed that IWG had more earthy, grassy and Play-Doh® aromas than HRW samples. IWG had more peanut butter and beany flavor and was also stronger in the five basic flavors and aftertaste than HRW samples. Samples with lower bran content had lower taste, flavor, and aftertaste intensities. Steam treatment may be a viable option for enhancing the storage stability of IWG flour, specifically the partially refined and whole flour. The interruption of enzymatic activity by steam treatment could help prolong the shelf life of IWG, thus off-setting unfavorable odor development and ultimately protecting its properties and rendering it marketable.

Novel grain quality attributes, processing approaches and functional properties

J. M. AWIKA (1)

(1) Texas A&M University, College Station, TX, U.S.A.

Excess calorie intake and associated chronic diseases is a growing global problem. At the same time, climate change is a grand challenge that threatens the future of global food security. A shift towards more healthy and climate resilient crops such as sorghum is therefore of great interest. Sorghum performs relatively well under water scarcity and elevated temperatures compared to the major cereal crops, wheat, rice, and maize. From a nutritional perspective, a major advantage of sorghum as a healthy and nutritious crop is its higher proportion of slowly digestible and resistant starch components compared to the other staples. This property is known to

reduce postprandial hyperglycemia in humans, and could potentially be manipulated to reduce overall calorie intake of sorghum-based products. Sorghum is also uniquely rich in diverse bioactive polyphenols and other compounds that are associated with benefits against nutrition-linked chronic diseases, including type II diabetes, cardiovascular disease, and some types of cancer. Some of the bioactive compounds in sorghum, such as high MW tannins, also have technological appeal in their ability to modify protein and starch functionality; this property can be used to produce new bioactive ingredients or enhance food quality. The key challenges associated with sorghum as a food ingredient are its reduced endosperm functionality and relatively lower protein digestibility; both attributes are related to the tendency of the hydrophobic sorghum endosperm kafirin protein to cross-link during processing. Recent developments employing traditional genetics to alter sorghum kafirin protein structure and functionality show a lot of promise in unlocking the full food use potential of sorghum. These improved sorghums have demonstrated enhanced food use quality and protein digestibility. Processes such as fermentation appear to further enhance the functionality and nutritional quality of the new sorghums. Emerging opportunities and challenges associated with sorghum production and utilization as a healthy food ingredient both in developed and developing regions will be discussed.

Effect of chemical components on porosity and mechanical properties of rice kernels

M. OPPONG SIAW (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

Rice, unlike other cereal grains, is consumed mostly as intact kernels or head rice, which makes its economic value twice that of broken kernels. The percentage of broken kernels is one of the factors determining the grade of milled rice with maximum limit of 4% and 50% for U.S. No. 1 and 6, respectively. Fissures and chalkiness are macro-structural defects which have been recognized to weaken kernel mechanical strength, and thereby increase breakage during milling. However, high percentages of broken kernels (up to 70%) are sometimes recorded even though these defects are controlled prior to milling. Proteins and lipids are the major chemical components in rice after starch and are present in the spaces outside of amyloplasts which contain compound rice starch granules. It was hypothesized that the structural arrangement and interactions of proteins and lipids affect void space sizes that change porosity, and consequently kernel strength and head rice yield. This study thus aimed to investigate ways of improving the interaction of rice components with starch through protein denaturation by heating and lipids removal, so as to reduce porosity and increase mechanical properties. Four long-grain cultivars with kernel thickness of 1.98-2.03 mm were selected. Rice protein was denatured under vacuum at 100°C for 1 hr, and rice lipid was removed with hexane extraction for varying times. The porosity and breaking force of treated samples were determined. Significant negative correlations were found between protein denaturation ($r = -0.86$) and lipid removal ($r = -0.68$) with porosity, and significant positive correlations between protein denaturation ($r = 0.994$) and lipid removal ($r = 0.74$) with breaking force. Protein solubility, which is a measure of protein denaturation showed a significant negative correlation ($r = -0.99$) with protein denaturation. This significant decrease in protein solubility evidences an increased protein-protein interaction, which reduced the void spaces, and thus improved mechanical strength. The presence of lipid weakened brown rice kernel strength because its hydrophobic nature limited its interaction with other components, and thus lipid removal led to better interaction between the components. In conclusion, the increase in mechanical strength could imply an increase in head rice yield and consequently economic value of the rice.

Genome-wide association of lipase activity in wheat for quality improvement of whole grain products

C. WEI (1), S. Yates (2), A. Hund (3), B. Studer (2), L. Nystroem (1)

(1) Laboratory of Food Biochemistry, ETH Zurich, Zurich, Switzerland; (2) Molecular Plant Breeding, ETH Zurich, Zurich, Switzerland; (3) Crop Science, ETH Zurich, Zurich, Switzerland

Quality of whole grain wheat flour and whole grain products is strongly governed by lipase activity (EC-3.1.1.3) found in wheat seeds. Endogenous lipase and other esterases cause lipid rancidity in whole grain flours, which leads to adverse nutritional, sensory and technological properties. Traditional processes to deactivate the enzymes often involve thermal treatment, which not only are energy consuming but may also decrease the nutritional value of products. Nevertheless, numerous wheat germplasm with broad genetic diversity are available. This study evaluated over 300 European wheat varieties grown in two years (2015 and 2016), within which 66 varieties were grown in an additional year (2014), at the same site with identical field management. Esterase and lipase activities in the whole grain flour were measured photometrically with *p*-nitrophenyl butyrate and *p*-nitrophenyl palmitate as substrates, respectively. Within each year, both esterase and lipase activities showed wide ranges among all varieties, with a difference up to 3-fold ($p < 0.005$). The results suggest some varieties, such as 'Julius', 'Lona' and 'Banquet', are better suited for stable whole grain products, as they had consistently low lipase activities in all years. Genome-wide association study (GWAS) was performed and revealed associations to single nucleotide polymorphism (SNP) located in the high quality wheat genome sequence of IWGSC (International Wheat Genome Sequencing Consortium). Four candidate genes were tentatively proposed to be associated to the lipase activity in whole grain flour. The results are the first steps for evaluation of wheat varieties for whole grain end use. This study offers a versatile tool to improve lipid stability of

whole grain wheat by genomics-assisted breeding methods, thereby offering new opportunities to optimize the quality of whole grain wheat flour and whole grain products.

The role of starch during lamination, fermentation and baking of multi-layered wheat flour pastry products

N. OOMS (1), K. Brijs (1), J. A. Delcour (2)

(1) KU Leuven, Leuven, Belgium; (2) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium

Fermented pastry is produced from laminated dough consisting of alternating layers of (pre-)dough and bakery fat. During baking, gas entrapment within the layered structure results in the typical honey-comb pastry crumb. We here studied the role of starch during lamination, fermentation and baking of multi-layered wheat flour pastry products on laboratory scale. Starch structure and thus functionality was selectively changed in two ways, (1) by ball-milling wheat flour, which increased the level of damaged starch (DS) from 6.8% to 9.2%, and/or (2) by including α -amylase in the recipe. Pastry dough strength was determined as the load at 40 mm extension, using a 'pastry burst rig' probe coupled to a texture analyzer. Pastry lift and collapse during baking were studied by filming the baking process with a digital camera mounted on the outside of the oven. Starch gelatinization and network formation were examined with differential scanning calorimetry and low resolution ^1H nuclear magnetic resonance experiments (NMR), respectively. The larger DS content increased pastry dough strength by 64%. Presumably, the increased water absorption capacity of DS limited the amount of water available for gluten, thereby impacting the properties of the gluten network formed. In contrast to native starch, DS is impacted by amylase use already at the dough stage. Inclusion of *Bacillus subtilis* α -amylase (1.6 enzyme units/g dry matter flour) in the recipe decreased dough strength by 21% in the DS enriched samples. During baking, the gelatinization of intact starch and the associated increase in dough viscosity seemed to obstruct gas cell expansion and pastry dough lift. Indeed, lowering the dough viscosity by enzymatic starch hydrolysis increased pastry lift by 11% and 7% in the control and DS enriched samples respectively and improved the crumb structure of both samples. The starch networks formed in the DS enriched and control products produced with and without amylase use differed from one another both in the extent of network formation and the relative distribution of amylose and amylopectin in the extra-granular and intra-granular spaces, as shown with ^1H NMR. However, neither these differences nor those in dough strength reported for the DS enriched samples had a notable impact on the product's structural collapse during or after baking. These results suggest a significant role for gluten proteins in pastry product structure setting.

A world without grains: Why research says no

Y. PAPANIKOLAOU (1)

(1) Nutritional Strategies, Paris, ON, Canada

Current and previous dietary guidelines routinely identify a healthy dietary pattern to include higher consumption of whole-grains, with limited consumption of enriched-grains. Recently published data in American adults show that whole- and enriched-grain food consumption is associated with greater intake of Dietary Guidelines' shortfall nutrients, including dietary fiber, iron, magnesium and folate. Nonetheless, some eating trends are suggesting the reduction or even elimination of grain foods from the diet may have health benefits, however, this concept lacks scientific substantiation. The current presentation will provide an overview of current and emerging research on grain consumption and identify whether both enriched- and whole-grain foods can be part of a healthy eating pattern. Additionally, there are limited data on the contribution of grain foods to nutrient adequacy. Therefore, a modeling analysis was completed using data from the National Health and Nutrition Examination Survey (2009-2016) to estimate usual intake for nutrients when 25, 50 and 100% of all grain foods were removed from the diet (N = 20,810; ≥ 19 yr-old). Findings showed that eliminating 25, 50 and 100% of all grains resulted in a greater percentage of adults not meeting recommendations for dietary fiber, folate DFE, iron, magnesium, thiamin and niacin. For dietary fiber, only 6.14 ± 0.1 , 4.3 ± 0.3 , and $2.0 \pm 0.2\%$ of adults exceeded Adequate Intake when 25, 50 and 100% of grains were removed. For folate DFE, 16.5 ± 0.7 , 23.2 ± 0.7 , and $49.1 \pm 0.9\%$ of adults were below the Estimated Average Requirement (EAR) when 25, 50 and 100% of grains were removed, respectively. For iron, 6.4 ± 0.2 , 8.3 ± 0.3 , and $16.7 \pm 0.4\%$ of adults were below the EAR when 25, 50 and 100% of grains were eliminated, respectively. For magnesium, 56.7 ± 0.8 , 61.3 ± 0.8 , and $70.0 \pm 0.8\%$ of adults fell below the EAR when 25, 50 and 100% of grains were removed, respectively. For thiamin, 9.5 ± 0.5 , 14.4 ± 0.6 , and $33.0 \pm 0.8\%$ of adults were below the EAR when 25, 50 and 100% of grains were removed, respectively. For niacin 1.8 ± 0.2 , 2.8 ± 0.3 , and $7.1 \pm 0.5\%$ of adults were below the EAR when 25, 50 and 100% of grains were removed, respectively. These findings indicate the removal and/or lowering of grain foods in the diet can result in greater percentages of adults not meeting recommendations for several nutrients and may have unintended public health consequences.

Global whole grain intake recommendations

N. M. MCKEOWN (1)

(1) Jean Mayer USDA HNRCA at Tufts University, Boston, MA, U.S.A.

No globally consistent recommendation for whole grain (WG) intake exists, with current recommendations varying considerably across the globe. In fact, recommendations range from quantitative advice (e.g., “eat X grams of WG per day” or “three or more servings of WG daily”) to qualitative advice (e.g., “choose WG (over refined grains) where possible”). Scientists and policy makers need to work together to harmonize the message around whole-grain recommendations’. Within their respective countries, consumers fail to meet the recommendations for whole-grain intake. Consequently, refined grains are the predominant grain consumed by both adults and children. Setting a global recommendation for WG intake is challenging because diets across the globe focus on regionally relevant sources of grains. Expert opinion can (1) recommend how to quantify amounts of WG (e.g., grams of product or servings of whole grain); and (2) establish a minimum WG recommendation based on reported health benefits. In order to guide public health decision making, identification of the gaps that are contributing to this lack of a “global WG recommendation” is needed to promote increased consumption of WG.

Exploring dry grain fractionation as a means to valorize high protein malting barley

M. S. IZYDORCZYK (1), J. Kletke (2), S. Nam (2)

(1) Canadian Grain Commission, Grain Research Laboratory, Winnipeg, MB, Canada; (2) Canadian Grain Commission, Winnipeg, MB, Canada

Malting barley varieties are potentially the most profitable commodities for producers; however, barley selected for malting purposes has to meet stringent quality requirements. Excessive grain concentration (>12.5%) is often the reason why barley is rejected for malting grade and sold at a lower price on the feed market. The objectives of this study were to explore dry grain fractionation as a means to valorize high protein malting barley by producing high fibre fractions for human nutrition and starchy fractions for adjunct brewing. Several Canadian malting barley varieties with grain protein concentration above 14% (db) were milled on a Buhler laboratory mill resulting in six flour streams. Coarse and fine shorts were further processed using a Buhler laboratory shorts duster resulting in coarse fibre fractions and two additional flour fractions. The total yield of combined flour fractions ranged from 50.2 to 51.6%, whereas the yield of fibre fractions ranged from 41.5 to 43.7%. The fibre fractions were enriched in beta-glucans (9.3-11.2%, db), arabinoxylans (9.9-11.3%, db), and proteins (22-26%, db) with average 2.2, 1.7, and 1.5-fold increase of these constituents, respectively, compared to the whole grain. The content of vitamin E in fibre fractions was higher than in the whole grain, ranging from 82 to 109 µg/g. The fibre fractions also exhibited an improved ratio of tocotrienol to tocopherols. The combined flour fractions were depleted of beta-glucans (0.6-0.7%, db) and arabinoxylans (0.5-0.6%, db), contained acceptable levels of proteins (11.5-13.5%, db), and high levels of starch (79-82%, db). Mashing experiments with 20% replacement of malt with flour fractions showed a significant improvement in malt extract without any negative effects on other malting quality parameters, such as wort beta-glucans, wort viscosity and the average degree of polymerization of starch dextrins. The results of this study clearly showed that high protein barley can be valorized by fractionation into health beneficial fibre fractions and starchy fractions that can be used as adjunct in brewing.

Gene editing of rice grain quality traits: Prospects for application and acceptance

K. L. KORTH (1), K. N. Haydon (1), S. Zhao (1), V. Srivastava (1)

(1) University of Arkansas, Fayetteville, AR, U.S.A.

The precision and relative ease of gene editing techniques have substantially transformed how biotechnologists and plant breeders can consider alteration of specific traits in rice plants. Agronomic input traits as well as desired output traits have been the focus of many gene-editing approaches to plant improvement. Introduction of gene editing material and regeneration of intact plants in elite rice, *Oryza sativa*, cultivars would vastly improve prospects of rapid development of desired traits. Multiple varieties of U.S. grown, long-grain rice were tested for their performance in tissue culture in terms of callus growth and plant regeneration. Oxidation of free fatty acids by lipase and lipoxygenase enzymes in the rice bran layer contributes to reduced storage longevity of brown rice products. Lipases release free fatty acids from lipids in rice bran and lipoxygenases act on these fatty acids to produce rancid odor compounds. Several lipases and lipoxygenases expressed primarily in seed tissue are ideal targets for gene editing to reduce or eliminate reduction of brown rice quality. Lipoxygenase-3 (LOX3) and a lipase designated L2 were selected as targets for mutation. Genes for these enzymes were individually or simultaneously targeted for mutation via CRISPR-Cas9 at two locations per gene. Multiple lines with mutations in targeted regions of both LOX3 and L2 were identified in the vegetative stages of T₀ plants, and seed was collected from two T₀ lines with mutations in the L2 gene. Resulting T₁ plants were screened for mutations and three distinct homozygotic lines were selected for grain production in the T₂ generation. Harvested grain will be subjected to accelerated aging in rough rice and brown rice forms, and evaluated for lipoxygenase and lipase activities, free fatty acid content, conjugated diene formation, and seed longevity. It is hypothesized that

concurrent mutation of LOX3 and L2 will have a synergistic effect resulting in significant reduction of oxidative products in rice bran. Public perception and regulatory hurdles will ultimately impact global adoption of gene-edited cereals. Current marketing challenges and the prospects for wider acceptance of food crops produced with this technology will be discussed.

Pre-harvest desiccant timing and effects on the fine chemistry of wheat starch

M. MALALGODA (1), K. A. Howatt (2), S. Simsek (2)

(1) University of Minnesota, MN, U.S.A.; (2) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Pre-harvest desiccants are occasionally used during wheat cultivation to promote uniform crop maturation and timely harvest. Such pre-harvest aids are recommended to be applied at the ripe stage of physiological maturation. However, due to non-uniform maturation, pre-harvest desiccants can come into contact with crops that have not reached ripe stage. In this context, the aim of this study was to determine if pre-harvest desiccant application at different developmental stages (ripe vs. soft dough) has an effect on the physicochemical properties of wheat starch. For this purpose, a greenhouse study was conducted where pre-harvest desiccant was sprayed at ripe stage and soft dough stage to a commonly grown wheat cultivar in North Dakota. Samples were collected before application and every three days after application until harvest. The controls used in the study were sprayed with water in place of pre-harvest desiccant at the same developmental stages. The obtained samples were milled and analyzed for differences in starch granule distribution, amylose and amylopectin ratio, amylose and amylopectin molecular weight, starch granule morphology, amylopectin chain length and starch thermal properties. The results of the study indicate that pre-harvest desiccant timing does not impact the spatial distribution and morphology of starch granules. The percentage of amylose and amylopectin, amylose and amylopectin molecular weight did not show significant differences between treatments. However, the results showed that pre-harvest affected the thermal characteristics of wheat starch when applied at soft dough stage and that it decreased the average amylopectin chain length. Differences in the proportion of short, medium and long chain amylopectin were also observed in both treatments. Overall, this study shows that pre-harvest desiccant has some effects on wheat starch properties, especially when applied at soft dough stage, although it is unclear how these changes affect overall functionality of wheat starch in food systems.

The interrelationships of test weight, kernel size distribution, protein content, and yellow pigments and their effects on durum wheat quality

B. X. FU (1), K. Wang (1)

(1) Canadian Grain Commission, Winnipeg, MB, Canada

Durum kernel physical properties has large impact on not only the milling performance, but also semolina appearance and pasta quality. Due to overall dry growing conditions in 2017 and 2018, the majority of durum wheat produced in the Canadian prairies was high in protein content and met the test weight requirements for the top grades of Canada Western Amber Durum (CWAD). However, some durum samples, although graded as No. 1 or 2, had smaller kernel size and were significantly lower in milling yield and semolina quality. This study was conducted to investigate the impact of kernel physical characteristics, with a focus on kernel size and its distribution, on durum milling potential, semolina and pasta processing quality. Two sets of durum samples were used. The first set was a blend of 14 commercial cargo loading samples. The second set included 21 composites of four CWAD varieties (Transcend, Strongfield, Brigade and CDC Verona) segregated based on their test weight (75 to 84 kg/hL) and protein content (10.3 to 18.7%). To investigate the kernel size distribution in relation to functionality, kernels were segregated into five fractions based on their sizes with a set of sieve. Semolina yield decreased gradually from fraction > no. 8 (3.18×19.05 mm), fraction > no. 7 (2.78×19.05), to fraction > no. 6 (2.38×19.05). However, there was a large drop in semolina yield for fraction < no.6 and a drastic decrease for fraction < no. 5 (1.98×19.05). Semolina generated from two small kernel fractions had significantly higher ash content. The yellow pigment and protein contents increased by 55% and 32%, respectively, with the decrease of kernel size from > no. 8 to < no. 5. Results showed that the small kernels (< no. 6) had a very detrimental impact on the milling quality and its proportion is a better predictor for milling quality than test weight. Because of the strong negative relationship between kernel size and protein content, spaghetti prepared from samples with a high proportion of small kernels was firmer in texture but less bright in appearance. The much higher yellow pigment content in semolina milled from small kernels did not result an increase in yellowness in both semolina and pasta.

Production of an enzymatic extract from *Fusarium oxysporum* f. sp. *melonis* using sonicated brewers' spent grain as substrate

I. A. ARREOLA (1), R. G. Troncoso (1), F. Vasquez (2), E. G. Martinez (1), A. G. Rascón (1), A. R. Islas-Rubio (2) (1) CIAD, AC, Hermosillo, Mexico; (2) Research Center in Food & Development, AC, Hermosillo, Mexico

Mexico, the fourth largest producer of beer, generates 1.87 million tons of brewers' spent grain (BSG) per year. This contains high levels of dietary fiber, being 25% hemicellulose, formed by arabinoxylans and ferulic acid. It has been reported that arabinoxylans favor growth in intestinal microbiota populations, whereas ferulic acid is a natural antioxidant. The BSG has been modified by chemical treatments, commercial enzymes, fungus and/or bacteria, for the production of bioethanol. Therefore, the objective of this work was to obtain an enzymatic extract from *Fusarium oxysporum* f. sp. *melonis* using BSG as substrate for the production of β -1,4-xylanase and evaluate its potential use in BSG modification, increasing arabinoxylans and ferulic acid availability. Wet BSG provided by a brewing industry was dried at 45°C during 48 h. Afterwards, chemical composition, including contents of lignin, soluble, insoluble, and total dietary fiber was analyzed. In addition, the contents of total phenolic compounds, free and bound phenols, and phenolic acids were determined. The production of the enzymatic extract was monitored, divided into 2 stages: first an inoculum was obtained and later, the enzymatic extract containing β -1,4-xylanase, using sonicated BSG (600 W, 30 min) or BSG without sonication (control) as substrate was obtained. The moisture content of BSG decreased from 83.0% to 4.4% after drying. The dried BSG had 24.3% protein, 8.7% fat, and 4.1% ash. The total dietary fiber was 60.7%, corresponding 0.9% to soluble fiber and 59.8% to insoluble, which 24.4% was lignin. The content of total phenol compounds was 3.85 mg AGE/g of sample, which 3.73 corresponded to bound phenols and 0.12 to the free ones. The phenolic acids found were: ferulic 1.14 mg/g, p-coumaric 0.18 mg/g and sinapic 0.01 mg/g. At the first stage of the production of the enzymatic extract, an activity of β -1,4-xylanase of 15.5 U/mL (day 4) was obtained, remaining constant during the following 2 days. At the second stage, a higher activity (26.5 U/mL at day 6) of this enzyme was measured. The sonicated BSG is a good substrate for the production of β -1,4-xylanase. The application of ultrasound to BSG could be an alternative to the use of chemical treatments which can represent a risk to human health and the environment, allowing the use of this residue in human nutrition.

Thomas Burr Osborne Medal Award Presentation – Understanding the genetics of wheat quality

C. F. MORRIS (1)

(1) USDA – Western Wheat Quality Lab, Pullman, WA, U.S.A.

My involvement with food and agriculture began at a early age on a maize, soybean, and livestock family farm in Iowa. My interests led to a B.S. from Iowa State University in agronomy and seed science. The next chapter played out at Kansas State University (KSU) where I obtained M.S. and Ph.D. degrees in crop and seed physiology. Before moving to Kansas I had never seen a wheat plant! At KSU I was mentored and influenced by Profs. Gary Paulsen, Jon Faubion, R. Carl Hoseney, Paul Seib and others who were generous with their time. My next mentor and post-doctoral advisor was Dr. Kay Walker-Simmons, a USDA scientist at Washington State University. In 1989 I was hired to direct the USDA Western Wheat Quality Lab, my current position. The mission of the lab has always been to conduct mission-oriented research and cooperatively develop new wheat cultivars. Regarding research, I followed the 1986 landmark paper of Greenwell and Schofield on friabilin and its association with grain hardness. This field of study eventually lead to the establishment of puroindolines and related proteins as the genetic basis of endosperm texture throughout the Triticeae and Aveninae. Of note was the discovery, with Dr. Mike Giroux, of mutations in the puroindolines that associated with a soft-to-hard phenotype in wheat. With co-authors, we have published numerous papers related to grain hardness and puroindolines. This work led to the creation of soft kernel durum wheat, perhaps the single most notable event since domestication of wild emmer. The puroindolines further provide a means to understand evolution and phylogeny in these taxa, and are showing promise to fight drug resistant pathogenic bacteria. A fellowship with Drs. Wrigley and Batey in Australia highlighted the importance of starch pasting in wheat quality. Our early work contributed to better understanding the connection between genetics, pasting and noodle quality. We registered the first waxy wheat in the U.S. Polyphenol oxidase was another focus, where we contributed to a deeper understanding of the role of PPO in product discoloration, especially noodles. Our PPO L-DOPA method is widely used for selecting low PPO wheat. Over the years we have contributed to the areas of arabinoxylan, quality testing, and a more concise understanding of wheat quality. Lastly, the opportunity to work with wheat breeders has been highly satisfying and provided a rich resource of genetic variation and research materials.

Effect of pre-harvest desiccant application on properties of β -glucan from oat groats

A. ALAHMED (1), J. Ransom (1), S. Simsek (2)

(1) North Dakota State University, Fargo, ND, U.S.A.; (2) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Pre-harvest desiccants are commonly used to control moisture levels in cereal grains before the harvest. It has been claimed that oat composition is affected by pre-harvest desiccant application. The aim of this study was to evaluate differences in β -glucan in the treated versus untreated (with or without pre-harvest desiccants) oat groats. Two cultivars (Rockford and Souris) of oats were grown at Minot and Prosper, North Dakota in 2015, and the desiccant was sprayed at the soft dough stage, ripe stage, or not applied. β -Glucan viscosity was determined by treating ground groats with digestive enzymes measuring viscosity with a Rapid Visco Analyzer (RVA). β -Glucan solubility was determined according to AACC Approved Method 32-23.01. Molecular weights were analyzed using high performance size exclusion chromatography with light scattering detection (HPSEC-MALS). β -Glucan viscosity was not significantly ($p > 0.05$) affected by treatment at soft dough (1,082 cP) or ripe (1,166 cP) stages compared to untreated (1,150 cP) controls. Use of the desiccant at the soft dough stage significantly ($p < 0.05$) reduced the percentages of β -glucan content and solubility versus untreated samples. β -Glucan content and solubility ranged from 4.35 to 4.65% and 52.1 to 60.6%, respectively. No significant ($p > 0.05$) differences were observed in β -glucan solubility from the desiccant treated at the ripe stage. Treatment at soft dough (4.4×10^6) and ripe (3.8×10^6) stages significantly ($p < 0.05$) increased β -glucan molecular weights compared to the untreated controls (3.5×10^6). The solubility of β -glucan decreased as the molecular weights of β -glucan in groats increased. Overall, the desiccant application seems to have effects on quality of oat groats and β -glucan characteristics from the groats if applied at too early of grain development.

Effect of dietary polyphenols on intestinal amylase/glucosidases and consequences on carbohydrate digestion

B. R. HAMAKER (1)

(1) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.

Rate of glycemic carbohydrate digestion is important as it affects postprandial glycemic response and slowly digestible carbohydrates potentially can activate the gut-brain axis and ileal brake for satiety response. One strategy to slowing rate of carbohydrate digestion is to partially inhibit the associated digestive enzymes, α -amylase and the four mucosal α -glucosidases (maltase, glucoamylase, sucrase, isomaltase). Certain naturally occurring polyphenolic compounds in foods have been shown to have selectivity to the different enzymes, and when paired with carbohydrate structures that are digested preferentially by an enzyme, could be used to obtain a slowly digestible carbohydrate effect. *In vitro* inhibition studies using mammalian small intestinal carbohydrases, mammalian recombinant enzymes, and mouse studies will be presented and discussed in terms of the possibility of food-based polyphenols slowing carbohydrate digestion and glucose delivery to the body, as well as affecting appetitive response.

Effects of sorghum proanthocyanidin interactions with partially gelatinized wheat starch and potato starch on resistant starch content

S. A. ALTHAWAB (1), J. M. Awika (1)

(1) Texas A&M University, College Station, TX, U.S.A.

Proanthocyanidins (PA) have been shown to increase resistant (RS) in cooked corn starch by interacting with amylose. Increasing RS in widely consumed starch-based foods, at the expense of quicker digested starches, could increase satiety and decrease total caloric intake. Our work aimed to determine the effect of PA on RS content of partially gelatinized wheat starch (WS) and potato starch (PS). Extracted sorghum tannins were incubated with WS and PS at 70°C, and 90°C in 30% and 50% ethanol solutions (E) for 20 min. The different temperatures were used to examine PA interactions with starch at different gelatinization stages. Ethanol was used to limit starch swelling and increase PA solubility. The RS content was determined by *in vitro* starch digestibility. WS and PS samples incubated with PA in 50% E were significantly ($p < 0.05$) higher in RS % than the control samples at both temperatures. RS increased in WS from 23.1% to 76.1% at 70°C, and from 1.5% to 20.9% at 90°C. On the other hand, PA had a lower impact on RS formation in PS, which increased from 84.7 to 91.3% at 70°C, and from 36.8% to 42.7% at 90°C. PA-PS interactions were limited likely due to a more tightly packed granule without the surface channels found in WS. In the more gelatinized 30% E treatments, however, the opposite effect was observed: WS showed a significant increase in RS only at 70°C; 18.8% RS vs 5.7% RS in the control. By contrast, PA treated samples increased in RS from 40.2% to 63.5% at 70°C and 26.2% to 50.5% at 90°C. Therefore, PA seems to have higher interaction with WS under conditions restricting gelatinization, whereas the interaction is higher with PS under more gelatinized conditions. This suggests PA-starch interactions can be optimized depending on starch source to enhance RS formation.

Influence of phenolic compounds on the functional and sensorial quality of products made with whole sorghum

V. V. QUEIROZ (1)

(1) Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Sete Lagoas, Brazil

It is well documented that the whole grains play protective action on the human healthy, thus, the demand of these ingredients to produce food with functional appeal has increased. In addition, governments have emphasized the importance of sustainable food system to future-proof production practices. Thus, promoting the consumption of whole grains that are particularly tolerant to abiotic stresses, is desirable. In this context, sorghum is an attractive cereal because it is drought tolerant, gluten-free, has neutral flavor, low allergenicity and is an important source of dietary fiber and antioxidant phenolic compounds, including flavonoids, tannins, anthocyanins, among others. The antioxidant activity of sorghum is 3-4 times higher than some of other whole grains. Studies have associated the consumption of sorghum with a reduction in the incidence of chronic non-communicable diseases. This protective effect has been attributed to the sorghum phenolic compounds that are involved in the inhibition or reduction of oxidative stress and inflammatory, mutagenic and carcinogenic processes. However dietary fiber and polyphenols can affect quality parameters, such as the color, texture and taste of the food products. For example, the 3-deoxyanthocyanins (3-DXA), which have a strong antiproliferative activity against human colon cancer cells, are mostly present in the genotypes with darker-colored pericarps, but, products made with these sorghums are darker colored and may have lower acceptability than those made with white pericarp ones. Similarly, the presence of tannin, a phenolic compound present in sorghum with pigmented testa, has advantages and disadvantages. The high-tannin sorghums are associated with several health benefits and play important agronomic roles by reducing bird predation and grain damage in the pre and post-harvest. On the other hand, tannins can impart more bitter and astringent flavor of the products, which may compromise the palatability of them. Besides that, due to the hardness of sorghum, it must be processed before consumption and this procedure can alter the physical structure and the chemical composition of the grains, promoting increasing or reduction of their bioactive compounds. Thus, as important as assessing the retention degree of these compounds is to evaluate the sensorial acceptance of the products made with different types of sorghum. In this way, several studies have been carried out and the results have shown that the functional and sensorial quality of the final products depends on the genotype of sorghum used, the cultivation conditions, the type of product and the technologies or processes applied to them.

Compositional and structural factors of coat and cotyledon tissue of red kidney beans (*Phaseolus vulgaris*) from different varieties and growing locations

L. ROMAN (1), R. Park (1), L. Widjaja (1), L. Falardeau (2), I. J. Joye (1), M. M. Martinez (1)

(1) University of Guelph, Guelph, Canada; (2) Bonduelle Americas, St-Denis-Sur-Richelieu, Canada

Dried beans (*Phaseolus vulgaris*) have long been a part of human diets; they are a rich source of dietary fiber, protein, antioxidants, minerals, and B-vitamins. They also reduce the risk of diet-related chronic disorders such as obesity, type 2 diabetes and cardiovascular disease. Therefore, its consumption and importance in the diet is on the rise. In this work, we aim to identify the compositional and structural factors responsible for bean processing and nutritional quality. To do so, 19 samples from different varieties of dark red kidney beans harvested at two different locations were studied in this project. Whole beans were characterized for bean size, seed coat to cotyledon ratio and thickness (SEM), micropyle and hilum size (SEM), water holding capacity and ash content. In addition, the seed coat was isolated and analyzed for pectin, protein and phenolic fractions, namely extractable polyphenols (EPP), non-extractable hydrolysable polyphenols (HPP) and non-extractable proanthocyanidins (NEPA). Meanwhile, cotyledon tissue was analyzed for total starch, pectin and protein content. The pasting behavior of whole bean flour was analyzed at 130°C under high pressure, to emulate cooking in cans, with the new RVA 4800. RVA and water holding capacity were performed with and without calcium to evaluate the ability of pectin to form insoluble pectates that affect cooking quality. The growing location had a great influence on the protein content in the cotyledon and, consequently, on the total starch content. Pectin and ash content, pasting properties and microstructural features were all affected by both location and variety. Mechanistic information about the cooking quality of beans was obtained through soaking and cooking experiments. Coat characteristics such as coat to cotyledon ratio, coat thickness, micropyle and hilum size were determining factors in the soaking behavior (water absorption capacity) of beans. On the other hand, bean size and the pasting properties at 130°C were the most important factors to consider for effective cooking as they affected swelling ability. Interestingly, bean coats contained high amounts of EPP, HPP and anthocyanidins. This work provides compositional and structural information for the selection of beans for manufacturing premium bean-based food products.

BRICE project: Understanding checking and breakage of biscuits and dry cereal products

P. LE-BAIL (1,2), M. Bedas (2,3), B. Jaillais (4), C. Jonchère (5), L. Ribourg (2), A. M. Le Bail (3,6)

(1) SFR-IBSM 4202, Nantes, France; (2) INRA-BIA, Nantes, France; (3) SFR-IBSM 4402, Nantes, France; (4) INRA-USC STATSC, Nantes, France; (5) INRA, Nantes, France; (6) GEPEA-UMR CNRS 6144, Nantes, France

The 4 Years BRICE collaborative project (started 2015) has the following objectives; i) to better understand checking and breakage (C&B) of different products (rusk, crackers and biscuits), ii) to develop tools and analytical means allowing a better on line or at line control of the status of the products and iii) to develop process-based solutions in order to mitigate C&B in industry. This presentation will focus on the case of biscuits. A round and thick biscuit (ROB) and a rectangular (REB) and thinner biscuit with piercing points have been used. The C&B counting was done over a 15 days storage. A higher C&B occurrence was observed for the ROB opposite to REB. Karl Fischer (water content determination) was combined to an automated near-infrared imaging bench to monitor water distribution at center and at surface of the products as well as the apparition of checking. A non-homogeneity of the distribution of water in ROB was observed along the plan and thickness dimensions, unlike REB, confirming that C&B can be explained by a non-uniform water distribution in the biscuit. A bench marking has been done between surface water content (determined by Karl Fisher) and by using a NIR hyperspectral imaging bench to assess the relevance of surface information on checking apparition. As a result, checking was found to occur within 1 to 2 days after baking. A PCA applied on a large number of ROB and REB biscuits yielded in specific wavelengths along the two main axis. The first axis was linked to the water wavelengths. The second axis was linked to different wavelength in relation with carbohydrates. The apparition of checking on the second axis was effective and visible with false color based on the axis's wavelengths before the apparition of the checking on the biscuits. An in-depth study has been done considering a model recipe made of water, sugar and flour. Indeed, sugar and water are expected to play a significant role on starch gelatinization and therefore on the mechanical stability of the final product. Seven flour/sugar ratio and two dry matter/water ratio were tested in terms of gelatinization temperature and degree of starch gelatinization, showing that the formulation interfere on water penetration in starch granule and with the degree of gelatinization. Acknowledgments: BRICE project is co-funded by Région Pays de la Loire, INRA, ONIRIS (Ministry of Agriculture) and confidential industry partners

Cells walls, their variability in grain and their impact on grain quality, in relation with genetic and environmental aspects

L. SAULNIER (1)

(1) INRA, Nantes, France

Much attention has been paid to the cell walls of wheat grains and their main components, arabinoxylans and mixed-linked beta-glucans, due to their impact in cereal food technology, human and animal nutrition¹. These impacts will be briefly recalled and especially the importance of grain cell walls as dietary fibres. Indeed in most western diets, the consumption of wheat products accounts for more than 50% of the dietary fibre intake. The cell wall components in the different parts of the grain and how breeders could influence their amount or their physico-chemical properties to enhance either techno-functional or nutritional properties of wheat grain will be presented. In addition, the possible impact of cell walls on grain size or shape, and in response to changes in environmental conditions will be discussed. Many excellent works have been done on cell walls around the world by different teams. This presentation will not be an exhaustive review of the literature and will mainly focus on some of the recent findings²⁻⁶ obtained at INRA in Nantes. [1] Saulnier, L. (2019). Types and Functionality of Polysaccharides in Cereal Grains. In T. Beta & M. E. Camire (Eds.), *Cereal Grain-based Functional Foods* (pp. 54–84). The Royal Society of Chemistry. <http://pubs.rsc.org/en/content/ebook/978-1-78801-148-8>. [2] Verhertbruggen, Y., Falourd, X., Sterner, M., Guillon, F., Girousse, C., Foucat, L., Le Gall, S., Chateigner-Boutin, A.-L., Saulnier, L., 2019. Challenging the putative structure of mannan in wheat (*Triticum aestivum*) endosperm. *Carbohydr. Polym.* 224, 115063. [3] Fanuel, M., Ropartz, D., Guillon, F., Saulnier, L., & Rogniaux, H. (2018). Distribution of cell wall hemicelluloses in the wheat grain endosperm: a 3D perspective. *Planta*, 248(6), 1505–1513. [4] Chateigner-Boutin, A.-L., Lapierre, C., Alvarado, C., Yoshinaga, A., Barron, C., Bouchet, B., Bakan, B., Saulnier, L., Devaux, M.-F., Girousse, C., Guillon, F., 2018. Ferulate and lignin cross-links increase in cell walls of wheat grain outer layers during late development. *Plant Sci.* 276, 199–207. [5] Chateigner-Boutin, A.-L., Ordaz-Ortiz, J.J., Alvarado, C., Bouchet, B., Durand, S., Verhertbruggen, Y., Barrière, Y., Saulnier, L., 2016. Developing Pericarp of Maize: A Model to Study Arabinoxylan Synthesis and Feruloylation. *Front. Plant Sci.* 7, 1476. [6] Freeman, J., Lovegrove, A., Wilkinson, M.D., Saulnier, L., Shewry, P.R., Mitchell, R.A.C., 2016. Effect of suppression of arabinoxylan synthetic genes in wheat endosperm on chain length of arabinoxylan and extract viscosity. *Plant Biotechnol. J.* 14, 109–116.

Effect of peeling on milling of hull-less barley and the nutritional quality of barley flour

B. ZHAO (1), S. Zhou (1), L. Wang (1), L. Liu (1), L. Tong (1), X. Zhou (1), J. Shang (2), Y. Ma (1,3), S. Wang (1,4)

(1) IFST, Chinese Academy of Agricultural Sciences, Beijing, China; (2) Henan University of Technology, Zhengzhou, China; (3) Department of Food Science and Formulation, Gembloux Agro-Bio Tech-ULg, Gembloux, Belgium; (4) Tibet Academy of Agricultural and Animal Husbandry Sciences, Lhasa, China

In the process of hull-less barley milling, it is desirable to obtain a flour with good sensory quality and low nutrient loss, but they always exist in a contradictory form. In this study, the distribution of dietary fiber and beta-glucan in different layers of hull-less barley and their influence on the yield of barley flour were investigated. The results showed that, with a 20% peeling rate, it can obtain better milling characteristics. Compared with flour prepared without peeling, the flour yield increased by 23%, the content of beta-glucan of barley flour increased by 79%, soluble dietary fiber (SDF) increased by 7%, and insoluble dietary fiber (ISDF) decreased by 15%. The effects of two kinds of highland barley flour, which are obtained from peeled barley with 80% of the yield flour and unpeeled with 65%, on the quality of barley noodles (adding 50% barley flour) also were investigated. There was no significant difference in sensory quality between the two kinds of barley noodles. In the process of barley milling, the treatment of peeling can improve the nutritional and yield of barley flour without reducing the quality. This study provides a new idea for barley milling and hopes to promote the further development of grain science.

Impacts of short-term germination on the chemical compositions, technological characteristics and nutritional quality of yellow pea and faba bean flours

R. Setia (1), Z. Dai (1), M. T. Nickerson (1), E. Sopiwnyk (2), L. Malcolmson (3), Y. AI (1)

(1) University of Saskatchewan, Saskatoon, SK, Canada; (2) Canadian International Grains Institute, Winnipeg, MB, Canada; (3) Warburton Foods Ltd., Winnipeg, MB, Canada

This research aimed to investigate the changes in the proximate compositions, functional properties and nutrition attributes of yellow pea (CDC Amarillo variety) and faba bean (CDC Snowdrop variety) flours as a function of germination periods (0, 24, 48 and 72 h). Alpha-amylase activities of the yellow pea and faba bean flours gradually increased during the germination, while negligible changes were found in their chemical compositions. Soaking (0-h germination) and 24-h germination noticeably increased the pasting viscosities of the pulse flours, whereas a further longer germination duration decreased the viscosities due to the increased endogenous alpha-amylase activities. Germination effectively enhanced the emulsifying and foaming properties of both pulse flours. With respect to nutritional value, improvement was observed in the *in vitro* digestibility of starch and protein of flours after germination; the treatment, however, did not enhance the *in vitro* protein digestibility corrected amino acid scores (IV-PDCAAS). The raw and 72-h germinated yellow pea and faba bean flours were also used to replace hard wheat flour at 10% and 20% levels for bread baking. In comparison to the 100% wheat flour control, the incorporation of germinated pulse flours at both levels decreased the falling numbers and pasting viscosities. The composite flours tended to require a shorter mixing time for the optimum dough development, and the generated doughs were stickier than the control dough. In addition to the observed changes in the flour and dough properties, the bread baked from the composite flours displayed a reduced loaf volume and slice area but increased firmness. This study revealed the influence of short-term germination on the functional characteristics and nutritional profiles of pulse flours and showed the potential of using the modified pulse flours in bread baking.

Nutritional and functional properties of wheat bran protein concentrate and its application in pasta products

N. T. TISKAM ALZUWAID (1)

(1) The University of New England, Armidale, Australia

Background and objectives: Plant industrial by-products are relatively low cost and a good source of nutritional compounds. Wheat bran is the main by-product of wheat milling and contains more than 15% high-quality proteins. However, these proteins are present in a form which is poorly digested as they are enclosed within a matrix of cell wall polysaccharides. Adding value to bran by extraction of protein is a worthwhile pursuit. The purpose of this work was to extract protein from durum wheat bran, characterize the fraction and investigate the benefits of adding to spaghetti. Using an improved alkaline method, proteins were extracted from fine bran to produce a wheat bran protein concentrate (WBPC). WBPC was to add to spaghetti formulation at 0, 1, 5, 10 and 20% w/w substitution. **Findings:** Bran yielded ~22% WBPC containing ~61% protein, 8% starch, 7% Dietary fibre, 24% fat. WBPC had enriched phytosterol content compared with wheat bran (11.59 vs. 5.14 mg/g) with β -sitosterol predominant. WBPC amino acid profile showed increases in essential amino acids, especially lysine and valine compared to bran. WBPC showed high solubility and high water and fat absorption capacity. Compared to bran, WBPC had higher amounts of p-hydroxybenzoic acid and syringic acid but an 8-fold lower total phenolic content. WBPC retained about half of the antioxidant (DPPH) activity of the bran. Fortification of

pasta with WBPC made significant changes to its chemical composition: increased protein content from 12.3 to 23.4%, phytosterol content from 3.02 to 4.77 mg/g and amino acid profile which showed increases in essential amino acids in fortified pasta. Fortification of pasta with WBPC increased pasta firmness with 5% while retaining the same cooking loss, water absorption and stickiness as control pasta. However, above 5% level, firmness decreased, and cooking loss and water absorption were negatively affected. From these results it appears that WBPC is a promising material to enhance the nutritional value of pasta products up to 5% addition without significant negative changes in cooking properties and provides an alternative use of the low value bran milling stream.

Protein quality determination: Practical issues faced by industry

M. STEWART (1)

(1) Ingredion Inc., Bridgewater, NJ, U.S.A.

Protein quality reflects the human body's ability to utilize a protein source for growth and maintenance. Multiple methods are currently accepted by regulatory authorities across the globe, which poses unique challenges for food formulators who address a global market. Additionally, the currently accepted methods are resource intensive. This presentation will summarize common methods used to assess protein quality and describe the existing literature to support alternative methods for protein quality determination. Practical aspects related to food ingredient development and food formulation will be integrated in this presentation.

One pot preparation of rice-gels from white rice using Rapid Visco Analyzer

J. MATSUKI (1), T. Sasaki (1), K. Yoza (1,2), J. Sugiyama (1), H. Maeda (3), A. Shigemune (4), K. Tokuyasu (1)
(1) Food Research Institute, NARO, Tsukuba, Ibaraki, Japan; (2) Kagoshima-Osumi Food Technology Development Center, Kanoya, Kagoshima, Japan; (3) Central Region Agricultural Research Center, NARO, Joetsu, Niigata, Japan; (4) Western Region Agricultural Research Center, Fukuyama, Hiroshima, Japan

“Rice-gel” is a novel material which is used as an ingredient to modify the texture of bakery products and noodles. However, its gelling mechanism and the effects of processing conditions and rice characteristics on the gel properties are still not well understood. The processing of rice-gel includes three steps: 1) cooking of rice grain, 2) high-speed shearing, and 3) gelling. The original processing procedure calls for 300 g of rice grain, whereas a recent report from Sasaki^{a)} used about 20 g of rice for preparation of cooked rice. In this study, we used 4 g of rice on a Rapid Visco Analyzer (Newport Scientific) for each step of the processing procedure and evaluation. 1) 4 g of white rice was cooked in 22 ml of water, using a temperature program that follows the temperature change of a rice cooker. 2) For high-speed shearing, the paddle was rotated at 2000 rpm for 10 to 20 min after rice was cooked. 3) For the gelling procedure, the temperature was quickly brought down to 7°C while measuring the viscosity of the paste. For comparison, hot rice paste was taken out of the canister just after high-speed shearing and poured into an acrylic mold, pressed between glass plates, kept at 4°C to make a solid gel, and hardness of the gel was determined with a compression test. Effects of variety and shearing conditions on gelling and gel hardness were determined using this small-scale evaluation system. Rice with high apparent amylose content showed higher viscosity compared to those with lower amylose content. Rice paste sheared at 80°C showed higher viscosity than those sheared at 20°C. The hardness of the gel after one hour showed a positive correlation with the viscosity of the paste. These results were compared to the hardness of the gel prepared with larger scale process. Thus, this small-scale method is expected to be a useful tool for small quantity evaluation such as in the breeding program or basic research for studying the effects of conditions and additives on the properties of rice-gel. ^{a)} Sasaki et al (2018) Food Sci. Nutr. 7: 721-729.

Progressive alterations in swelling and pasting characteristics of tapioca starch by heat-moisture treatment with different holding times and iterations

C. L. Lin (1), J. H. LIN (2), J. J. Lin (1), Y. H. Chang (1)

(1) Providence University, Taichung, Taiwan; (2) MingDao University, Changhua, Taiwan

Cross-linking modification is a cost-effective approach to restrict the swelling of starch during gelatinization. Due to the health concern over residual chemicals, researchers are actively seeking for physical approaches to alter the gelatinization properties of starch. In this study, tapioca starch was subjected to heat-moisture treatment (HMT) at 95-96°C for 0-60 min with up to 6 iterations, then its swelling power (SP) at 60-90°C and pasting profiles were analyzed to investigate the impact of HMT parameters on its gelatinization properties. Additionally, the correlation between SP of HMT starch and its pasting properties was evaluated. Results showed that HMT led to considerable decreases in SP at 90°C of starch from 42.6 g/g to 15.9-22.4 g/g. Moreover, increasing the holding time of HMT progressively reduced the SP at 90°C. The progressive decrease in SP was also observed with increasing the iteration of HMT. In addition to the lowering of SP, HMT altered the peak viscosity (PV) of starch from 2,194 cP to 1,410-2,211 cP and the percentage ratio of breakdown to PV (%BD) from 57.6% to 3.5-37.5%. Concurrently, the final viscosity was increased from 2,178 cP to 2,839-3,733 cP with the percentage ratio of setback to hot paste viscosity (%SB) ranging between 105.2-147.4%. In addition, increasing the holding time and

iteration progressively reduced the PV and %BD, and increased the %SB. In terms of the correlations between pasting parameters of HMT starch, it was observed that the decrease in PV (ΔPV ; $PV_{\text{Native}} - PV_{\text{HMT}}$) was negatively, linearly correlated with %BD ($R^2 = 0.908$), and was positively with %SB ($R^2 = 0.913$). Furthermore, ΔPV was found to positively correlate with the decrease in SP (ΔSP ; $SP_{\text{Native}} - SP_{\text{HMT}}$) at 90°C ($R^2 = 0.833$). The findings of this study demonstrate that the adjustment of holding time and iteration of HMT could progressively alter the granular rigidity, SP and pasting properties of tapioca starch. This approach would also further widen the applicability of tapioca starch to the situation when a chemically-modified starch with restricted swelling properties during heating and high viscosity during cooling is needed. Besides, the observed correlations between (a) pasting parameters of HMT tapioca starch and (b) PV of the starch and its SP may be useful to estimate the HMT-induced change in viscosity of tapioca starch by its SP.

Differentiation of PHS and LMA

A. P. DERKX (1)

(1) School of Agriculture, Food & Wine, The University of Adelaide, Adelaide, Australia

PHS and LMA both result in low Falling Number (FN) primarily due to the synthesis of high pI α -amylase prior to harvest. The ability to differentiate between the two traits is important for some sectors of the wheat industry and is dependent not only on an understanding of the different mechanisms and environmental interactions involved but also in some situations, on detailed climatic data during ripening. PHS and LMA are genetically independent traits that are triggered by different environmental conditions: PHS by rain on ripe grain prior to harvest; LMA by cool temperature or a cool temperature shock during a specific stage of grain development. At the genetic level, loci controlling major components of resistance have been identified that can be deployed in marker-assisted-selection to identify breeding lines with a lower risk of low FN. Aside from genetic factors, the traits differ in their physical presentation and in a range of biochemical attributes. During sprouting, the embryo swells, the coleoptile breaks through the grain coat and may progress to development of a shoot and rootlets. These physical changes are accompanied by the production of high pI α -amylase by the scutellar tissue then later by synthesis of high and low pI α -amylase, as well as other hydrolytic enzymes, by the aleurone tissue. This pattern of α -amylase synthesis establishes a substantial gradient in activity from the embryo end to the distal of the grain. By contrast, LMA is not accompanied by any physical changes, enzyme synthesis appears to be limited to the high pI α -amylase and the aleurone tissue, and is usually distributed roughly equally between proximal and distal halves of the grain. These spatial differences in α -amylase can be useful in distinguishing LMA-affected from sprouted grain. The caveat here is that both traits can be present simultaneously, in which case visual inspection of grain and access to reliable weather information during grain ripening are critical.

Composition and foam properties of whole wheat dough liquor as affected by pentosanase and glucose oxidase

L. LIU (1), S. Zhou (1), L. Tong (2), L. Wang (1), X. Zhou (1)

(1) IFST, Chinese Academy of Agricultural Sciences, Beijing, China; (2) Chinese Academy of Agricultural Sciences, Beijing, China

Pentosanase (Pn) and glucose oxidase (Gox) are effective in improving the quality of whole wheat buns, forming higher loaf volume and better crumb structure. The discontinuities of liquid lamellae structure formed from the aqueous phase of dough, known as dough liquor (DL), play a critical role in gas cell stabilization and finally influence crumb structure. However, the effects of Pn or Gox on the composition and physicochemical properties of DL (rheological behavior, foam properties, etc.) extracted from whole wheat buns dough are remaining unclear. In the present study, DL was separated from Pn or Gox treated dough of whole wheat buns through ultracentrifugation method. Their composition and physicochemical properties, especially the foam properties were investigated. The results indicated that either Pn or Gox could increase the DL yield and changed its composition. Pn promoted the increase of water extractable arabinoxylan and Gox enhanced protein level in DL. Additionally, Gox catalyzed the formation of large protein aggregates, as well as protein-polysaccharide conjugates linked through disulfide and/or non-disulfide. As a result, the size of foams prepared with DL and their stability were significantly modified by Pn and Gox, especially at 60°C , which can assigned to the enhanced ability to resist thermal stress, probably through retarding their coarsening and/or coalescence. The smaller bubbles size and higher stability were supposed to be good for forming fine crumb structure and higher loaf volume of the products. This study extended knowledge of the relative contribution of Pn and Gox to the texture of whole wheat products by improving the foaming properties of DL during processing.

Effects of drying temperature and relative humidity on the quality properties of Chinese dried noodles

Y. ZHANG (1), Y. Hui (1), B. Guo (1), Y. Wei (1)

(1) Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences, Beijing, China

Drying process is the last and key step in Chinese dried noodle (CDN) production and has a substantial influence on noodle quality. In order to improve the drying process and product quality, an attempt has been made to investigate the influence of drying temperature and relative humidity on the quality properties of CDN. Wheat variety Yongliang 4 was used to make CDN in laboratory, and relative properties were evaluated. The experiment was designed with two factors at three levels for the drying conditions: 300 minutes for drying with varying temperatures (40°C, 60°C and 80°C) and relative humidities (65%, 75% and 85%). The results showed that the relative humidity had the greatest impact on the quality characteristics of dried noodle products followed by temperature and factor interaction. Compared with the conventional drying method (40°C, 75%), high-temperature and high humidity drying process (85°C, 85%) contributed to a slight decrease in the L* value of CDNs, a slight increase in the a* value, and a significant increase in the b* value, the bending strength, breaking distance and breaking work of CDNs. Relative humidity was the main factor that affected the density of CDNs. The high temperature and high relative humidity environment increased the density of the products. The drying temperature was the most important factors affecting the quality of cooked CDNs, followed by factor interaction and relative humidity. Compared with the conventional drying process, the optimal cooking time of CDNs dried by high temperature was significantly prolonged, and the cooking loss rate was increased. The cooking absorption rate was the highest when CDNs being dried at high temperature and low humidity (80°C, 65%). Compared with the conventional drying process, the hardness, adhesiveness, gumminess and chewiness of cooked CDNs dried by high temperature and high relative humidity were increased, while the elasticity, cohesiveness and resilience were significantly reduced. Temperature and relative humidity have significant effects on the qualities of dried noodles and noodles after cooking. In the actual drying process, the influence of temperature and relative humidity on CDNs should be comprehensively considered.

Suitability of selected Australian varieties for premium yellow alkaline noodles as measured by sensory evaluation and triple cutting ring (TA-XT2iPlus)

L. CATO (1)

(1) Australian Export Grains Innovation Centre, Perth, WA, Australia

Textural properties of premium yellow alkaline noodles (YAN) (referred to as ramen in Japan) are an important quality attribute influencing consumer acceptance. Ideally, YAN in Japan should be firm, springy, not sticky and smooth. In addition to these quality characteristics, textural stability in a hot soup is a critical quality trait of YAN. Wheat and flour protein have been positively correlated with noodle firmness and elasticity and negatively with smoothness. In 1999 Crosbie et al reported a requirement of low to moderate starch-swelling properties, flour swelling volume (FSV) ~14–17.5mL/g for ramen noodles. The objective of this study was to benchmark selected varieties of APH and AH for their suitability for ramen noodles using sensory evaluation by a trained panel. Most common method to evaluate texture of noodles is by sensory evaluation. Preferences for YAN vary due to the many different noodle types. In general YAN texture is a complex relationship of firmness and springiness immediately after boiling and the stability of the noodle texture following a resting period of 7 minutes in hot soup. YAN stability equates to change in noodle texture from assessment at time zero to assessment at time 7 minutes. In addition to texture, colour and colour stability are very important quality traits for ramen noodles. Australian wheat varieties grown in Queensland (WLD) and New South Wales (NSW) ranged in grain protein content from 11.4 to 15.8 (11%mb), and wheat varieties grown in South Australia (SA) and Western Australia (WA) had a grain protein content in the range of 12.3 to 14.8% (11%mb) have been compared to North American wheats and assessed by sensory and triple cutting ring (TA-XT2iPlus) for their suitability for YAN. Three textural properties (firmness, springiness and stability) of YAN were evaluated by trained sensory panel first, followed by the triple cutting ring measurements. North American wheat showed stronger mixing properties, while Australian wheat in general showed higher starch gelatinisation when analysed by MixoLab. The objective of this study was to develop a new method using Stable Micro Systems (SMS) new triple cutting ring attachment to address the textural properties of noodles immersed in a hot soup and measure changes that occur between the end of cooking time and noodle consumption.

Marketing opportunities (sustainability, whole grain, ancient grain, etc.)

S. SEXTON-BOWSER (1)

(1) Center for Sorghum Improvement, KSU, Manhattan, KS, U.S.A.

Consumers seek products with novel attributes, for example, sustainable, nutritious and ancient. A holistic understanding of an ingredient is necessary to ensure the satisfaction of consumer demand and identify opportunities for new applications to drive value. The Center for Sorghum improvement is a platform for collaborative research and development of sorghum technologies for the benefit of the sorghum value chain. Join the session to learn about the story of sorghum and new learnings from current research. You will gain

knowledge regarding the properties of sorghum and the story of farmers and landscapes where sorghum is grown. Current research reveals we have yet to tap the potential for sorghum, a grain adapted from harsh agro climates with considerable genetic diversity for nutritional and functional traits.

Associations of HMW-GS composition and rye translocations with dough mixing properties and sugar-snap cookie baking quality of soft winter wheat

F. MA (1,2), J. Kim (2,3), B. K. Baik (1)

(1) USDA-ARS Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.; (2) Department of Horticulture & Crop Science, The Ohio State University, Wooster, OH, U.S.A.; (3) Chonbuk National University, Jeonju, Korea

The sugar-snap cookie baking test is the most commonly performed baking test in the evaluation of soft wheat end-use quality. Soft wheat varieties with good cookie baking potential are believed to be suitable for many other soft wheat products. The high molecular weight glutenin subunits (HMW-GSs) and rye translocations of hard wheat and their associations with bread-baking quality are well understood, whereas those of soft wheat and their associations with cookie-baking quality are still poorly understood. The influences of HMW-GSs and rye translocations on dough mixing properties and cookie-baking quality were investigated using 50 selected U.S. eastern soft winter (ESW) wheat varieties carrying fourteen predominant HMW-GS profiles accounting for 80% of the recently developed ESW wheat varieties. The 149 ESW wheat varieties grown in 2016 and 2017 were analyzed for grain characteristics (test weight, grain protein content and kernel hardness), milling quality (softness equivalence and flour yield), sodium carbonate and lactic acid solvent retention capacities (SRCs), flour protein content and cookie-baking quality to identify the grain and flour characteristics that predict cookie diameter. Wheat varieties possessing different HMW-GS profiles exhibited large variations in dough mixing properties and cookie baking quality, as indicated by midline peak times (MPTs) ranging from 0.6 to 4.6 min and cookie diameters ranging from 16.3 to 19.5 cm in 50 varieties. HMW-GSs at the *Glu-D1* locus significantly affected both dough mixing properties and cookie diameter, whereas HMW-GSs at the *Glu-A1* and *Glu-B1* loci exhibited significant associations only with dough mixing properties. MPTs of ESW wheat were ranked in the order of subunits $1>2^*$ at the *Glu-A1* locus, $7^*+8=13+16>7+8=7+9$ at the *Glu-B1* locus and $5+10>2+12>2+12_1=2+10$ at the *Glu-D1* locus. For cookie diameter, individual subunits at the *Glu-D1* locus were ranked $2+12_1>2+10=2+12=5+10$, indicating that subunits $2+12_1$ are favorable for cookie baking. The influence of rye translocations on MPT and cookie diameter was dependent on HMW-GS profile. Three HMW-GS profiles containing subunits $2+12_1$ were identified to be the most desirable for the production of cookies as determined by a cluster analysis based on cookie diameter. Sodium carbonate SRC, softness equivalence, flour protein content and lactic acid SRC together effectively predicted cookie diameter ($R^2 = 0.79$, $P < 0.0001$). These results support that soft wheat breeders and cookie manufacturers could make an initial selection of the soft wheat breeding lines and varieties possessing desirable cookie baking potentials by just determination of the subunits $2+12_1$ presence.

Structural characterization of starch isolates from the electrolysis treatment of barley flour

I. EKAETTE (1), M. D. A. Saldana (1)

(1) Department of Agricultural, Food and Nutritional Sciences, University of Alberta, Edmonton, Canada

This study was carried out to understand the effects of electrical voltage treatment of barley flour on the structural properties of the final starch isolate. Barley flour (starch 75%, protein 11%, ash 0.9% dry basis, 0% amylose) slurry was prepared in the proportion of flour to water 1:6 w/w and treated by electrolysis utilizing pure platinum electrodes (>99%) of 1.5 mm in diameter each, at voltage (5, 10, 15, 20, and 25 V), electrode length (4, 6, and 8 cm), and constant time of 30 min. Electrolysed barley flour slurry was centrifuged at 1,593 g and upper protein layer was removed to recover the white portion starch granules. Starch isolates were dried at 40°C and stored at room temperature until characterization. Results showed that electrolysed starches compared to the alkali treated starch (conventional isolation method) had lower gelatinization onset, peak and conclusion temperatures measured by differential scanning calorimeter, as $57.52 \pm 0.21^\circ\text{C}$, $63.56 \pm 0.03^\circ\text{C}$, $70.43 \pm 0.02^\circ\text{C}$, for 25 V/8 cm, respectively, and $59.92 \pm 0.08^\circ\text{C}$, $66.36 \pm 0.01^\circ\text{C}$, $73.80 \pm 0.78^\circ\text{C}$ for alkali treated starch, respectively. The lower gelatinization temperatures may be related to loss in crystallinity of the treated starch. Syneresis of starch gels (11% solids, 57°C) was observed for 37 days at room temperature and showed that starches treated at 5 V/8 cm, and 25 V/8 cm had significantly lower water loss as 87.5% and 25.0%, respectively, compared to 100% syneresis of alkali treated starch. This showed that starches treated with high voltage had superior retrogradation characteristics possibly due to strengthened hydrogen bonds from hydrogen and hydroxyl ions produced during electrolysis. Starch gels (10% solids, 67°C) were left at room temperature (23°C) for 40 days, fast-frozen using liquid nitrogen, and lyophilized; swelling capacity of electrolysed starch gels ranged from $1,486 \pm 10.37\%$ (25 V/8 cm) to $1,631 \pm 14.83\%$ (5 V/8 cm). The extremely high swelling/water retaining capacities show that ionic species during electrolysis produced strong networks for superabsorbent hydrogels valuable for the bio-based polymer industry. Color differences of starch gels showed increased opacity of all electrolysed starches with whiteness indices of 89.15 ± 1.83 at 5 V/8 cm and 90.82 ± 0.53 at 25 V/8 cm compared to 95.78 ± 0.01 of alkali treated starch which was distinctly transparent. This may be related to the re-alignment

of the starch molecules caused by electric polarization effects. Overall, the electrolysis process showed modification of the structural properties of barley starches.

Waste bread recycling by utilizing tailored biotransformation

M. O. IMMONEN (1), N. H. Maina (1), R. Coda (1,2), H. Nihtilä (1), Y. Wang (1), K. Katina (1)

(1) University of Helsinki, Department of Food and Nutrition, Helsinki, Finland; (2) Helsinki Institute of Sustainability Science, University of Helsinki, Helsinki, Finland

Current estimates indicate that 5-10% of bakery production is wasted before retail due to several reasons such as excessive production and system failures. Waste bread is mainly utilized for non-food purposes, like animal feed and bioethanol feedstock. To match the modern demands for sustainable food systems and more efficient production practices, food waste should be minimized, and food-grade materials re-utilized for human nutrition. The aim of this study was to investigate the potential of recycling bread into a new bread ingredient with minimal processing or by utilizing tailored microbiological biotransformation. The waste bread was homogenized with water with or without amylolytic enzymes and fermented with lactic acid bacteria (LAB) producing dextran or β -glucan exopolysaccharides (EPS). This sourdough-type bread slurry was then mixed with other baking ingredients and the dough was prepared according to typical straight dough process (including yeast leavening). Waste bread homogenization with water followed by direct recycling to new bread dough yielded impaired quality breads with 20% lower specific volume and up to 75% faster staling. Deteriorating effect increased with higher level of waste bread addition. EPS production by starter LAB during waste bread fermentation increased waste bread slurry viscosity up to 7-fold and led to mild acidification. LAB fermentation in general was considered beneficial since it effectively prevented germination of heat-resistant *Bacillus* spores during recycling. Fermentation of bread slurry with dextran-producing *Weissella confusa* A16 helped to maintain bread quality with 12.5% waste bread addition, by increasing specific volume (12%) and decreasing crumb hardness (37%) compared to non-fermented recycled waste bread. However, production of β -glucan EPS by *Pediococcus clausenii* E-032355T in waste bread did not provide similar beneficial effect for bread quality. In conclusion, waste bread can be recycled within the bakery with tailored biotransformation.

How much is enough? Getting the whole grain balance right

C. J. SEAL (1)

(1) emeritus, Newcastle University, Newcastle upon Tyne, U.K.

The health benefits of consuming whole grain foods are reported widely. For example, a recent publication has suggested that globally 3 million deaths and 82 million disability-adjusted life years are attributable to low intake of whole grains. The supporting evidence showing advantages of whole grains is largely derived from meta-analyses of data from large observational studies where a negative dose-response relationship between higher whole grain intake and lower disease risk/incidence is seen. Intervention studies also show some improvement in biomarkers of disease risk with higher whole grain intake, but the effects have generally been smaller and less convincing than the observational data. This may be due to the size of the studies and the limited scope of intervention doses and types of whole grain investigated. As a result, the levels of whole grain needed to deliver a health benefit remain unclear and while the message that whole grains should be part of a healthy diet is recognized by consumers, intake of whole grains is universally low. Many health agencies now include recommendations to consume more whole grains in their dietary guidance. The 2015-2020 *Dietary Guidelines for Americans*, for example, recommends that a healthy diet pattern includes 'Grains, at least half of which are whole grains'. In Denmark the recommendation is to consume 75 g whole grain per 10 MJ of energy per day. The recent *Lancet-EAT* report suggests that to achieve a healthy and sustainable diet we should consume all cereals as whole grain with a target of 232 g whole grain per day. So, how much whole grain is enough? Is 'some better than none' or is it a case of 'the more the better' or 'only eat whole grains'? Does it matter which type of whole grain is consumed? This presentation will address these questions by drawing on evidence from both observational and intervention studies showing the range of benefits which can be achieved to inform the development of robust public health recommendations.