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ABSTRACTS

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2016 Annual Meeting Abstracts

Abstracts submitted for presentation at the 2016 AACCI Annual Meeting in Savannah, Georgia, October 23–26. The abstracts are grouped by presentation category (Special Session, Oral, and Poster) and listed within each group in chronological order by presentation number. Abstracts are published as submitted for citation purposes. They have not been edited by AACCI editorial staff. Please send questions or comments to aacc@scisoc.org.

The recommended format for citing annual meeting abstracts, using the first abstract below as an example, is as follows: Castura, J. Perception dynamics of grain-based ready-to-eat cereal products using TCATA. (Abstr.) Cereal Foods World 61(Suppl.):A1, 2016. http://dx.doi.org/10.1094/CFW-61-6-A

2016 Abstracts of Special Session Presentations

102-S
Perception dynamics of grain-based ready-to-eat cereal products using TCATA
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Consumers begin to experience feelings, tastes, aromatics, and sounds of a ready-to-eat cereal at the first bite. Sensations arise and evolve rapidly. The multi-bite eating experience is not static, but dynamic. Temporal check-all-that-apply (TCATA), which has recently been introduced as a temporal sensory method, extends the use of check-all-that-apply questions by allowing continuous selection of attributes based on applicability or noticeability. TCATA can permit characterization of the perception dynamics of real-world products. TCATA data can be useful, for example, in early-stage development (to investigate how sensations evolve in different products within a product category), in factorial experiments investigating how ingredients/process changes affect sensory outcomes, in product matching (to ensure that sensations elicited by a prototype match the benchmark), and in product reformulation (to confirm that ingredient or process changes successfully differentiate the product). In this study, TCATA data are used to characterize the grain-based ready-to-eat cereals that are co-investigated by the presenters in this workshop.

103-S
Harmonizing Sensory Attributes with Nutrition Claims and Emotional Benefits for Ready-To-Eat Cereals: A Case Study
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What is for breakfast today? For many households, the unequivocal answer has been and continues to be: "cereals". While ready-to-eat cereals provide a quick, easy and convenient way to start the day (and occasionally end it…), they are also relatively low in calories, and full of nutrients. In most western countries where diet-related chronic diseases such as heart disease, obesity and type II diabetes are especially concerning, RTE cereals are perceived by many as a healthier alternative to other breakfast and snack options. But are all RTE cereals created equal? More specifically, do consumers' expectations differ for RTE cereals made with different grain types? As the category expands beyond the more traditional grains (wheat, corn, oat, rice) to include more ancient grains, such as barley, millet or quinoa, what sensory, nutritional, functional and emotional benefits do consumers now expect? Through a series of consumer and sensory studies, this very question was investigated. Results highlight where consumer expectations and sensory experience align, and where gaps currently exist between expectations of benefits based on concept, visual and actual product experience, allowing food manufacturers to devise strategies for product development and ensuring stronger alignment between product positioning and sensory experience.

104-S

The relevance of flavor complexity to consumer acceptability of food products

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It requires a holistic view of the eating experience to deliver food that is sustainably accepted by consumers. Traditional descriptive analysis is often used to interpret consumer responses to food products, which in turn is used to guide reformulation efforts during product development. As descriptive analysis only provides intensity ratings for the singular sensory attributes associated with the products, the complexity of the flavor experienced by consumers is not measured. Ultimately multiple sources of information (e.g., consumer response, complexity profile, descriptive analysis) are required to provide key product insights that maximize development efforts. This presentation will illustrate that optimizing the harmony, balance, and/or blend of flavors in a grain-based product can translate to improved consumer acceptability.

201-S

Understanding starch swelling behavior and how it impacts functional and sensory properties of food systems

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Starches are well-known thickening agents, and the complexities of such soft particle suspensions must be carefully considered during product development. Even in simple systems, textural properties can vary in surprising ways as the swelling of the starch and concentration-in-use change. Small changes in processing conditions or recipes cause big changes in the thickening performance. A viscosity-swelling volume map has been created that can be overlaid with target zones for different food applications, a cohesiveness curve, shear-thinning regimes and elasticity curves. Such textural state diagrams allow the formulator to predict textural characteristics for starches based on information about their swelling behavior, concentration-in-use and processing. This portion of the session will look at the current understanding and methods of measurement associated with starch swelling and thickening properties. In addition, the use of these texture state diagrams in order to allow products to be proactively and intelligently formulated by relating the function of an ingredient to a specific application will be described. When properly applied, starches can influence specific variations in adhesion, elasticity, stickiness, gumminess, firmness, water retention and a number of other critically important yet commonly discounted sensory properties. This presentation covers the current understanding of how the chemical and physical structure of starches relates to the macro textural properties of foods.

202-S

Designing novel starch-based texturizers for snack applications that drive consumer acceptance

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Starch-based texturizers can play an important role in dough binding, machinability and final texture development for commercial sheeted and baked snacks. For example, while the texture of non-laminated snack crackers is primarily driven by a strong network of gas cells generated by film formation and steam entrapment, added starch-based texturizers exhibit a significant impact on dough binding properties, moisture release during baking and final product texture. This section of the session will explore the mechanism of starch functionality and key starch characteristics that drive snack performance. The influence of starch structure will be directly correlated with the functions that lead to desired snack texture characteristics as profiled through descriptive sensory analysis and compared with localized product texture maps created through principal component analysis. This understanding enhances how a manufacturer can control the quality of existing products or introduce novel textural experiences into snack applications.

203-S

Improving pasting and textural properties of waxy wheat flour and starch by chemical and physical modifications

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Waxy wheat is a potentially valuable specialty wheat. Starch in waxy wheat endosperm comprises essentially amylopectin. In normal wheat, starch contains approximately one-fourth of its weight as amylose. The physical properties of starches when heated with water depend in large measure on their amylose content. Amylose promotes the gelling and film-forming properties of a starch, and creates highly associated starch. The highly associated starch in food digests slowly and incompletely when consumed by humans. Amylopectin, on the other hand, increases the thickening power of starch and promotes clarity of starch pastes and gels. Starch pastes control the consistencies of soups, gravies, sauces, and fillings, while starch gels control the textures of puddings,

spoonable salad dressings and confections. Waxy wheat starch gelatinizes and begins to swell at a temperature about 10°C below that of waxy corn starch. The lower cooking temperature increases waxy wheat starch's marketing potential in microwaved foods and as a starch thickener that saves energy during food processing. However, when cooked in water, waxy wheat starch gives a cohesive texture, which is not desirable in many food applications. In this study, waxy wheat starch was chemically cross-linked to eliminate the undesirable cohesive texture. Cross-linked waxy wheat starch gave a somewhat higher thickening power compared to cross-linked waxy corn starch. Furthermore, the same modification on both waxy corn and wheat starches gave a modified waxy wheat starch with better freeze-thaw stability than waxy corn starch. Freezer-stability of starch-based thickeners is required for frozen foods. In comparison, thermal processes were used to develop non-cohesive texture from waxy wheat flour.

204-S
Designing starch based textures using extrusion
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Extrusion is a powerful and versatile technology that enables the creation of unique and desirable textures for the consumer. Starch is the most important carbohydrate biopolymer in the generation of these textures. The chemistry of starch, it's physical-chemical properties combined with its interaction with water, protein and lipids, gives the texture designer a rich selection of textures with the appropriate flavors. This talk will organize the vast research in this field to offer a unique understanding of the available and emerging design rules which are based on fundamental understanding of starch behavior during extrusion.

205-S
Advances in the use of starch for imparting fat-like texture to foods
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Excessive intake of dietary fats is associated with the development of cardiovascular diseases, obesity, and diabetes. However, the removal of fats from foods usually results in products with significantly different textures and sensory attributes from those of the original products, which may adversely affect consumer acceptability. To address this problem, fat replacers have been developed to compensate for the loss of sensory qualities in low-fat or non-fat foods. A number of carbohydrate fat replacers have been reported. In general, these fat replacers have lower energy density and are added in the low/non-fat foods to provide the texture characteristics similar to those of the original whole-fat products. Starches and other hydrocolloids, such as cellulose derivatives and inulin, are frequently evaluated as fat replacers in various types of food. In this talk, we will discuss our work of using starches as milk fat replacer to improve the physical and sensory qualities of strained non-fat yogurt. The non-fat and whole-fat strained yogurts were used as controls. Rheology tests were used to characterize the flow and viscoelastic properties of yogurts supplemented with starch, thus to predict the sensory outcomes of various formulations. In addition, the microscale structures of yogurt gel networks were imaged using Cryo-SEM and correlated with their rheological properties. Based on the physical information, the sensory qualities of starch-added yogurts will be evaluated for assessing their consumer acceptability.

301-S
Applicability of plant proteins and protein-rich agro side-streams towards cereal foods
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The global protein supply security, restricted availability of animal proteins and consumers' interest towards increased protein content in food are driving the need to utilize existing plant sources and agro-side streams more efficiently. Restricted protein availability within the plant matrix, nutritional and sensory quality, anti-nutritional factors as well as poor technological functionality of plant proteins compared to animal based ones are the major challenges. Dry fractionation has shown to be an efficient method to physically separate protein-rich particles into enriched fractions (oat and faba bean: 50-60 % protein, rapeseed press cake: 46% protein). Despite moderate protein concentration particularly for the rapeseed protein concentrate; the fraction had solubility >30% at pH 7-10 and high dispersion stability after microfluidization. The applicability of plant proteins was demonstrated for high protein pasta and bread. Pasta prepared with faba bean had 2.5-fold higher protein content than semolina pasta. Compared to semolina, faba bean pasta had lower cooking quality but many textural parameters and starch hydrolysis index (HI) were similar. Protein enriched noodles (17-25% protein) were made by using oat protein and semolina. Oat protein enrichment did not affect texture, cooking loss or HI compared to the semolina noodle. Gluten-free high protein oat bread was made using oat protein concentrate (35%) and corn starch-oat endosperm flour and compared with a reference made from corn starch and oat endosperm flour. GF high protein oat bread gave similar loaf volume but better structural and textural properties

compared to reference bread. The results indicated that hybrid processing technologies combining dry fractionation and bioprocessing can be used to obtain multi-functional protein concentrates for diverse high protein cereal applications.

302-S

Physical modifications of plant protein for new and improved functionality

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Increasing cost of dairy-based ingredients, emerging dietary preferences (e.g., gluten-free and vegan) and consumer demand for healthier ingredients are leading the market trends towards more cost-effective and plant-based alternatives, which are gaining increasing market share as food ingredients. Plant proteins are normally considered inferior to animal proteins in terms of functionality. This presentation will introduce recent efforts to improve plant protein functionality by physical approaches. The impact of physical processing on protein molecular structures, subsequently their functionalities will be discussed. Their applications will also be demonstrated using cereal and pulse proteins as samples.

303-S

Air-water interfacial properties of enzymatic wheat gluten hydrolysates determine their foaming behavior

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In many food products, such as meringues, beer or chocolate mousses, protein foams play an important structural and textural role. Wheat gluten proteins, a co-product of the industrial wheat starch isolation process, have very low solubility in water. Controlled enzymatic hydrolysis increases its solubility in aqueous media but also enhances the foaming properties. The air-water interfacial properties of wheat gluten hydrolysates were evaluated and related to their foaming properties. The use of such, for protein hydrolysates not very commonly used, techniques can be helpful to determine their air-water interfacial behavior in more complex media. Foaming capacity and stability of structurally different peptic and tryptic wheat gluten hydrolysates with degrees of hydrolysis (DH, i.e. the percentage of cleaved peptide bonds) of 2 and 6, were related to the kinetics of their adsorption at an air-water interface as well as to the properties of a compressed protein film at this interface. Foam formation increased with increasing protein concentration, as did the rate of adsorption to the air-water interface of all samples. Foams from DH 2 hydrolysates were more stable than those from their DH 6 counterparts, and this at all protein concentrations tested. However, at protein concentrations from 0.010% to 0.050% (wprot/v), peptic DH 2 and 6 hydrolysates had better foaming stability than their tryptic counterparts of the same DH. The opposite was observed when protein concentrations ranged from 0.050% to 0.150% (wprot/v). The calculation of an average elasticity (up to 20–25 mN/m) from the variation in surface pressure for a variation in surface area in Langmuir isotherms showed that DH 2 samples had higher elasticity than DH 6 samples, which was in agreement with their foaming stabilities at various protein concentrations.

304-S

Upgrading cereal side stream proteins for food use

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There is a global need to increase dietary intake of plant protein. Side-streams from cereal grain processing are a good source for new protein ingredients, but in order to utilize the potential of these under-exploited raw materials, there is a need to develop new protein fractionation technologies and to modify the protein concentrates to function in a variety of end products. The presentation describes technologies for development of protein ingredients from cereal industry side streams, focusing on cereal bran and spent grain. Concentration of proteins is often challenging as they are entrapped within the complex cell wall matrices. Furthermore, components that adversely affect sensory and nutritional quality are easily co-enriched with protein. Protein concentration can be based on dry fractionation, enzyme and solvent-aided wet fractionation, or their combinations. Dry fractionation techniques including milling and air-classification should disassemble interactions of cell walls, protein, starch and lipids in the plant cell matrix, and separation may be improved with pre-treatments such as SC-CO2 extraction. Thermo-mechanical re-structuring of raw materials prior to fractionation may enhance protein separation or extractability. Hydrolysis and modification of cell walls by bioprocessing with enzymes or microbes has in some cases improved protein separation in wet processing. Extraction with deep eutectic solvents is a new method for dissolving proteins from side streams, as recently demonstrated for spent grain.

305-S

Unlocking the full potential of legume proteins

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The expected growth of the world population to more than 9 billion people in 2050 and an increasing demand for highly nutritional foods will lead to an enormous pressure on the future food production system. The protein supply is in this respect most critical, both for human consumption, and for animal feed. Plant proteins are considered more sustainable and more cost-effective than animal proteins. (Partly) replacing animal protein in existing products with (new) plant protein ingredients or developing new plant protein-based products is an effective approach in making more protein available for a larger part of the world population. However, plant proteins are still used in limited food applications due to their low solubility, lack of functional properties, and their off-flavour and taste. This presentation focuses on the functional properties of plant proteins and the importance of mild processing to obtain ingredients with the potential to replace animal-derived proteins. Protein blends will be considered as a means to enable addition of plant proteins in existing products.

401-S

Effects of rice variety and milling method on the quality of Chinese traditional fermented rice noodles

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To investigate the effects of rice variety on the quality attributes of rice noodles, 21 rice varieties were used for producing fresh rice noodles. The relations between physiochemical properties of rice and sensory quality of fresh rice noodles were analyzed. The results showed that, some of the quality characteristics of rice had a significant ($P < 0.05$) effect on the sensory characteristics of fresh rice noodles. Consider the operability of the actual production process and combine rice varieties cluster analysis, protein and amylase content were chosen as core indexes of quality evaluation. Good quality of fresh rice noodles could be obtained from raw material with 6.0%~7.0% proteins and 21.0%~25.0% amylose. To investigate the effects of semidry-milling on the quality attributes of rice flour and rice noodles, rice flours prepared from wet-, dry- and semidry-milled rice were measured. As the results, the level of starch damage of semidry-milled rice flour at 30% moisture was significantly decreased to the level of wet-milled rice flour ($P < 0.05$); the whiteness of dry-milled rice flour was decreased compared with wet-milled rice flour ($P < 0.05$), while that of semidry-milled rice flour was not; the wet- and semidry-milled rice flour showed similar morphology and water hydration properties; dry-milling reduced significantly the hardness, chewiness, and resilience of rice noodles ($P < 0.05$) compared with wet-milling, but semidry-milling did not; the cooking qualities of rice noodles produced by semidry-milling were comparable to wet-milling. It indicated the semidry-milling at 30% moisture may provide the protective effects on the characteristics of rice flour and the similar qualities of rice noodles to the wet-milling.

402-S

Importance of feedstock and soaking conditions on parboiled rice quality

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Parboiled rice constitutes about 20% of the world's milled rice. Parboiled rice finds useful application in the industrial and food service markets because of its ease of preparation durability, and stability. It is widely used in soups, puddings, and dinners, canned and frozen foods. In relation to nutrition, parboiled rice is a good source of slowly-digestible and resistant starch, B vitamins, and minerals. Parboiling is an energy-intensive hydrothermal process that involves soaking, steaming, and drying. All three steps in parboiling may affect starch composition, structures, and physicochemical properties; however, there are many variables in each step and their contributions to starch properties in the resultant parboiled product have not been thoroughly elucidated. The inherent kernel properties and parboiling conditions, particularly soaking conditions, that are crucial to the production of parboiled rice with consistent, desirable end-use qualities will be discussed.

403-S

Enhancing the health-beneficial qualities of whole grain rice

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The majority of rice consumed is in its milled form and is primarily composed of starch. The evidence is increasing that the portion of starch that is resistant to hydrolysis in the small intestines has health benefits. We evaluated a set of high amylose varieties for resistant starch levels. Varieties with higher resistant starch content, after cooking, compared to conventional US high amylose types were identified. The consumption of whole

grains is recommended by many health related agencies because this may reduce the risk of developing various chronic diseases. Whole grain rice, with the bran layer intact, provides more nutrients than milled rice, including the lipophilic antioxidants and phenolics. The typical whole grain rice sold across much of the world is light brown in color. Recently, rice varieties with purple and red colored brans have gained significant attention because of their higher levels of phenolic compounds including anthocyanins and proanthocyanidins, respectively. These phenolics have been proposed as having health beneficial properties in addition to their antioxidant property. We have studied a diverse set of genotypes with purple and red pigmented brans and determined that it is possible to develop improved varieties with bran containing high levels of total phenolics, anthocyanins and proanthocyanidins. Significant genotypic variation in concentrations of lipophilic antioxidants (vitamin E family and gamma-oryzanol) has also been found. Since rice is consumed after cooking, results on the stability of these compounds to hydrothermal processes will be discussed. In conclusion, high levels of and varying profiles of bioactive compounds in the bran and endosperm of rice were identified using diverse genotypes. This provides opportunity to develop specialty rice varieties enriched with compounds proposed as having health-promoting properties.

404-S

Sensory quality of cooked rice as affected by degree of milling

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Rice is one of the grains with the largest planting area and highest yield in China. Two-thirds of Chinese people eat rice as their staple food, with China's per person consumption of rice exceeding 90kg and 60% to 70% of the energy needed for the human body being gained from rice and products made from rice. The milled rice yield from brown rice is usually lower than 85% now in China. Excessive milling process caused a huge resource waste of grain as well as energy. The effects of different milling degrees on rice quality, including nutritional properties and taste score were invested with rice materials from milling industries and those made in the lab in this study. The results indicated that with the improvement of milling degree, the rice taste value showed a downward trend after increase first, and when controlling the milled rice yield to the range of 88% to 92%, the taste value reached the highest. The content of VE and VB were negative related to rice milling degree. The rice whiteness, amylose content and protein content increased as the milling degree improved when the milled rice yield higher than 85% and kept steady as the yield lower than 85%. Therefore, we considered that it's feasible to improve the rice quality by increasing the milled rice yield within a reasonable range, and as the taste value reached the highest, the nutrient also could be maintained from 40% to 75% of husked rice, which was significantly higher than current market level. In addition, excessive polishing may cause the decline of rice eating quality. As is known that reducing milling degree and polishing process will be conductive to reduce energy consumption, so energy consumption in a ton of rice could be one of the indicators to evaluate the rice milling degree. Based on it, milling degree control could be realized with the balance between milled rice yield and whiteness.

405-S

What are the technological keys for producing a steam-cooked bread (Ablo) from rice

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Processing rice is an opportunity to add value to African rice that fails to compete with imported rice due to its poor grain quality. Ablo is a traditional steamed-cooked bread-like product of West-Africa (Benin/Togo/Ghana); it is prepared from imported rice and its quality largely varies due to the large diversity in the traditional process. We studied and developed a flow-sheet for processing Ablo from local rice. The most critical steps in the process appear to be the pre-cooking and fermentation steps. An increase of the gelatinization level during pre-cooking, increases the expansion during the fermentation (proofing) but decreases the final volume of Ablo. This appears linked to the texture of the fermenting dough; a high gelatinization level increased the viscosity and elasticity of the dough and hence its gas retention ability during fermentation but inhibits the expansion during steaming. Expansion of the dough indeed stops rapidly during steaming when starch gelatinizes and dough firmness increases. An optimum gelatinization level close to 6-7% is thus recommended. In addition, it has been shown that pre-cooking on fire is preferable in place of pre-cooking out of fire. It indeed induces a complete gelatinization of starch whatever the rice cultivars and their gelatinization temperature. An increase of the intensity of the fermentation (increase of the duration and/or of the yeast level) induces a decrease of the viscosity of the dough and of the density of Ablo. As for pre-cooking, the lower the viscosity of the dough, the higher was the expansion of the Ablo. Finally, the cultivars with high amylose content should be preferred for processing Ablo; the obtained Ablo has indeed higher final expansion and porosity and higher firmness.

501-S

Targeted proteomic approaches for detection of CD-specific epitopes

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Proteomics analysis comprises the detailed characterization of protein composition of biological extracts. LC-MS, liquid chromatography on-line coupled to mass spectrometry, is able to deliver an extremely detailed inventory of the protein extracts. So-called non-targeted analysis will generate protein lists per sample, containing identity and quantity information. *Non-targeted* proteomics analysis is the method of choice for discovering quantitative differences between sample groups, in order to discover relevant changes in protein composition and select for marker peptides that can be used for subsequent targeted detection analysis. The targeted approach focusses on accurate and sensitive quantitative detection of selected peptides for which specific detection procedures are developed. We have developed a targeted detection assay for epitope-specific a-gliadin peptides that are known to be the major toxic epitopes involved in celiac disease (CD). CD-patients that have to maintain their gluten-free diet are dependent on reliable testing and labeling of gluten-free products. Detection of gluten proteins containing CD-epitopes is affected by the extraction protocol and the accuracy of the detection method. So far, the R5-ELISA is the approved method to detect if food products can be labelled gluten-free. The R5-ELISA makes use of monoclonal antibody that detects gluten in general and does not specifically detect CD stimulating epitopes. Recent research has demonstrated that the CD-immunogenicity varies across the variety of gluten proteins among and within different wheat varieties and species. Our targeted LC-MS MRM method can detect quantitatively and simultaneously 9 different a-gliadin peptides, of which 7 contain CD-inducing epitopes. We have tested our method by analyzing several wheat varieties that vary in CD-epitope content.

502-S

Barley grain proteomics: Current status and future prospects

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The protein composition of barley grains has been studied systematically for over a century, and barley grain proteins have been studied by two-dimensional gel electrophoresis for more than two decades. Mass spectrometry enables identification of proteins in complex mixtures and identification and characterization of their post-translational modifications, making it the cornerstone of proteome analysis. Recently, the experimental system based on isolated barley aleurone layers was exploited to gain more insight into the protein secretory system responsible for secretion of hydrolytic enzymes into the starchy endosperm during malting. Using proteomics, secretory hydrolases can be identified both within the aleurone layers and after their release to the incubation medium. Many proteins are N-glycosylated in the secretory pathway, but little is yet known about the post-translational modifications of grain enzymes. A glycopeptide-enrichment strategy enabled identification of 73 glycosylation sites in 65 proteins, a significant improvement in characterization of the barley glycoproteome. The proteins in mature cereal grains are major factors influencing quality. However grains are also colonized by complex microbial communities that actively interact with the plant via e.g. secretion of enzymes for breakdown of cell wall components. These may influence grain quality and be a source of enzymes for exploitation in grain processing. Analysis of surface-associated proteomes of barley grains enabled identification of 53 proteins of bacterial or fungal origin including cell-wall degrading enzymes such as xylanases, in agreement with microbial xylanase activity isolated from the grain surface. Ongoing efforts to characterise grain proteomes and post-translational modifications will provide new targets for functional analysis and improvement of grain quality.

503-S

The Age of -omics: Enabling Trait Selection in Wheat Variety Development

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Historically, and still today, wheat breeders rely on visual phenotyping to select or eliminate lines from the early generation breeding material. Identifying unique phenotypes earlier in the variety development process ensures lines with novel genetics will be selected for continuation in the program. Whether it be end-product quality or disease resistance, the breeder's ability to create a screening population far surpasses the resources needed to screen for valuable traits. Furthermore, traits like basic flour quality aren't typically tested until year five of the breeding process after many thousands of lines have been eliminated. With the advancement of high throughput genetic sequencing, wheat breeders now have a cheap and fast tool to collect broad genetic information from thousands of lines with only a small amount of green tissue. Researchers have linked dozens of agronomic phenotypes to specific genetic markers and new discoveries have identified genetic markers for several end-

product traits such as loaf volume. Many more product-quality markers have yet to be discovered. Our work aims to speed the identification of markers for end-product quality by employing multiple –omics based approaches to improve current genomic selection models.

504-S

Proteomics approaches for gluten and allergen analysis

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Proteomics approaches combine high resolution two-dimensional separation techniques such as isoelectric focusing and gel electrophoresis or chromatography with mass spectrometry (MS) followed by database searching. Powerful bioinformatics tools are required to extract the relevant data from the complex mass spectra, predict protein/peptide masses, isotopic patterns, enzymatic cleavage sites and possible modifications like ammonia loss, water loss or oxidation. Trace amounts of gluten and food allergens are most commonly analyzed using enzyme-linked immunosorbent assays (ELISAs) that are specific, sensitive, comparatively cheap, easy to handle and suitable for routine analyses. However, ELISAs may face difficulties in detecting the target antigen in foods that have been extensively processed, hydrolyzed or fermented or that contain a variety of possibly interfering substances, such as polyphenols. Due to its versatility, sensitivity, selectivity and wide applicability, MS may serve as an independent reference method, especially for foods where ELISA results typically have low recoveries. After appropriate extraction of gluten and allergens from the food matrix and enzymatic digestion, the resulting peptide mixture is purified and separated by liquid chromatography prior to the detection and quantitation of characteristic marker peptides. In case of gluten, this workflow has been applied to the detection of wheat flour in oat flour, the relative quantitation of gluten in a variety of beers and to identify wheat varieties with low immunogenic potential. One major difficulty is to relate the amount of peptides back to the original protein content to comply with legislation. Due to the expensive equipment and expertise required, proteomics approaches are limited to specialized laboratories, but allow the simultaneous detection of gluten and multiple allergens in one run.

505-S

A grain of truth: Using proteomics to elucidate grain protein composition

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Consumers, especially those with allergies and/or intolerances, should have confidence in two critical areas of food safety: foods should be correctly labelled and free from contamination. Coeliac disease is a condition that affects about 1% of the population, while non coeliac gluten sensitivity may affect up to a further 10% of the population. There is no current treatment for either of these conditions other than strict adherence to a life-long gluten-free diet. To ensure these diets are gluten-free it is critical to understand protein composition of gluten-containing grains, wheat, barley and rye, as well as oats for some sufferers of coeliac disease. This knowledge can then be used to develop quantitative markers for detection of the presence/absence of these cereals and for the specific proteins that comprise gluten from each species. These markers must be robust enough to not only work using the native cereals, but also when the samples are processed foods. Here we present the comprehensive characterisation, using mass spectrometry, of wheat and barley focussing on the "gluteome". In addition we present a comparison of MRM-MS, the gold standard for peptide quantification to the relatively new data-independent acquisition strategy known as SWATH (sequential window acquisition of all theoretical spectra) MS.

601-S

Arabinoxylans from cereal processing byproducts as a basis for biodegradable food packaging

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Arabinoxylans (AX) are non-starch polysaccharides in the cell-walls of cereal crops including wheat and corn. Both of these crops are highly processed, and during the processing of these crops, there are large quantities of byproducts produced including wheat bran (WB), corn bran (CB), and dried distillers grains (DDG). These byproducts are currently used in animal feed, but they can also be used as a basis for biodegradable food packaging. When AX is used as a basis for food packaging, plasticizers must be added to create a flexible material that has the desirable mechanical and barrier properties. In this research, AX from WB, CB, and DDG was extracted using 3% sodium hydroxide, purified with alpha-amylase and protease, fractionated with 95% ethanol, dialyzed, and freeze-dried. Then the AX was combined with glycerol or sorbitol at 10, 25, or 50% of the AX dry weight and used to create biodegradable food packaging material. The packaging materials had significantly

different ($P < 0.05$) mechanical and barrier properties. The tensile strength of the CB AX with 10% glycerol was significantly ($P < 0.05$) higher than the other materials at 29.3 MPa. The material made from WB AX with 50% sorbitol had a puncture resistance of 10.1 N, which was significantly ($P < 0.05$) higher than the other materials. The WB materials had a significantly ($P < 0.05$) lower percentage of water soluble material than the CB and DDG materials. The water vapor transmission rate through the packaging materials increased significantly ($P < 0.05$) as the amount of plasticizer increased from 10 to 50%. These qualities all show great promise in the area of food packaging for a variety of foods. Once it is possible to package foods in this type of biodegradable food packaging on a commercial scale, the food industry will greatly increase its sustainability.

602-S

Effect of proanthocyanidin MW profile on dough rheology

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Proanthocyanidins (PA) strongly complex with proteins and may be exploited to naturally expand gluten functionality. This study investigated the effect of PA with different MW profiles (from sorghum and grape seed) compared to monomeric catechin, on wheat gluten properties. Two gluten profiles were used: a bread wheat with a high ratio of high molecular weight glutenin subunits (HMW-GS) (SG) and a deletion line with reduced HMW-GS content (WG). PA were added at 0.8-2.5 mg/g flour or purified gluten. PA, dough, and gluten profiles were analyzed by HPLC and rheological methods. Sorghum PA was more (91%) polymeric than grape PA (42%). Mixograms and extensibility data showed catechin significantly ($p<0.05$) weakened dough, as expected of an antioxidant. However, grape and sorghum PA strengthened dough by increasing mixing tolerance, peak time, and force to extend dough. Sorghum PA had a greater strengthening effect. Retarded compliance (J1) in WG decreased from 3.5 (control) to 3.0 and 1.9 KPa-1 with grape and sorghum PA, respectively (at 2.5 mg/g flour). This indicates sorghum PA produced a stiffer structure. Catechin increased deformation to 4.1 KPa-1. Similar but less differentiated trends were seen in SG. Sorghum PA also reduced deformation vs control for WG (4.5 vs 14.4 KPa-1, respectively) and SG (1.0 vs 2.8 KPa-1, respectively) in purified glutens. Size-exclusion chromatography on SG showed sorghum PA increased insoluble polymeric protein (IPP) significantly vs other treatments and control (12.3 vs 8.2-8.4 AU, respectively). In WG, both sorghum and grape PA increased IPP (9.1 and 7.5 AU, respectively) compared to catechin (4.1) and control (4.3). The evidence suggests higher MW sorghum PA, crosslinked gluten more effectively than grape seed PA. Additional work is investigating the nature of the interactions. Sorghum PA is a promising natural ingredient to improve and expand gluten functionality.

603-S

Influence of soft kernel texture on the flour and baking quality of durum wheat

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Durum wheat is predominantly grown in semi-arid to arid environments where common wheat does not flourish, especially in the Middle East, North Africa, Mediterranean Basin, and portions of North America. Durum kernels are extraordinarily hard when compared to their common wheat counterparts. Due to this extreme level of kernel hardness, durum is primarily milled on specialized mills into semolina; a coarse granular product utilized in pasta and couscous. Semolina is not nearly as versatile as flour, thus limiting the variety of products which can be produced locally in regions durum growing regions. Via non-GMO homologous recombination, the puroindoline genes responsible for kernel softness in common wheat were introduced to durum. The subsequent soft kernel phenotype expression has allowed durum to be milled into flour and the utilization of durum wheat to be greatly expanded. Soft durum wheat does not fall into any of the commonly utilized U.S. wheat marketing classes; making it effectively a new classification in itself. The objective of this study was to evaluate the flour components, rheological properties, and baking quality of the new soft durum wheat class. Several check varieties were included: Xerpha, a soft white wheat, Expresso, a hard spring wheat, and Svevo, a hard durum wheat. These check varieties were used to make preliminary comparisons between soft durum and established wheat classes. Soft durum wheat exhibits a unique set of flour and baking attributes which tend to fall between those of soft and hard hexaploid flour, which allow it to be utilized in a wide variety of products traditionally made with durum semolina as well as flour. In the near future soft durum wheat may have a profound impact on the food supply chain in regions such as North Africa, the Middle East, and the Mediterranean Basin.

604-S

Pre-milling interventions to reduce the microbial load of wheat grain with minimal impact on flour functionality

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Reducing microbial contamination in wheat is desirable to ensure consumer safety. The purpose of this study was to determine the efficacy of adding organic acids and NaCl to tempering water to reduce microbial load in hard wheat prior to milling, and to determine the impact that these treatments might have on the microbial quality and functional properties of straight-grade and whole grain flours. Wheat was tempered to 15.5% moisture under controlled (24h, 73-75°F, 60% RH), aseptic conditions by adding water (control) or tempering solutions containing acid (acetic or lactic; 2.5% and 5% v/v) and NaCl (26% w/v). Wheat was analyzed before and after tempering for Total Plate Counts (TPC), yeasts, molds, and Enterobacteriaceae (Eb). The microbial load of the tempered wheat was significantly reduced by all organic acid-NaCl treatments ($p<0.05$). The combination of lactic acid (5%) and NaCl was the most effective against TPC and Eb ($p<0.05$), with an average reduction of 3.5 and 4.7 log CFU/g, respectively. After experimental milling, fractions were collected and recombined to obtain straight-grade or whole grain flours. All combinations of organic acid-NaCl were effective in reducing the microbial load of the final milled product ($p<0.05$). Even though some significant differences in mixing properties were observed, their impact on functionality was minimal. Only whole grain flour from wheat tempered with acids at 5% required longer times (5.3 min) for optimum dough development compared to the control (4.5 min). Straight-grade flour obtained from all treatments showed higher maximum force for mixing than the control flour. Additionally, dough mixing tolerance in both flours was not affected, regardless the acid level. Implementation of organic acids and NaCl in tempering water provides milled products with improved microbiological quality, without compromising functionality.

605-S

Novel approach to the analysis of gluten by mass spectrometry

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A strict gluten-free diet is the only effective therapy for celiac disease (CD) patients. Currently, enzyme-linked immunosorbent assays (ELISA) are most commonly used for gluten analysis to monitor the safety of gluten-free products, but these assays primarily target the alcohol-soluble prolamin fraction of gluten. The gluten content is then calculated by multiplying the prolamin content by a factor of 2. The problem is that different types of grains contain variable proportions of prolamins and alcohol-insoluble glutelins. As a result the calculated gluten content may be either over- or underestimated, which is a food safety issue for CD patients. The aim of the present study was to develop a new independent non-immunochemical method for the quantitation of prolamins and glutelins (= total gluten) by liquid chromatography–tandem mass spectrometry (LC-MS/MS). First, protein fractions (prolamins and glutelins) and protein types from wheat, rye, barley and oat flour mixtures were isolated and purified to serve as defined reference proteins. All isolated proteins (fractions and types) as well as the flours were partially hydrolyzed with chymotrypsin and analyzed by LC-MS/MS. Several peptides were identified which are specific indicators for each protein type (marker peptides) and suitable for gluten quantitation. Two to three marker peptides were selected for each protein type and will be quantitated by a stable isotope dilution assay. Then, peptide concentrations can be converted to protein concentrations, because the yield of peptides obtained from a given amount of protein is known. The sum of all protein concentrations will result in the true gluten content of the food sample. This versatile new method will allow the accurate detection of gluten especially in processed or hydrolyzed products where many ELISA have been shown to underestimate gluten contents.

606-S

Human colon bacteria show substrate dependent hierarchical preference to dietary fibers, with structure determining rank

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The human colonic microbiota is significantly affected by its food supply. Accordingly, there has been an increasing interest to modify its composition via dietary fibers (DF), as a way to improve health. However, in order to achieve a predicted manipulation, it is essential to understand how colonic bacteria respond to different DFs. Here, we aimed to understand the strategies of *Bacteroides ovatus* (*Bo*) and *B. thetaiotaomicron* to utilize different glycans presented as a mixture. We performed a series of time course assays in which both bacteria were individually grown in a media containing different DFs: amylopectin (AP), arabinan, chondroitin sulphate, pectic galactan, polygalacturonic acid, and rhamnogalacturonanI (RGI) of which they both are capable of degrading.

Remaining substrates were measured over time as well as gene expression profiles. Both bacteria utilized certain glycans before others, but with different priorities indicating that bacterial species show species-specific hierarchical preference to DFs. Co-culturing of these organisms in the same mixture revealed that hierarchical preferences of human gut symbionts are preserved even in competitive environments. Their different glycan priorities mediate their stable coexistence. Additionally, a hypothesis was tested whether molecular structure of a glycan affects its place in the hierarchy. To test this, we repeated the hierarchical study for *Bo* by substituting AP with a structurally simple starch analog [maltohexaose (MH)]. AP was used after RGI by *Bo* when AP was included in the mixture, whereas MH was used before RGI, so the utilization of RGI by *Bo* was delayed in the presence of MH, showing that bacteria species' preferences of a particular glycan can be changed by manipulating its chemical structure. Our results provide essential information how bacteria species respond to different glycan structures.

701-S
Introduction: Practical Implications of Getting Sampling Wrong
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Food products are generally complex, heterogeneous amalgamations of ingredients and raw materials which can be inherently variable. In assuring the safety and quality of materials throughout the supply chain, it is critical to manage the risk associated with sampling and analysis. Often the weakest link in management processes is product sampling, not the accuracy of analytical methods. False positives or negatives risk safety and quality, with implications for brand equity, reputation and viability of products. This session will consider the importance of a rigorous approach to sampling and provide practical illustrations of the impact of incorrect sampling techniques. This presentation will review examples of the challenges of sampling for safety and quality in grain. In the safety arena, the mycotoxin content of grains is a key area of concern. Mycotoxins are generated by fungal infection, either in the field in the case of the Fusarium mycotoxins DON and ZON, or during storage in the case of aflatoxins. Infection tends to be unevenly distributed (either in the field or in storage), so that 'hot spots' of infection and mycotoxin generation occur. Sampling for mycotoxin content in wheat requires a systematic and statistically-sound approach to generate a representative sample for analysis. An unrepresentative sample containing a mycotoxin 'hot spot' can easily lead to a false positive and rejection of an otherwise sound cargo. A false negative result could result in dangerous material entering the food chain. In the quality arena, a similar issue of 'hot spots' occurs in pre-harvest sprouting, leading to localised high levels of a-amylase (and so low Hagberg Falling Numbers). This could lead to an otherwise sound cargo being rejected or adjusted. In both cases, appropriate sampling and analysis is essential in managing the risks involved producing safe foods.

702-S
Statistical Methods to Evaluate the Risks of Misclassifying Lots by Mycotoxin Sampling Plans
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Agricultural commodities are often inspected for mycotoxins and classified into acceptable and unacceptable categories depending on whether the mycotoxin level in a sample. Because of the large variability associated with the sampling, sample preparation, and analytical steps of a mycotoxin test procedure, the true mycotoxin level in a lot can't be determined with 100% confidence and as a result some lots will be misclassified by the mycotoxin sampling plan. Some good lots will be rejected (seller's risk) and some bad lots will be accepted by the sampling plan (buyer's risk). These two risks can be described by an operating characteristic (OC) curve. A statistical method based upon the knowledge of the variability and distribution among replicated sample test results from the same lot was developed to calculate an OC curve related to a specific mycotoxin sampling plan design. The total variance associated with a mycotoxin test procedure was partitioned into the variance associated with sampling, sample preparation, and analysis. The sampling step was typically observed to be the major source of variability. The sampling, sample preparation, and analytical variances were shown to be a function of the mycotoxin concentration and regression equations were developed to describe the functional relationships. The observed mycotoxin distribution among replicated sample test results was positively skewed and could be adequately described by the negative binomial or the compound gamma distributions. These two distributions were chosen because they are skewed distributions and the distribution parameters match the observation that the variance is greater than the mean. The method to evaluate and design mycotoxin sampling plans has been used to manage mycotoxin levels in the food and feed industries regulatory agencies, and international organizations (Codex).

703-S

Development of the FAO Mycotoxin Sampling Tool to Evaluate Risks of Misclassifying Lots with Mycotoxin Sampling Plans

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It is important to be able to predict the number of good lots rejected (seller's risk) and bad lots accepted (buyer's risk) by a sampling plan design so that sampling plans can be designed to reduce one or both risks to acceptable levels for available resources. Using experimentally determined variability and distribution information among sample test results, a method was developed to calculate operating characteristic (OC) curves which provides a measures of the buyer's and seller's risks of a specific mycotoxin sampling plan design. The variability and distribution among sample test results have been studied for approximately 24 different mycotoxin/commodity combinations. The distribution and variance information for all 24 mycotoxin/commodity combinations were combined into a single model that calculates an OC curve for given sampling plan design elements such as sample size, number of samples, and the accept/reject limit. The OC calculator is currently supported online by FAO who has enhanced and improved the OC calculator using Analytica to make the model more user friendly. The OC calculator, currently called the FAO Mycotoxin Sampling Tool can be found on the web under FAO Food Safety Risk Analysis Tools http://www.fstools.org/. The FAO Mycotoxin Sampling Tool can compare the performance of up to 10 different mycotoxin sampling plan designs at one time. By inputting the sampling plan design elements (sample size, number of samples, and accept/reject limit) into the FAO Mycotoxin Sampling Tool, the program will calculate the chances of accepting and rejecting lots over a range of lot concentrations (OC curve) for the sampling plan designs of interest. The OC calculator has been used to design mycotoxin sampling plans for regulatory agencies, commodity organizations, food and feed manufacturers, and international health organizations such as Codex.

704-S

So, You Want a New Analytical Method? Past and Modern Day Considerations in Co-lab Set-Up and Data Analysis

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The busy technical people in AACCI are often involved in developing new analytical methods or improving older, established methods. International chemical analytical organizations met at a workshop sponsored by IUPAC in 1987 and established Harmonization Guidelines which are still being used. These guidelines were set up for methods measuring constituent concentrations. The guidelines provide numbers required for laboratories, matrices, blind duplicates, and outlier testing plus they give formulae for calculating method performance parameters, most specifically Repeatability within labs and Reproducibility across labs. Modern methods developed by AACCI members often fit into the Guidelines but many are not exact fits. The Guidelines do not address measuring near zero where Limits of Detection and Limits of Quantitation are estimated. Physical tests often do not conform well to the Guidelines. In our modern electronic age, method development sometimes cannot be separated from instrument development. Technical Committees work with the developers to ensure the new methods are evaluated correctly. The role of the statistician is not to judge whether a method is good enough, but rather to ensure that the performance parameters are calculated correctly. Potential users of the method should be able to compare methods based on accuracy and precision plus other criteria such as portability, costs and time required.

705-S

What are you trying to learn? Study designs and the appropriate analysis for your research question

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One fundamental necessity in the entire process of a well-performed study is the experimental design. A well-designed study can help researchers understand and have confidence in their results and analyses, and additionally the agreement or disagreement with the stated hypothesis. This well-designed study also gives confidence to the scientific community of the objectivity and purity of findings. Often, however, the specific questions and objectives of a researcher's study are not fully developed when designing the experiment. This misstep often leads to difficulty in properly analyzing studies, and in some cases, decreases the usefulness of the data that has already been collected. The purpose of this talk is to explain why deciding on the overarching question we are trying to answer in our research is the most important first step in conducting research. Once the question has been distilled, we can move on to the best study design to create an unbiased, objective, controlled experiment with adequate replication and without confounding. Some of the important factors to consider when designing an experiment are identifying which factors to control and which to vary, what specifically needs to be measured, the number of replications, the cost of the experiment, quantitative vs. qualitative factors, and how the

study will be analyzed. Taking all of these factors into consideration helps to create a strong design with high statistical power and a straight-forward analysis.

801-S

The effects of extruded pulse products on post-prandial glycemia and satiety

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Whole pulses have been studied for their beneficial effects on post-prandial glycemia and satiety in acute human trials. However, whether pulse ingredients retain the health benefits of whole pulses when consumed as processed food products is unclear. The objective of this trial was to examine the effects of extruded pulse snacks on food intake at an *ad libitum* meal, as well as appetite and blood glucose responses before and after the meal. In a repeated-measures crossover trial, adults (n = 26) randomly consumed extruded snacks made with: 1) whole yellow pea flour, 2) split yellow pea flour, 3) green lentil flour, 4) chickpea flour, 5) pinto bean flour, and 6) corn flour (control). Pulse snacks contained 40% pulse flour and 60% corn flour, whereas the control was 100% corn flour. Food intake was measured at a pizza meal (120 min). Appetite and blood glucose were measured pre-pizza (0-120 min) and post-pizza (140-200 min). Pinto bean and chickpea snacks led to lower pre-pizza blood glucose area under the curve compared with control, whole yellow pea and green lentil snacks ($p < 0.05$). The effects on blood glucose at specific time points were dependent upon pulse type. At 30 min, blood glucose was lower after pinto bean compared to green lentil snacks, whereas at 45 and 60 min, pinto bean led to lower blood glucose compared to whole yellow pea snacks ($p < 0.05$). There were no differences between treatments in post-pizza blood glucose, food intake or appetite. This trial indicates that effects on post-prandial blood glucose are dependent on pulse type and supports the use of pulse flours as value-added ingredients in foods designed to improve glycemic control. Further research is needed to test the health benefits of pulse flours in other processed food products.

802-S

Pea hull fiber modulation of gastrointestinal function and fecal microbiota

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Human gut microbiota is increasingly associated with chronic disease risk and progression. Given the preference for carbohydrate fermentation by the majority of bacteria that constitute the microbiota, fiber is a key modulator of its composition and metabolic activity and these changes provide potential mechanisms to explain the associations of fiber with chronic disease risk reduction and treatment. Although pea hull fiber has been shown to positively impact gastrointestinal function, such as decreased gastrointestinal transit time and increased stool frequency, its effects on gut microbiota are less known. In young adults, pea fiber may enhance protective species, such as *Faecalibacterium prausnitzii* and various butyrate producers, whereas phylum level changes show mixed results. In older adults with chronic disease, pea hull fiber enhances motility and may reduce gut-generated, inflammatory compounds such as *p*-cresol, which suggests depression of proteolytic activity. As pea hull fiber may have little impact on genera thought to be health enhancing (e.g. *Bifidobacteria and Lactobacillus* spp.), its potential beneficial effects may be instead be related to suppression of proteolytic gut organisms and their activity through decreased transit time and/or slow saccharolytic fermentation that extends to the distal large intestine. Further research is needed to determine the extent of fermentation of pea hull fiber and as it relates to gastrointestinal transit time and various target group characteristics, as well as the related effects on health outcomes.

803-S

The carbohydrate digestion rate of navy bean flours measured in vitro: the role of particle size and processing

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Consumption of navy beans is associated with positive health outcomes including improvement of blood glucose control and blood lipid profile. The formulation of foods with added pulse flours may provide some health benefits known for whole pulses. However, pulse flours available on the market represent a broad range of products varying in their processing. The objective of this project was to evaluate the carbohydrate digestion rate in navy bean flours varying in particle size and to determine whether these properties were affected by thermal processing. Methods: navy bean flours were produced by Canadian International Grain Institute using pin milling of raw navy beans to the following fractions (mean particle size, μm): coarse (C, 1101.6), regular (R, 630.7), fine (F, 301.7), very fine (VF, 144) and superfine (SF, 26.8). Raw or cooked flours (baked at 350°F for

12 min) that were subsequently masticated and minced were used in the experiment. Carbohydrate digestion rate was determined via simulated digestion of flour samples conducted in triplicate over 180 min using modified Englyst method. The released glucose was assayed using hexokinase method. Results: There was a significant effect of particle size on carbohydrate digestion rate in raw ($P<0.0001$) and cooked flours ($P<0.0001$). For raw flours, area under the curve (AUC) for glucose was 13065, 16723, 19857, 24259 and 33488 mg/mL×min for C, R, F, VF and SF fractions, respectively. For cooked flours, AUC for glucose was 8247, 9096, 19180, 23581 and 32799 mg/mL×min for C, R, F, VF and SF fractions, respectively. Particle size was inversely correlated with glucose AUC for both raw and cooked flours ($r=-0.9$, $P<0.0001$). Conclusion: particle size of navy bean flours obtained by dry milling method predetermines carbohydrate digestion rates as measured in vitro and this relationship is sustained after dry-heat cooking.

804-S

Functional attributes of pulse flours and flour constituents

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Pulse flours and fractions are currently of significant interest as food ingredients, principally for their nutritional and health benefits. Many examples of their incorporation into pasta and noodles, baked goods, and snack and breakfast foods exist. However, acceptability in a particular application is determined ultimately by functionality. Pulse flours vary widely in colour, flavour and other sensory properties depending on source, which will dictate end use. Milling method and particle size distribution of pulse flours have been shown to affect their functionality and best application. The starch component of pulse flours exhibits unique functionality due to its intermediate amylose content, and its associated high pasting temperature, high viscosity, and tendency to retrograde once cooked. Pulse flours and starch-enriched, air-classified pulse flours range in starch content from 50-90 percent, hence starch functionality is a significant determinant of flour functionality, including in extruded products. The proteins of pulses are similar to those of soybean. However, pulse flours contain 20-25 percent protein versus 50-90 percent in soy protein products. Pulse protein products similar in composition and functionality to corresponding soy products can be prepared from pulse flours via wet or dry processing or alcohol washing. The functionalities of these products reflect both their composition and processing history. Pulse flours and some fractions have substantial cotyledon (cell wall) fibre contents. The high water holding capacity of cell wall fibre is reflected in the hydration properties of pulse flours and therefore in the water holding capacities of foods containing pulse flours.

805-S

Real-time monitoring of the effect of pea fibre addition and its particle size on dough proofing potential

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The addition of yellow pea hull fibre to wheat bread supports the growing trend of improving health through diet. However, fibre addition tends to affect the structural and mechanical properties of dough, specifically through its destabilization of the developing gas bubble structure so that final bread volume and crumb texture are impaired. Understanding the mechanisms by which pea fibre detrimentally affects dough structure during proofing will improve our capacity to manage the factors that affect the design of fibre-enriched breads. A broadband ultrasonic transducer was used in reflection mode to measure the properties of dough pieces as they proofed. Two ultrasonic parameters that measure the rheology of dough (phase velocity and attenuation coefficient) were used to characterize changes in dough properties with time. The objective was to determine how pea fibre particle size, fibre addition level, and optimization of water absorption affected changes in velocity and attenuation during dough proofing with a view to understanding fibre's effect on gas cell development. For both the control and fibre-enriched doughs, attenuation increased while velocity decreased at the beginning of proofing, demonstrating substantial gas cell expansion. The fibre-enriched dough also had broader peaks in velocity than the control, indicating the presence of smaller bubbles, likely due to a low degree of coalescence. Fibre-enriched doughs with optimized water absorption had ultrasonic patterns with proofing time that were more similar to the control dough than doughs with non-optimized water absorption. Although improving contact between dough and transducer (especially at long proofing time) is necessary to improve reliability of the technique, ultrasonic measurements are a useful tool for optimizing pea fibre addition to bread.

901-S

Making a Protein Claim: Factors impacting Protein Quality and a New Way for Measuring

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High-protein foods are increasingly desired by consumers and have been demonstrated to help satisfy an individual's feeling of hunger for a longer period of time than when consuming comparatively lower protein foods. The feeling of fullness that high-protein foods can give helps limit overconsumption of food and can help promote a healthy lifestyle. Further, a high-protein diet can support muscle 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. Before marketing these products, manufacturers must first assure that their product meets a minimum of 10% DV of quality protein on both a per serving basis and a per RACC basis. The methodology prescribed by law in the U.S., and in many jurisdictions around the world for determining protein quality is the PDCAAS (Protein Digestibility Corrected Amino Acid Score). However, beyond being an expensive and time consuming test, the standard PDCAAS method also requires the use and sacrifice of animals for determining digestibility. We discuss here an animal-safe method for determining protein quality equivalent to PDCAAS (R2 ~0.98) which does not use animals for the determination of digestibility.

902-S

Formulating with Protein – Opportunities and Challenges: "Don't take my steak away!"

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Proteins are in high demand, by 2050 we need about twice the amount of food proteins. Projections are that when this protein demand will be filled by animal proteins, the consequences are severe. More obesity, health problems and cancer is the expected future for a meat-eating society. Whether the disastrous projections on continuing an animal based protein culture are true or not, for reasons of sustainability we do need to change our way of food production. Alternatives for high protein foods and dairy products are in high demand in generation Y. Plant-based 'meat', yoghurts made from coconut and soymilk are examples of products that are growing in demand. It is clear that meat is not centre of the plate anymore. Healthy, no animal derived products and allergen-free dominate our eating habits the next decades. Our challenge now is to develop these products, source the proteins and be able to open-up new functionalities. This will force food protein scientists to radically change their thinking about what is called: 'protein functionality' and how we define it. The framework of our current knowledge has been built on animal proteins, with terms such as: solubility, gelling, denaturation and digestibility. Plant derived proteins are different, processing that is suitable for animal proteins cannot be applied on plant proteins. Two protein axioms will dominate future protein product development. Protein axiom I: every protein can be functionalized by using the right processing conditions; protein axiom II: proteins will be made on demand. By using the model of multiple phases and the two protein axioms every mixture of proteins can be (re-)structured into a palatable product, whatever the origin of the protein. Several companies have intentionally or by intuition embraced the multiple-phase approach and the two protein axioms to improve texture, taste and juiciness.

903-S

Impact of formulating high-protein foods on obesity

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No Abstract Submitted

904-S

Oat protein amino acid composition and digestibility to support food formulation and consumption

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Protein is an important macronutrient in the diet and high biological value protein is required to meet nutritional needs and support health and well-being. This macronutrient is key to meeting human nitrogen requirements and provides indispensable amino acids (AA). Protein amino acid composition, once corrected for digestibility, is used globally as a measure of protein quality. The amino acid content of a protein is compared to the reference amino acid profile (as specified by the Food and Agriculture Organization (FAO) and is based on nitrogen requirements and specific amino acid needs) to determine if it is a nutritionally adequate protein (also known as a complete protein). Complete proteins provide all indispensable amino acids in the proportion that best supports human growth and development. Total digestibility is used to correct the amino acid score in most of the world, however recent FAO guidance is recommending ileal digestibility become the primary assessment

for protein quality. To determine the amino acid profile and PDCAAS of our oat protein concentrate, we provided 6 nonconsecutive lots of ingredient for amino acid analysis at Medallion labs. Additionally we had in vivo testing for protein digestibility performed in a pig model at the University of Illinois. Oat Protein, like the plant source which it comes from, is lower in lysine content. This lower lysine content limits the PDCAAS of oat protein. In our study we were able to combine these data and calculate the PDCASS of our oat protein concentrate as approximately 46%. However, combining oat protein concentrate with other sources of protein which are higher in lysine content would be recommended when creating a product to provide a more complete amino acid profile. Oat Protein can be used as a source of supplemental dietary protein and can be used in a wide variety of food applications.

905-S
Formulating with Protein – Opportunities and Challenges from a Consumer Packaged Goods Perspective
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Protein-fortified food has high appeal for many consumers, and interest in novel protein sources, especially plant proteins, appears to be on the rise. It's an exciting and sometimes over-whelming time to work with proteins as the number and diversity of protein options continue to grow for product developers and consumers. We have a lot of choices as food scientists from fava beans to rice protein to pea protein…what's important and what should be considered when selecting protein ingredients for functionality or fortification purposes?

1001-S
Novel fiber-rich lentil flours as snack-type functional foods: an extrusion cooking effect on bioactive compounds
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Novel snack-type functional foods based on extruded pulse flours could convey the related health benefit of their bioactive compounds, provide a gluten-free alternative to consumers, and potentially increase their consumption. Lentils (*Lens culinaris*) and other pulses are foods with a remarkable nutritional profile and healthy compounds with beneficial potential impact on human wellbeing, including glycemic and cholesterol indexes stabilization, body lipids accumulation reduction, intestinal transit promotion, and may help in the prevention of cardiovascular diseases and some cancers. Extrusion cooking is a high temperature, short-time process in which food materials are cooked by the combination of temperature under pressure and mechanical shear, resulting in molecular transformation and chemical reactions. Lentil-based formulations containing gluten-free and gluten containing ingredients, such as wheat bran, were extruded processed into prototype snack products. Extrusion caused a significant ($p < 0.05$) reduction in the trypsin inhibitors content and completely inactivated lectin, in all processed samples. Additionally, the process reduced the content of inositol phosphates by about 70%. While at the same time, extrusion promoted an increase on alfa-galactosides of 31%, and increased the total phenolics and hydroxycinnamic acids from 2 mg GAE/g to 9.1 mg GAE/g and from 7.5 to 11.2 mg FAE/g, respectively in wheat-brand formulation; as well as hydroxybenzoic acids, from 2.9 to 5.7 mg GAE/g in the gluten-free formulation. All these compounds are related to beneficial health effects. These results highlight the potential of novel lentil-based formulations as functional ingredients in order to develop healthier snack-type foods that would encourage the consumption of pulses in children and young adults.

1002-S
Pulse ingredients in novel food applications
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Pulses are excellent source of energy, proteins, carbohydrates, dietary fiber, vitamins and minerals. Traditionally pulse crops are utilized in soups, canned goods, fried snacks, sprouts and in Oriental noodles; when further milled pulses can also provide functional, nutritional and labeling benefits as food ingredients. Pulse ingredients can be processed with various processing and fractionation technologies at variable protein and carbohydrate levels. Pulse ingredients provide excellent nutritional, functional and cost reducing benefits for food industry. Recent research indicated that whole pulses and pulse ingredients lower cholesterol, triglycerides and blood pressure; pulses lower blood glucose, fasting insulin levels and insulin resistance; and reduce hypertension and the likelihood of obesity. In this presentation the use of pulse ingredients and formulation solutions in meat-free, dairy-free, gluten-free and egg-free novel food systems will be discussed.

1003-S

Lentil-corn-fermented C.S. seed flours made into expanded extrudates: physico-chemical and nutri-functional attributes

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California is the fourth largest wine producer in the world. The main waste by-products of the wine industry are grape pomace, seeds and skins. However, grapes and their by-products have been touted as powerful antioxidants with important health benefits. Fermented Cabernet Sauvignon seed flour (FCSSF) at a concentration of 5%, 12.5% or 20% were mixed with based formulations of corn-lentil (30:70 ratio), starch, and flavoring agents, and extruded at 20% feed moisture content and 140°C die temperature. The protein content in the extrudates decreased more with an increase in starch than FCSSF in the formulations. Conversely, the fat and ash content presented an opposite effect in the extrudates. Formulations with highest percentage of FCSSF had the highest amount of TSP and antioxidant capacity after processing. However, the total soluble phenolics significant decreased ($p< 0.05$) in all formulated flours, at consequence of the extrusion process. The in vitro protein digestibility of the extrudates was significantly greater ($p< 0.05$) for the control and formulation with the least content (5%) of FCSSF. All other evaluated samples were not significantly different ($p< 0.05$) to their unprocessed formulations. The greatest expansion ratio of 3.236 was obtained for formulation containing the least content (5%) of FCSSF and highest starch content (20%). Control extrudate, based on corn-lentil flour, expanded significantly ($p< 0.05$) greater that extrudate based on starch. This effect was generally observed in all other extrudates formulated with different concentration of FCSSF and starch. Effect of processing on color was only evident for formulation containing 12.5-12.5% and 12.5-20% FCSSF and 12.5% starch, respectively, with deltaE = 1.00. In general, the inclusion of FCSSF showed to have potential in the fabrication of healthy expanded food products.

1004-S

Gluten-free spaghetti made with chickpea, unripe plantain and maize: functional, chemical and starch digestibility

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An increase in celiac consumers has caused an increasing interest to develop good quality gluten-free food products with high nutritional value. In this sense, flours from different products have been used to substitute durum wheat semolina to develop pasta that satisfies the nutritional need of specific people such as those following a celiac diet. To the date there is some information on composition of gluten-free pasta but no available information about the digestibility of these products. Therefore, the goal of this study was to determine the chemical composition, cooking quality and starch digestibility of gluten-free spaghetti elaborated with mixtures of chickpea, unripe plantain and maize flours. Chemical composition, cooking quality and starch digestibility were measured accordingly to AACC official methods. The *in vitro* rate of hydrolysis was measured using hog pancreatic a-amylase, according to Holm *et al.* (1985). The gluten-free spaghetti presented a higher protein, fat and ash content than the control semolina spaghetti. The solid loss among all the gluten-free spaghetti was in the range of 10.04–10.91% and not significantly different from each other. The gluten-free spaghetti had lower available starch and higher resistant starch contents which were associated with their lower rate of hydrolysis and predicted glycemic index. The results of this study showed the potential for developing gluten-free spaghetti with reduced amount of glycemic carbohydrates from suitable mixtures of chickpea, unripe plantain and maize flours.

1005-S

Pulse-based expanded extrudates fortified with nutritional yeast: quality and functional attributes

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Lentil (*Lents culinaris* L.) and other pulses are rich source of nutritious and healthy food components and considered original functional foods and superfoods that have great potential to enter the food pipeline in a convenient snack form, as ready-to-eat breakfast cereals and snacks-type foods. Nutritional yeast is grown from pure strains of *Saccharomyces cerevisiae*, on a purified nutrient source, specifically for its nutritional value. This study aimed to develop unique, healthy, tasty crunchy extruded snack-type foods from lentil-based formulations fortified with nutritional yeast. Lentil flours and lentil-based formulations with and without nutritional yeast were extruded using a Clextral EVOLUM HT-32-H twin screw extruder, run at die temperatures of 140-160°C and constant screw speed of 500rpm, to produce the snacks-type product. The specific mechanical energy (KWh/Kg) of the process significantly decreased ($p = 0.05$) with an increase in nutritional yeast addition to the formulation undergoing extrusion cooking. However, the expansion ratio and bulk density of the extrudates was not significantly ($p = 0.05$) different among the lentil-nutritional yeast extrudates. Shelf stability of the developed

products was similar to those of dehydrated food products, presenting water activity in the range of 0.44-0.50. Extrusion processing significantly increased ($p = 0.05$) the in vitro protein digestibility in the final extrudates. Moreover, the incorporation of nutritional yeast into lentil-based formulations produced extruded snack-type products with enhanced textural characteristics and acceptability than the control extrudate. The development of value-added expanded extrudates from formulations based on lentil flours fortified with and nutritional yeast, have a great potential to provide the population with highly nutritional, healthy, acceptable and convenient food.

1101-S
Processing of dietary fibers: Practical considerations
D. PANZER-BIDDLE (1)
(1) J. Rettenmaier USA LP, Schoolcraft, MI, U.S.A.

Psyllium is a well-known soluble fiber that has many health benefits as well as functionality in various food products. General consumers would easily recognize key brands such as Metamucil® manufactured by Procter and Gamble sold in retail markets. Products under these well-known brands are easily recognized by consumers for their multiple health benefits including heart health by reducing cholesterol. There are many health benefits for consumers that incorporate psyllium and other fiber sources into their everyday eating habits. However, the way psyllium is processed may not be as easily understood by the general consumer. This presentation will cover some of the basic ways that psyllium is produced in order to have a clean, safe, and healthy food ingredient soluble fiber source.

1102-S
Novel applications of dietary fibers
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Although dietary fibers for labelling purpose are considered essentially as one entity and credence is put solely on amount, it is becoming apparent that the wide range of fibers found in nature have different functions and outcomes in regard to gut health. From the perspective of the colon microbiota, different fiber structures are needed to meet the needs of the various bacterial groups and this must be put into the broader context of the highly competitive environment that exists for food in order to identify fiber types that promote health. Ingestion of fibers with different physical structures is likely also important with soluble fibers being more accessible and utilized by luminal bacteria, insoluble fermentable fibers favored by certain groups bacteria (e.g. mucosal located *Clostridium* clusters), and insoluble less fermentable (or unfermentable) fibers having a critical role in maintaining good transit time and possibly acting as a platform for adherence of certain bacteria groups. Functional fibers with targeted and desirable actions in the colon which can be incorporated into processed foods are clearly on the horizon, and understanding how different fibers thus function will be increasingly important. This will be true whether it be to create or maintain healthy microbiota communities or to act to improve gut function (e.g. reduce constipation) or generally affect whole body function in a positive way (e.g. reduce systemic inflammation). In this presentation, new ideas regarding function and use of dietary fibers in foods will be presented.

1103-S
Dietary fibers as gluten replacers
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(1) University of Milan, Milan, Italy; (2) University of Milan, Italy

Although the demand for better-tasting, better-textured, and healthier gluten-free (GF) products offers great market opportunities for food manufacturers, the replacement of gluten functionality still presents a major technological challenge. As regards GF bread, several ingredients such as modified starches, gums, and hydrocolloids have been used as alternatives to gluten in order to create a starch-based network, enabling the mass to increase in volume following gas production during proofing. More recently, the incorporation of fiber ingredients in GF formulations has drawn the attention of academia and the food industry. Fiber ingredients not only improve the nutritional quality of the GF products currently available on the market, but some of them also play a technological role in breadmaking, improving crumb softness and assuring a long shelf-life. Moreover, some fiber ingredients - such as *Psyllium* - enhance the physical properties of the dough, due to the film-like structure formed during mixing. This presentation will provide an overview on how to replace gluten functionality using fiber ingredients, highlighting effects on GF dough and bread characteristics.

1104-S

Characterizing the rheological properties of gluten replacers for gluten-free products

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The unique rheological properties of gluten proteins confer desirable viscoelasticity to food products in varying degrees depending on product formulation and processing. Successful replacement of gluten requires an intimate understanding of gluten functionality in different systems and does not lend itself to a one-size-fits-all approach. In products where gluten does not confer substantial functionality replacement can sometimes be as simple as substituting another non-gluten flour. However, this is not always the case, especially in products where gluten confers significant functionality, and significant loss of product quality can result without careful attention to all the functional properties that gluten imparts. Rheological characterization of gluten replacers such as gums, fibers, and hydrocolloids can aid in identifying suitable biopolymer systems that mimic gluten in different product applications. This presentation will walk through the various considerations to take into account for rheological characterization of biopolymers followed by examples using Brabender instruments.

1105-S

The Health Benefits of Psyllium: Understanding the Mechanisms That Drive Health Benefits

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Enduring misconceptions about the physical effects of fiber have led to misunderstandings about the health benefits attributable to insoluble and soluble fiber. In the small bowel, clinically meaningful health benefits (e.g. cholesterol lowering, improved glycemic control) are gel-dependent ('visco-elastic') effects, and highly correlated with the viscosity of soluble gel-forming fibers: high viscosity gel-forming fibers (e.g. psyllium, β-glucan, raw guar gum) exhibit a significant effect on cholesterol lowering and improved glycemic control, while non-viscous soluble fibers (e.g. inulin, wheat dextrin) and insoluble fibers (e.g. wheat bran) do not provide these gel-dependent benefits. In the large bowel, there are two mechanisms that drive a laxative effect. Both mechanisms require that the fiber resist fermentation to remain intact and present throughout the large bowel, and increase stool water content, resulting in bulky/soft/easy-to-pass stools. The two mechanisms are the 'plastic' effect (insoluble fiber) and the 'visco-elastic' effect (gel-forming soluble fiber), both of which increase stool water content, albeit by different mechanisms: the 'plastic' effect mechanically irritates the gut wall to stimulate water/mucous secretion (e.g. wheat bran, but only if particles are large/coarse), while the 'visco-elastic' effect has high water-holding capacity that resists dehydration (e.g. psyllium). Fermentable soluble fibers (e.g. wheat dextrin), and finely ground insoluble fiber particles (e.g. fine wheat bran), do not provide a laxative effect and can actually have a constipating effect (harder stools). It is important to recognize which fiber types possess the requisite physical attributes to exert a beneficial physiologic effect. For most fiber-related beneficial physiologic effects, 'fiber needs to gel to keep you well'.

1201-S

Analysis of Gluten Proteins – Challenges and Solutions

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The analysis of gluten proteins has a long and distinguished history of more than 250 years. Investigation of gluten by current methodologies is often challenging due to the limited genome information of cereals and their poor solubility in aqueous solvents. Enrichment and general isolation of gluten proteins can be achieved by extraction, precipitation and traditional column chromatography. For in-depth characterization of gluten proteins other techniques are required. For example, reversed-phase high-performance liquid chromatography (RP-HPLC) and gel-permeation (GP) HPLC with UV detection have been widely applied to gluten proteins and have proven to be highly efficient tools for the qualitative and quantitative investigation and isolation of gluten protein types and subunits. After suitable calibration, these techniques provide absolute concentrations of proteins. While these one-dimensional (1D) separation techniques are proficient for the analysis of gluten profiles from flours, they are inadequate for individual gluten proteins due to limited selectivity and sensitivity. Modern 2D proteomics approaches combine high-resolution separation (isoelectric focusing, SDS polyacrylamide gel electrophoresis or chromatography) with mass spectrometry (MS) using soft ionization such as matrix-assisted laser desorption/ionization (MALDI) or electrospray ionization (ESI) followed by time-of-flight (TOF), ion trap or triple quadrupole detection. For gluten proteins, most MS applications involve protein identification after proteolytic digestion and chromatographic separation prior to MS of individual ions from the peptide mixtures. The identification of gluten proteins or peptides after MS analysis requires extensive database searching with powerful tools to predict protein/peptide masses, isotopic patterns, enzymatic cleavage sites and possible modifications.

1202-S

Challenging the different aspects of protein and quality measurement along the wheat to bread chain

A. DUBAT (1)
(1) CHOPIN Technologies, Villeneuve la Garenne, France

Cereal technology aims to provide the final consumer with products satisfying different palates and organoleptic requirements. Each link of the wheat chain must provide the link following with adapted raw material and data. For the industry that ultimately serves the consumer, adaptation in the process or the formula is always possible (even if not desired by the baker) in order to comply with customer's requests. But as we move downstream to the cereal field, or to the grain itself and to the breeders, we get far away from the final user and we know that many events in the process will impact the grain potential. The question then becomes 'how to ensure customers' needs from the beginning to the end of the chain. Literature is full of papers indicating the importance of protein. Not only the quantity but also the quality either from a conformation point of view (HMW, LMW…) but also in the manner they express their potential using empirical-rheological testing systems. Each step of the chain has specificity in terms of analytical requirements. Breeders need very precise tools to work on large numbers of samples with very limited quantity. Millers are not limited in sample quantity and can do a lot of testing. Wheat testing should be a dynamic process, taking into account new varieties, new crop practices and new consumers demands. Unfortunately, too often, control labs stays limited to the "do as always" law. Some specification books have been there for years and applied without questioning their adaptation to a moving and competitive world. The topic of this talk is to show how a different strategy, using new laboratory equipment or adapting the protocols, modern data treatment technologies, and based on the combination of information on protein quality, performance and overall quality would help meet final user's requirements and optimize specification books.

1203-S

100 Years of Cereal Chemistry, and Counting, Continues to Impact the Baking Industry

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Last year the AACCI celebrated 100 years of existence. It all started off with a few mill chemists, who agreed that there was a need for standardization of the methods for reporting analytical results, including baking results. The existence of the AACCI can be traced to the need for agreement on the basic analytical methods used. The early meetings of what became the AACC consisted of mill chemists, whose presentations, described different approaches to the determination of common flour constituents, such as moisture, protein and ash content, while provoking debate and criticism at the time. But constructive criticism leads to progress. The importance of this to the industry is emphasized by its extension to the formidable compendium of methods contained in the AACCI Approved Methods. Earlier research reports focused on the role of constituents such as sugar and fiber on flour performance, and the development of a consistent method for baking raised bread. Research on methodology was later extended to the plethora of basic research papers, foremost of which sought to explain the intriguing behavior of the gluten proteins. The first step in that direction was to report on "protein", rather than "gluten". Application of this knowledge and research to manufacture consistent grain based foods became the task of the bread and roll bakers. Utilizing the research results to correlate with the attributes consumers had come to expect, good volume, smooth texture and consistent crumb grain. Consistent consumer products from wheat flour that may or may not provide consistent mix time, absorption, ash contest day in and day out. Working to bring the analytical technology developments and the art of baking together for the advancement of the world of baking and cereal chemistry.

1204-S

What has near-infrared spectroscopy (NIRS) done for cereal chemistry

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Near-infrared spectroscopy (NIRS) is an analytical technique that uses no chemicals, gives accurate and precise results in minutes or even continuously, is capable of simultaneous analysis for several constituents, simple to install, and 100 % safe to use. Its introduction to the cereal industry came in 1976, when the Canadian Grain Commission switched from Kjeldahl to NIRS for testing the protein content of carloads of CWRS wheat for the segregation of wheat on the basis of guaranteed protein content for marketing their multi-billion dollar wheat inventory. Applications to the flour-milling industry happened soon after. The NIRS ash test takes about one minute, and protein and moisture contents can be determined at the same time, whereas even the "rapid" ash reference test (AACCI Approved Method 8-02.01) takes at least 2.5 hours, and is less precise than the NIRS method. The NIRS system can be set up for continuous monitoring of these three constituents. A network of 2 or more instruments can be used to monitor flour production in the mill, all controlled from a single desk-top or lap-top computer. Excellent NIRS predictions of quality factors in flour are presented, with r2 values ranging from 0.88 (ash) to 0.98+ (protein and moisture). The paper describes results of application of several

chemometric approaches to the prediction of wheat quality in whole grain. Quality factors were protein content, test weight, kernel texture (particle size index, or PSI), and Farinograph water absorption, dough development time (DDT) and mixing tolerance index (MTI). But dependable predictions of gluten strength in whole grains by NIRS, in terms of physico-chemical dough properties, have so far proved to be elusive.

1205-S
Analytical Measurements – What, How, and Why Do We Measure?
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(1) Independent consultant, Port Byron, IL, U.S.A.

We measure physical and chemical properties of grains and flours in order to better understand these materials. As we learn more about our raw materials and how they react to processing we can improve the quality of our end products. We use experimental designs to efficiently measure responses to inputs in a process. We use statistics to consolidate and clarify complex data. Statistical methodology in Cereal Chemistry has evolved alongside the computer and instrument based revolution in chemical analytic methods. Traditional wet chemistry methods have been upgraded with automated measuring allowing more data to be collected more accurately. Newer instruments are measuring more complex entities more often and more precisely. Statistical procedures have had to go from relatively simple descriptions and comparisons of a few simple measurements to the complex multivariate procedures required for large data sets of many interrelated variables. Fortunately statistical software continues to improve for both graphical and analytical examination of research results. This AACCI annual meeting is an important venue in which research needs can be identified and research results can be disseminated. However, communication between researchers and industry representatives can be a problem not only because of each group's technical jargon but also because of differences in personality types. The introverts from the labs don't always interact well with the extroverts from the offices. Each group has to make an effort to communicate with the other group. Industry needs to be clear about their needs and priorities and researchers need to explain complex results in understandable formats.

1301-S
Challenges in Food Safety, the Future?
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If there's one lesson the U.S. produce industry has learned from food safety events over the last decade, it's this: when a problem arises, we're all involved— and we're all at risk. Every produce outbreak, every illness, every recall sends ripples across the marketplace. The entire supply chain, from growers to shippers to retailers, feels the economic, operational and social impact of food safety events. The 2006 E. coli outbreak in spinach, the 2011 outbreak of listeriosis from cantaloupes, and the recent recalls of apples and stone fruit, are stark reminders of the supply chain disruption and human tragedy that can result from foodborne illness outbreaks. While the industry has made great strides in recent years, there's still a lot we don't know about what causes many produce outbreaks and how we can prevent them. But that knowledge gap is becoming narrower thanks to the work and mission of the Center for Produce Safety. Impressive record of success - CPS, a public-private partnership between industry, government and academia - was formed in 2007 to advance research needed to continually improve produce food safety worldwide. In just a few years, CPs has awarded $18.4 million and funded over 100 research projects. The results of that research have provided industry leaders with timely, actionable, cost-effective solutions to minimize produce safety vulnerabilities and protect their brand equity and continue to provide consumers' confidence in their purchases of fresh fruits, vegetables and nuts.

1302-S
Genome editing of crops: non-GM technology to increase food safety and nutritional quality
J. GIL-HUMANES (1)
(1) Calyxt, New Brighton, MN, U.S.A.

Methods for precise genome editing in plants have progressed remarkably in the last few years, due to the development of new-generation sequence-specific nucleases (SSNs), such as TALEN® and the CRISPR/Cas9 system. These customizable molecular DNA scissors are capable of inducing mutations at given genomic locations. Due to the simplicity of their mechanism for DNA recognition, SSNs can be designed to target virtually any DNA sequence, providing an efficient approach to edit genomes of important crop plants. GMO technology involves integrating foreign DNA into the plant genome (including antibiotic and/or herbicide resistance genes) and thereby expressing novel proteins. Traits created by GMO technology are usually oriented towards meeting farmer needs (e.g. pest resistance and herbicide resistance). Consequently, and despite considerable data that they are safe for consumption, GMOs have been perceived negatively by consumers. We believe that gene edited crops will be better accepted by consumers, since the final product does not contain any foreign DNA in the genome. Rather, only a few nucleotides are normally edited and no new proteins are expressed in the plant. At Calyxt, we

utilize TALEN® to edit the genome of some of the most important crops: wheat, soybean, potato, and canola, among others. The traits we create focus on benefiting the consumers by creating healthier and safer food products. Some of our first gene edited crop varieties, such as high-oleic soybean and the low-acrylamide potato, have been considered as non-regulated articles by the USDA, and they will be available to consumers in the next few years. In my presentation I will describe traits created by genome editing, and I will explain the potential of gene editing technologies to enhance food safety and nutritional quality.

1303-S
FSMA Regulations
M. OLEWNIK (1)
(1) AIB International, Manhattan, KS, U.S.A.

The sweeping regulations brought on by changes in FDA food safety requirements are defined in the Food Safety Modernization Act. This Act was signed into law in 2011, and in the ensuing years FDA has been putting in place the detailed requirements of this law. These requirements will guide the food industry on ensuring that the U.S. food supply is safe, by shifting focus from response to prevention. This presentation will touch on the main points of focus for these new regulations and provide some interpretation of how these regulations may impact the cereals business community.

1304-S
Virtual Reality Applications for Enhancing Food Safety Training and Science Communications
C. STEVENSON (1)
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Virtual reality, which is defined as a computer-generated simulation of a 3D environment that people can immerse themselves into, has emerged as an exciting technology in recent years because of its many capabilities. After many years of research and development, today this technology is available at a price point that many developers and consumers alike can afford. This session will explore and demonstrate the applications and possibilities for virtual reality to solve two urgent problems we are facing in the food industry: (1) increasing food safety and quality competencies through education and training programs; and (2) communicating food science to consumers. The audience may walk away with some ideas that they can put into action for both training/communications interventions and evaluations.

1401-S
Sorption and powder behavior
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For many food powders, the presence of moisture can change and compromise product performance as well as mixing and handling behavior. Food powders such as sugar, salt, whey, flour, starch and gravy mixes can all change due to uptake of moisture from a free-flowing powder to a caked, lumpy solid mass that does not flow at all. An overview of researches on the effect of moisture/water activity on powder flow behavior on selected food powders and comparative results on the changes in powder flow properties of these food powders using three types of powder flowability testers will be presented. The process of identifying critical moisture/Aw levels for different types of food powders when drastic changes in powder flow occur will also be discussed. Powder flowability is affected by a number of intrinsic and extrinsic factors such as physical attributes of the powder (moisture content/Aw, particle size, shape, hygroscopicity, cohesion, particle interaction, etc.), and environmental conditions (humidity, temperature). This presentation hopes to clarify how moisture sorption or moisture uptake influences flow behavior and the impact of these changes in powder properties on processes such as mixing, filling, compression, powder application (e.g. adhesion) and other processes.

1402-S
Modeling Particle Flow and Dynamics
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Having accurate models for predicting the kinematics and dynamics of particulates, such as agricultural and food products, is important for effective engineering design of processes involving these materials. The discrete element method (DEM) is well suited for such studies and has been used for several decades to investigate particulate systems. In this talk, recent research involving the modeling of assemblies of rod- and plate-like particles will be presented. Results from shear cell studies in which particle packing, orientation, deformation, and stresses will be shown. In addition, methods for predicting the breakage of rigid and flexible fibers will also be discussed.

1403-S
Cereal killers – the need for particle size and shape information in grain technology
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Every year serious injuries and deaths result from poor flowability of grains in silos. These tragedies arise from the grain size, shape, and silo construction and flow properties. This presentation summarizes the technical routes available to characterize grain size and shape including a review of the difficulties of representative sampling.

1404-S
Agglomeration of powders
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Agglomeration or granulation is a common unit operation to enhance the product characteristics such as flowability, bulk density, physical appearance, and to minimize dust and segregation. It is broadly used across many industries ranging from pharmaceuticals to agriculture, consumer goods (detergent and food) and fertilizers. During wet granulation, a liquid binder is added to a dry powder formulation to produce larger agglomerates. Wet granulation involves three rate processes, nucleation, consolidation and growth, breakage and attrition, all taking place simultaneously. Consequently, this makes it a very complex process to control. These different rate processes contribute to the generation of the agglomerate attributes, such as size distribution, density, and liquid distribution. Researchers have been putting effort to better understand the existing processes to be able to produce the granules with the desired attributes. This talk will focus on the current collective understanding of the rate processes; how to use the state-of-the-art modeling approaches and different quantitative engineering approaches to design, troubleshoot and scale-up agglomeration processes.

1405-S
Agglomeration of powders
E. RIEDL (1)
(1) Anton Paar GmbH, West Lafayette, IN, USA

No Abstract Submitted

1501-S
Lactic acid fermentation affects antioxidant capacity and polyphenol content in Chinese beans-based functional foods
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Fermentation is an ancient but effective food processing technology commonly employed to improve the nutritional and sensory qualities of foods. Edible beans are important grain legumes consumed by humans with a number of health benefits, which are at least partially associated with the antioxidant polyphenols in their seed coats. We found that fermentation had varying effects on antioxidant capacity of selected Chinese edible beans and bean milks, in general increasing their total phenolic content, which could be due to bioconversion between soluble phenolics and the release of bound phenolics triggered by the fermentation microorganisms. A selected genotype had substantially increased catechin content, probably due to bioconversion from proanthocyanidins. In addition, the lipophilic extract had much higher free radical scavenging capacity than the commonly investigated hydrophilic extract in lactic acid bacteria (LAB)-fermented mung bean and soybean milks. Vitexin and isovitexin, two C-glycosidic flavones, were found as the main polyphenols in mung bean milk, and fermentation did not markedly change their content, probably due to the lack of C-glycosyltransferase in LAB. Overall, fermentation is a valuable way to increase the bioavailability of bean polyphenols, and fermented bean products rich in antioxidants can be developed into novel functional foods with enhanced health benefits.

1502-S
New developments in uses of "cereals and pulses", traditionally a basic food ingredient in the East
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'Cereals and pulses' are very popular in the developing world. They provide a harmonious balance of amino acids, as pulses are high in lysine and low in methionine, while cereals are low in lysine and not in methionine. Over the years, a number of studies have been reported on improved nutritional value of high protein products using composite flours. These studies were catered to increasing the protein content of cereals flours to overcome issues of the developing world like protein-calorie malnutrition. In recent years with increased concern about

gluten sensitivity, and such has increased demand for animal protein, the need for good quality protein cannot be met only with animal based proteins without drastic adverse impacts for the environment and humanity. Due to their high gluten-free protein, high fiber and low fat contents, pulses offer alternate sources that are sustainable and affordable foods for the growing global population. New developments in the use of pulses as replacement of cereals will also be discussed.

1503-S

Effects of different lactic acid bacteria starters on ACE-I inhibition activity and functional properties of soy sourdough fermentation

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(1) Jiangnan University, Wuxi Jiangsu, China; (2) Jiangnan University, Wuxi, China; (3) Jiangnan University, China

Use of dietary approaches in control of chronic degenerative diseases such as hypertension have been on the rise. Sourdough fermentation continues to enhance product nutritional and functional properties through bioactive metabolites. In this study, the effect of lactic acid bacteria (LAB) starters (*L. plantarum, L. sanfranciscensis, L. brevis, L. crustorum* and *W. cibaria)* on angiotensin-I converting enzyme (ACE-I) inhibitory activity and emulsifying properties of soy sourdough fermentation were investigated. Using central composite design (factors varied: wheat bran, fermentation time and dough yield); based on ACE-I inhibitory activity, two formulas were selected: S1 (3% wheat bran) and S2 (0% wheat bran). All LAB strains adequately grew in both sourdoughs, S2 samples registered significantly (P<0.05) higher total count compared to S1 samples. Only *L. plantarum* and *L. sanfranciscensis* fermented sourdoughs exhibited ACE-I inhibitory activity with S2 (S2LP 52.8%, S2LS 40.5%) having higher (P<0.05) activity than S1 (S1LP 36.5%, S1LS 32.5%). Amino acid profiles and peptide molecular weight distribution were both determined by chromatographic methods. Seventeen amino acids were present in all; sourdoughs had higher amino acid levels (P<0.05) than the control samples. All sourdoughs (S2>S1) had higher (P<0.05) amounts of hydrophobic, aromatic, and branched chain amino acids than the control. Low molecular weight peptides in the range 0.2-3kDa were highest in S2 followed by S1 and least in the control samples. Compared with control samples, sourdoughs exhibited lower emulsifying activity and higher emulsion stability. The LAB starter type significantly affected the ACE-I activity and emulsifying properties of soy sourdough fermentation. *L. plantarum* and *L. sanfranciscensis* were the best strains and no wheat bran should be used in soy flour fermented by the two strains.

1504-S

Nutrient profiles and antioxidant activities of germinated brown rice and its food products

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Whole grain rice (brown rice) is of benefit to the health of consumers. Germination of brown rice may further enhance its health benefit compositions in the whole grain rice (brown rice). Dynamic alterations in the polyphenols, tocols, antioxidant activities (AOA), and gamma-aminobutyric acid (GABA) contents of white, red, and black germinated brown rice (GBR) upon different germination periods were studied. The results indicated that the contents of the free, bound, and total phenolics and AOA steadily increased during germination, even though the free part of colored GBR showed a notable decline at the earlier stages. The compositions of the nine phenolic acids and six tocols generally accumulated in a time- and variety-dependent manner during the germination process. The GABA in white, red, and black GBR accumulated to the highest content at the end of germination, which was 4.7, 14.2, and 6.7-fold of their respective nongerminated counterparts. We also investigated the effects of anaerobic treatment on these compositions in the GBR. The values of polyphenols and antioxidant capability significantly increased in treated groups, in which the three phenolic acids, i.e. ferulic, p-coumaric, and sinapic acids, showed the most pronounced increase. No significant change was observed in tocols. The contents of GABA increased 4.2, 9.7 and 4.8 folds in the white, red and black GBRs, respectively. The results indicated that additional anaerobic treatment could be used in the production of GBR as a functional food.

1505-S

GABA enrichment and functional metabolites produced by Mung bean and cereals fermentation system for foods

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(1) Jiangnan University, Wuxi, China; (2) MagiBake International, Inc., Wuxi, China

Gamma-aminobutyric acid (GABA), a four carbon non protein amino acid, acts as a major inhibitory neurotransmitter of the central nervous system has several physiological functions such as antihypertensive. Foods can be enriched in GABA by lactic acid bacteria (LAB). Traditionally fermented foods are rich in the GABA enriching LAB. In this study, GABA producing LAB strains were isolated from traditionally fermented rice noodles and fermented grains; primary screening done using culture techniques, secondary screening done using modified paper chromatography (MPC) and HPLC. A total of 621 and 124 LAB strains were isolated from

fermented rice noodles and fermented grains respectively. Based on GABA enriching potential, one strain (Identity: *Lactobacillus buchneri* (*L.bu*)) from fermented rice noodles and one strains (Identity: all *Lactobacillus brevis* (*L.br)*) from fermented grains were selected, used as starters to optimize GABA content in mung bean flour sourdough (MSD). Total free amino acid (FAA) of both sourdoughs significantly increased, MSD.*bu* (634.43) and MSD.*br* (596.76) compared to mung dough without fermentation (234.53mg/100g). In bread, mung sourdough bean bread (MSB.bu and MSB.br) in comparison with wheat bread (WB) and mung bean bread (MB), the FAA was in the order: WB (72.94)< sourdough through bread Mung of characteristics sensory and nutritional the enhanced significantly selected strains LAB conclusion, In compounds. flavor volatile unique different 10 contained also flavor, beany decreased showed MSB.*br*. MSB.*bu* however, flavor. MB increased WB, with compared for furan pentyl 2- alcohol isoamyl hexanol, Hexanal, in Increase respectively. breads experimental fermentation after detected were kinds 84 24 GC-MS, by studied compounds Volatile (257.58). (222.51)

1601-S
Nutritional Efficacy of Sprouted Grains – State of the Research
M. OMARY (1)
(1) The Omary Group, Riverside, CA, U.S.A.

Consumption of whole grains has shown to benefit against diabetes, cardiovascular disease and obesity among other lifestyle diseases; and their nutritional and bioactive components have been underlined to synergistically help prevent and manage them. The *2015 Dietary Guidelines for Americans* reinforced the consumption of whole grains given the recurring low dietary patterns among the majority of the U.S. population. Germination has re-emerged has a promising natural process to enhance the nutritional profile and bioactivity of whole grains. Efficacy data regarding the effect of sprouted grains on blood glucose, lipid profile, inflammation, and oxidative stress among others via *in-vitro* studies is rising, however substantiating *in-vivo* and randomized control human studies are lagging behind. A review of the current research on the nutritional efficacy of germinated edible grains will be presented.

1602-S
Sprouted whole wheat flour functionality evaluation in the biscuits
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Sprouting grains increases many of the grains' key nutrients, including B vitamins, vitamin C, folate, fiber, and essential amino acids often lacking in grains, such as lysine. However, there are few reports on biscuit application of the sprouted whole wheat flour especially the functionality application for biscuits. In this study, the flour functionality for soft red winter wheat whole wheat flour (SRWW flour) and soft red winter sprouted whole wheat flour (SRPW flour) was tested by measuring solvent retention capacity (SRC) and AACC wire-cut cookie baking. SRPW flour has significantly higher SRC water, SRC sucrose, SRC Sodium, SRC lactic than SRWW flour. This indicates SRPW flour is not good flour for biscuit application. The cookie made with SRPW has smaller cookie diameter (less spread, higher stack height) than cookie made with SRWW flour. The cookie made with SRPW also has higher moisture and dark color. The wire-cut cookie baking results suggested SRPW flour will have some potential baking challenges for biscuit application. The Cookie made with SRPW also higher break force which is measured by TA-XT plus texture analyzer. There is need to optimize the sprouted wheat flour production process to produce biscuit application sprouted flour.

1603-S
Nutrient bioavailability and application of sprouted crops in food products
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(1) Food Processing Development Centre / Government of Alberta, Leduc, AB, Canada

Unique flavour of dry pulses has been detrimental to increasing the human consumption of pulses in North America despite the excellent nutritive values. The partial germination (pargem) process has been known to reduce the unique beany flavour in other pulses. The objectives of the project were to evaluate and optimize the pargem process, to evaluate protein qualities and functional properties, and to develop and evaluate prototype food products utilizing pargem pea flours. Two partially germinated yellow peas were produced using under two processing conditions: i.e. pargem I using a short germination time and high drying temperature and pargem II using a long germination time and low drying temperature. Untreated and pre-cooked pea flour were also included in the study for comparison. Protein qualities, in vitro and in vivo, found that the processing method was without a major influence on the indices of in vivo protein quality. In general, the protein in the peas was highly digestible (90%). The pargem I exhibited a significantly lower PER score of 1.71 and the adjusted PER values ranged from 1.26 (pargem I) to 0.54 (untreated). Product prototypes were developed to evaluate the feasibility of using pea flours and were then evaluated using consumer acceptability methods. In general, pargem

flours worked well in formulations in selected product types, e.g. spaghetti, extruded snacks, cakes, tortillas, pancakes, and pizza crust. The products containing pea flours exhibited darker colour, crispness and slightly harder texture depending on pea flour inclusion levels. However the products also have higher fibre and protein contents contributed from the pea flours. Sensory analysis showed significantly higher aroma and flavour than control indicating that pargem flour has the potential to be used in the production of selected food products.

1604-S

Role of sprouted seeds in human health and disease prevention

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Specific diets can reduce the risks of and protect against cancer and other chronic diseases. The novelty of this approach is rooted in the concept that ingesting certain phytochemicals from specific plants can boost the intrinsic defensive mechanisms of cells that protect against oxidative damage, inflammation, and DNA-damaging chemicals—some of the fundamental causes of chronic disease and aging. We discovered over two decades ago that broccoli seeds and sprouts are remarkably rich in glucoraphanin, the precursor to the chemoprotective isothiocyanate phytochemical sulforaphane. This has resulted in a series of clinical studies that highlight the special place which the isothiocyanates hold in the armamentarium of protective natural products. Over the past half-decade a series of experiments in animals and humans has demonstrated that remarkably, the protective effects of sulforaphane extend far beyond protection against cancer and environmental hazards such as air pollution and food-borne toxins—most surprisingly, to neuroprotection. We and others are evaluating the effects of the seeds and sprouts of broccoli and related plant species in a range of conditions that include autism spectrum disorder, schizophrenia, Alzheimer's, Parkinson's, and acute spinal cord injury. Recent developments will be discussed.

1605-S

Panel Discussion for 30-minutes – Sprouted Grains: Opportunities and challenges

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(1) AAFC, Guelph, ON, Canada; (2) GrainMillers, Eugene, OR, U.S.A.

Sprouted grains have a long history as foods and it is believed to be healthier compared to their respective non-sprouted grains. Sprouted grains can be considered as an improved version of whole grains with better taste and health-enhancing properties. However, nutritional and therapeutic properties of sprouted grains still remain unclear, particularly when assessing optimum seed-modification and consensus on method-development to make such assessment. Discussions on sprouted grains in terms of nutrient bioavailability, safety and regulatory, and their role in human health and disease prevention together with the associated transparency have never been needed more than in today's competitive and health-driven food market and health-conscious consumers. This panel discussion gathers experts from academia, industry and government to discuss health beneficial effects and consumer perception of sprouted grain products and the opportunities and challenges facing the grain industry.

101-O

β-Glucan structure and breakdown in different barley varieties during baking

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The health benefits of mixed-linkage (1→3),(1→4)-β-D-glucan (β-glucan) are highly interesting and there is an approved health claim from EFSA on reduction of cholesterol levels, but other beneficial health effects are also investigated. It has been shown that the health effects of β-glucan are dependent on the molecular weight and that the beneficial effects are more pronounced at higher molecular weights. Bread is consumed all over the world in many different shapes, in the western world mostly from sifted wheat flour but traditionally also from rye and barley. The sifted flour from barley contains more β-glucan than sifted wheat flour does, but there are also differences between varieties of barley. This project investigated how different barley varieties, chosen for their wide variation in carbohydrate composition, were affected by bread making. One known effect of bread making is the breakdown of β-glucan. However, it was found that one of the six included barley varieties had a different breakdown pattern, and retained a higher molecular weight of the β-glucan than the other varieties. The β-glucan together with other components in this variety are investigated further and compared to the other varieties to explain the retained high molecular weight. This variety could hold the key to making a health promoting bread, with high molecular weight β-glucan.

102-O

Sprouted barley flour as a new ingredient for bread baking

Y. JIANG (1), L. Mo (1), G. Weaver (1), M. Martin (1), J. Hu (1), G. Guo (1)
(1) Ardent Mills, U.S.A.

Special attention is paid to sprouted barley flour due to its unique nutrition value and components for baking application. Raw barley contains a high amount of dietary fiber, and its barley starch is reported to be a substitute of wheat starch for bread baking due to its satisfactory loaf volume and texture. After sprouting, simple sugar content in barley spiked as high as 9%, making it possible to formulate bread with reduction of added sugar. In this study, Sustagrain®, the highest-fiber whole grain, was selected as a raw material for sprouting. Three, five and seven days were used to process sprouting in chambers with controlled temperature (14°C). Sprouted barely was steamed with different time length to deactivate amylase and glucanase. After milling, the sprouted barley flour was blended with either refined or whole wheat Ultragrain High Performance (UG-HP)® at a ratio of 25:75; and baked by sponge and dough method with 25% and 50% reduction of added sugar. Blend consists of sprouted barley and UG-HP® refined offered similar baking volume as regular whole wheat bread and slightly open internal crumb. The bread was a good source of fiber; blend of sprouted barley and UG-HP® whole wheat baked slightly nutty flavored bread with soft texture and full of body, with similar internal crumb and slightly lower volume (~20%) than regular whole wheat bread. The bread was an excellent source of fiber. Shelf-life study of all breads demonstrated similar or retarded bread staling compared to whole wheat bread. Breads from blends of selected process were acceptable or preferred to our sensory panels, especially in aspects of sweetness and flavor. The study showed that by optimizing sprouting and kilning process, sprouted barley flour can be a new ingredient for bread with reduction of added sugar and good/excellent source of dietary fiber.

103-O

Barley limit dextrinase: Determinants of substrate specificity and sensitivity to the endogenous proteinaceous inhibitor

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Cereal limit dextrinases (LDs) and endogenous limit dextrinase inhibitors (LDIs) are key players in degradation of a-1,6 glucosidic linkages from amylopectin and thus in starch mobilization of particular relevance in malting. Moreover LD and LDI are proposed to be important in starch biosynthesis. Notably, LD and LDI appeared essential in malting. Several crystal structures are determined of barley LD in complex with substrates, substrate analogues [1] and the potent endogenous LDI having picomolar affinity for LD [2]. Guided by the crystal structures we used site-directed mutagenesis to unravel determinants for substrate specificity and sensitivity to regulation of LD activity by LDI. Secondly, we examined the role of positions in the non-catalytic N-terminal domain of barley LD, which as reported by others may play a role in a variant of sorghum LD for elevated LD activity resulting in more digestible starch from this drought tolerant crop. Thus a finding connected with LD's proposed role in starch biosynthesis [3]. In complementary studies computational design of LDI variants will be validated. The results are of interest besides to malting industries and cereal breeders, particularly to industries

producing starch degrading enzymes and manufacture of starch products such as syrups. The findings are promising for future interdisciplinary achievements combining rational protein engineering with cereal crop improvements. This work is supported by a DTU PhD scholarship (SA) and a Research Talent grant from Danish Council for Independent Research | Technology and Production Sciences (MSM).

104-O

Study on the sensory evaluation methods of Lanzhou hand-extended noodles

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Lanzhou hand-extended noodles (LZHEN) as one of the most popular traditional food are normally made by cook masters, but the sensory evaluation methods for the noodle processing and cooked noodles have not been established yet, which retard the industrialization of this product. To establish sensory evaluation methods to evaluate the LZHEN on its processing and quality of cooked noodles, eight commercial wheat flours with significantly different quality properties (e.g. protein content varied from 11.83 to 14.72%, wet gluten content varied from 25.15 to 34.91%, and dough stability from 4.0 to 20.2 min) were made into noodles and evaluated by one cook master and panelists with preliminary methods developed, and the evaluation methods are modified according to the results; two wheat flours with the highest and lowest sensory scores were mixed in a certain ratios (100/0, 80/20, 60/40, 40/60, 20/80, and 0/100) and made into noodles to confirm the rationality of revised methods, where scores of noodles made by mixed flours showed a linear relationship with the flour qualities. Evaluation methods for the processing and cooked noodles were established ultimately by design, implementation and verification. The main quality attributes selected for the processing and cooked noodles quality of Lanzhou hand-extended noodles were as follow: 1) 'degree of mixing and hardness of dough', 'fracture and homogeneity of strips', 'slitting effort by hand and stickiness', 'dough color after resting' and 'extending force' were selected to assess the processing quality attributes; 2) 'color', 'surface appearance', 'hardness', 'stickiness', 'elasticity', 'smoothness' and 'flavor' were selected to assess the cooked noodles quality attributes. The specific weight of evaluation attributes will be determined based on the assessment of cook masters and consumers in the future work.

105-O

An investigation of the quality and functionality of gluten-free mixes available on the UK market

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This work investigates the functionality of gluten-free mixes available on prescription on the UK market. Six gluten-free mixes were used to prepare white breads following the methodology of their manufacturers. A number of textural and physical analyses were performed on the resulting breads using Volscan Profiler, Texture analyser (TA –XT2i) and C-cell analyser. Sensory evaluation for all the samples was carried out with 35 participants, all diagnosed with coeliac disease and members of the Coeliac UK. The participants were asked to sample six fresh white gluten-free breads and evaluate a number of attributes by ticking a line from 1 to 10 (1 – dislike and 10 – like) The attributes were as follows: appearance, crumbliness, softness, flavour, aftertaste and overall liking. The preliminary questionnaire and sensory evaluation were administered, resulting data collected and analysed. Additional information from the participants was obtained for the convenience of gluten-free mixes use for preparation of various gluten-free products. The data were analysed using SPSS 16.0. The results revealed that there was a significant difference ($P<0.05$) between all the samples in terms of loaf volume, area, weight, hardness, slice structure and shelf life. The sensory evaluation results indicated that there was a large variation seen in all attributes tested. It was apparent that some of the samples performed far below the expectations. The explanation is seemingly in the type of the ingredients used for developing gluten-free mixes and variety of suggested methodologies by manufacturers. In order to achieve good textural characteristics such as high loaf volume, crumb softness and structure, it is very important to understand the functionality and interaction of the ingredients (starches, proteins and hydrocolloids) used in gluten-free formulation.

106-O

How comprehensive does protein quality data need to be to predict gluten strength in a population of bread wheats?

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Gluten protein composition and small-scale dough mixing results were compiled for a set of 52 HRW wheats grown in one site and year. Flour protein content (FPC) ranged from ~11-14%. A mixograph was used w/o and with salt at constant absorption. Gluten strength was assessed by work input to peak development (WIP) and

other parameters, and varied considerably across genotypes. FP was fractionated using a basic differential solubility method in 50% 1-propanol w/o and with reducing agent yielding propanol soluble protein (SP), insoluble glutenin (IG) and residue protein. SP and IG were quantified by UV absorbance. Gluten proteins were also fractionated using a more comprehensive procedure to distinguish gliadins, LMW soluble glutenin, HMW insoluble glutenin, with subunits quantified by RP-HPLC. Prediction of WIP ranged from R2 = 0.23 (for FPC alone) to > 0.80 depending on the type and number of protein factors determined by stepwise regression and whether salt was used in dough mixing. Salt had a non-linear and genotype-specific effect that improved discrimination of samples and prediction of WIP; e.g. the most influential protein quality factor = FPC*IG/SP had R2 w/o and with salt = 0.59 and 0.69, respectively. Prediction of WIP could be improved to R2 ~ 0.76 and ~ 0.79 in 2- and 3-variable regression models by adding any number of protein quality parameters derived from detailed protein fractionation and HPLC results. Including individual subunits of reduced HMW or LMW glutenin did not enhance prediction of WIP. Results indicated that many of the most effective protein quality parameters for predicting gluten strength were confounded by FPC. It was concluded that a relatively simple gluten protein fractionation and quantification procedure could be successfully used to explain a high proportion of the variation of gluten strength in this population of genotypes.

107-O

Characterization of soy protein films with a durable water resistance-adjustable and antimicrobial surface

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The development of bio-based polymers from proteins has gained attention for the wide availability and renewable and biodegradable nature of protein. However, protein-based plastics have limited commercial applications because of several drawbacks, such as poor processability, brittleness, moisture sensitivity, and inferior mechanical and thermal properties. One of the objectives of this research work was to find a way to create functional soy protein isolate (SPI) films by immobilizing some functional polymers, such as pH or thermal sensitive, oxygen- or odour-resistant, and biocompatible polymers, on SPI films for different applications. In this study, a water resistant surface was first obtained by immobilizing hydrophobic copolymers (PSG) with functional groups on SPI films. X-ray Photoelectron spectrometer and Atomic Force Microscopy results showed that PSG copolymers were immobilized on the film by chemical bonding, and formed a rough surface with some bumps because of the segregation of two different phases on PSG copolymers. Water resistance of the modified films could be adjusted dramatically by further immobilizing different amounts of guanidine-based antimicrobial polymers (PHGH) on the resulting hydrophobic surface. The introduction of hydrophilic PHGH on the resulting surface generated many micropores, which potentially increased the water uptake of the modified films. Furthermore, the modified SPI films showed higher thermostability compared to the native SPI film and broad-spectrum antimicrobial activity by contact killing, attributed to the presence of PHGH on the surface. The modified SPI film with a multi-functional surface showed potential for applications in the packaging and medical fields.

202-O

The effect of starch composition on starch nanoparticles characteristics

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Starch is a GRAS ingredient in food products and formulation. Starch nanoparticles have a great potential for various applications such as nanocomposites, biomedicine, food processing, industry, and so on. Nanoprecipitation (desolvation) method is one of the best developed techniques for nanoparticulation of starch. The effect of different parameters on starch nanoparticles characteristics were optimized in this study. One of these parameters was the effect of starch type and composition, specifically the ratio of amylose and amylopectin. Starch granules were fully gelatinized using chemicals and heat treatment. Four corn starch types have been selected including native corn, Amioca (waxy starch), Hylon V (55% amylose), and Hylon VII (70% amylose) starches. The average particle size showed that the smallest particles were produced from native corn starch and Hylon V, the particle sizes were 119±3 and 120±11 nm, respectively. While Amioca and Hylon VII starches showed larger particle size, 150±5 and 170±10 nm, respectively. The stability of the nanoparticles was studied for five days, native corn starch nanoparticles were completely stable, and the particle size was constant. The particle size of Hylon VII nanoparticles increased from 170 to 201 nm in five days, which can be related to retrogradation phenomenon. The combination of particle size, zeta potential and stability studies showed that the native corn starch and Hylon V are the best types among the studied starches for preparation of small, uniform and stable

nanoparticles. SEM images showed relatively spherical and uniform nanoparticles. These nanoparticles have high potential to be used as delivery systems, Pickering nanoparticles, and other biological applications.

203-O

The link between starch molecular structure and its physical properties

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Cereal starch is a low cost raw material and is widely used in food as well as non-food applications. The structure and properties of starch vary greatly between as well as within species. This offers many possibilities for the industry to find starch with good properties for a wide range of applications. Starch structure and properties have been studied extensively for many years, but we still do not have a good understanding of the link between starch molecular structure and function. The choices of starch material for various applications are thus mostly based on empirical results. Improved methods to describe the amylopectin molecular structure is needed to reveal new factors that influence the properties of this molecule. A novel method focused on the branching pattern of amylopectin has been applied to barley starch and the results have been linked to thermal properties such as gelatinisation and retrogradation. Regression analysis indicates that the branching density locally in the amylopectin molecule is an important factor, especially for retrogradation.

204-O

Flour particle compactness and starch hydrolysis property

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Slowly digestible starch is recognized to contribute to the reduction of the risk of common chronic diet-related metabolic diseases. Several studies, including at our institute, have shown that increasing flour particle size slows down the starch digestion rate. However, the presence of large particles (>120 μm) can result in a poor quality of the final product. In this scenario, we hypothesised that a fine flour with a compact structure, such as that from maize hard endosperm, would be digested more slowly. The aim of this work was to study the effect of the compactness of maize flour endosperm on starch digestion. Both fine (126 μm) particles from hard and soft maize endosperm were obtained by adjusting the break passages until particles with similar size but different compactness were observed by SEM. Sections of flour particles were assessed for microstructure, and starch fine structure, crystalline polymorphism, thermal transitions, particle size; and *in vitro* starch hydrolysis was also analysed. Results suggest that not only particle size but also particle compactness are fundamental factors to control starch digestion rate. Both proteins and starch contribute to the hard endosperm compactness of conventional maize. As for the starch, amylose and amylopectin fine structure can improve the starch assembly at higher levels, slowing the starch digestion. This work is towards the larger goal of identifying appropriate starchy matrices to produce foods with a slow digestion property.

205-O

Pasting and cooking properties of aged high amylose rice affected by the changes of storage protein and starch

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The pasting and cooking properties of prolonged aging high amylose rice (HA) affected by the changes of storage proteins and starch fine structure are investigated. The glutelins isolated from HA aged at 38°C for 18 months are analyzed by capillary electrolysis under reducing conditions. The results indicate the oxidation occurred to form the disulfide bonds which the cross-linked proteins thicken the protein matrixes around the starch granules, especial for the prolonged aging HA at high temperature. The relatively low endogenous a-amylase activity and the high pasting temperature of HA resulted in the insignificant changes on the starch molecular weight before and after ageing and the pasting profiles of rice flour from the rice aged at 4°C over time. The pasting and cooking properties of the aged HA is mainly affected by the degree of oxidation of storage proteins and the thickness of protein matrixes surrounding the starch granules that will delay the water penetration, restrict the starch granule swelling, and enhance the integrity of swollen starch granules. Thus, high pasting temperature, low peak viscosity, high trough reflected by the disappearance of breakdown on the viscograms of the aged rice. The hard, lacking of stickiness, low cooking loss and high water uptake ratio of cooked rice are investigated in the prolonged ageing rice as well.

206-O

Pasting properties of dry bean powders from 25 Michigan-grown cultivars from two crop years

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It is well known that dry beans are rich in protein (20–50%) and fiber (23–32%), low in fat (0.5–1.5%), and lower in carbohydrates as compared to cereals (25–40%), making them a good nutritional food source for people around the globe. Michigan is the second largest producer of edible dry beans in the U.S. The objective of this study was to explore the utility of the Rapid Visco Analyzer (RVA) to discriminate 25 bean cultivars, grown in 2014 and 2015 in Michigan, for their unique pasting properties. Surface contact area of particles is related to particle size and affects hydration rate: smaller sized particles have greater surface contact area and generally higher hydration rates. Higher content of carbohydrates (including starch) in powder samples would increase the range of pasting viscosities using the RVA. Accordingly, bean samples were ground to two particle sizes, fine (= 0.5 mm) and coarse (= 1 mm), for studying the effects of hydration, and starch content was increased in the bean powder samples by blending bean powder with corn starch (70:30) to increase the pasting viscosity range. The blended bean powder samples were characterized by the RVA. It was evident that particle size affected pasting properties among the studied cultivars, e.g., final viscosity values ranged from 1730 to 3100 cP and from 1160 to 2160 cP for fine and coarse blended powders, respectively. A wide range of pasting properties was observed among the cultivars but with little variation between years for the same cultivar. Thus, genotype appears to have a greater effect than environment on the studied pasting properties. Furthermore, different retrogradation behaviors (setback values from the pasting curves) were observed among the studied cultivars, and hence the dry bean powders present potential opportunities for a wide array of food applications.

207-O

Genetic markers of wheat associated with flavor preference using a mouse model

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Whole wheat products provide critical nutrients for human health, though differences in wheat flavor are not well understood. Using the house mouse as a model system, flavor was examined using a two-choice feeding system and the Student's *t* statistic. To eliminate the confounding effect of processing, whole grain was used. The Student's *t* statistic used previously identified "Yummy" and "yucky" check varieties. The study took the Student's *t* statistic beyond a theoretical measure of flavor preference to use as a phenotype in genetic mapping study. The Clark's Cream x NY6432 RIL population was created in the early 1990s and has been mapped extensively. Both varieties are white wheats; Clark's Cream has a hard kernel texture and NY6432 has a soft kernel texture. The "Yummy" and "yucky" check varieties were soft white and hard white wheats, respectively. A new genetic linkage map was created for this population. Marker-trait association was performed using the Student's *t* phenotype from each check. Twenty-two significant associations were found among the two check comparisons. Because mice prefer soft kernel texture over hard, the effect of both the puroindoline haplotype and the phenotypic expression of kernel texture were used as covariates in further marker-trait association analyses. Twenty-eight markers exhibited significant associations with the Student's *t* in the two covariate analyses, with an additional five having significant associations in both the puroindoline covariate and kernel texture covariate. These five markers show that there is a definitive genetic basis for flavor preference beyond kernel texture. These markers open the door for closer examination of specific genetic regions where the "Yummy" and "yucky" genes are likely to reside. Identifying the flavor genes will allow the development of varieties with more palatability for whole-wheat products.

301-O

Laboratory Data (Mis)-Management

W. MOORE (1), (1) Wayne Moore Consulting

Almost all laboratories collect and report numbers/data but few really look at those data and fewer still conduct statistical analyses. Through a series of charts, graphs and pictures, I will show/demonstrate some interesting examples of data presentation.

302-O

Rheological properties of gums and starch nanoparticle blends as influenced by source, concentration and temperature

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Gums and hydrocolloids are commonly used as texturizing agents in food applications. Currently, research on starch nanotechnology is gaining momentum within the starch industry. Therefore, understanding the fundamental rheological behaviors of starch nanoparticles (SNPs) and their blends with commercial gums is of significant industrial importance. In this study we investigated how the SNP source, molecular structure, morphology and concentration influence the rheological properties of common food gums such as barley beta-glucan (BG), carrageenan (CAR) and xanthan (XAN). SNPs from waxy and high amylose maize starches were isolated by acid hydrolysis and binary blends consisting of 0.5% (w/v) gum and different concentrations of SNP were prepared. Static and dynamic rheological properties were determined using continuous shear tests, frequency and temperature sweep modes. All blends demonstrated pseudoplastic behavior at shear rates between 0.1-100 s-1. The effect of SNP concentration on viscosity and thixotropy varied with gum type, and was more pronounced in BG and CAR than XAN. The viscoelastic behavior was comparable for BG-SNP and CAR-SNP blends. At room temperature they behaved like a viscoelastic liquid which transitioned to an elastic gel with increasing temperatures. The addition of SNP resulted in a crossover ($G' = G''$) at lower temperatures in BG and CAR, while the effect on XAN was not significant. SNPs are insoluble in water, however during heating they undergo swelling and solubilization due to disruption of intermolecular bonds. The thermal stability of SNPs differs with source and positively correlates to the amylose content of the native starches. The SNP morphology, surface charge, thermal stability and intermolecular interactions with the gum play an important role in the network formation and thus the rheological properties of gum-SNP blends.

304-O

Investigation of Fiber components and sources for physicochemical, rheological and thermomechanical properties

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The inclusion of dietary fibers into food matrix has been widely reported due to its potential health benefits. Extrusion processing continually increasing attention as it has huge potential to deliver fiber enriched products such as breakfast cereals and expanded snacks. Previous researches were mainly focused on the optimization of the extrusion conditions and formulation to improve product texture and overall acceptability, whereas the relationship between the molecular structure and extrudate characteristics has yet been established. Blends of insoluble (Cellulose and lignin), soluble (Pectin) and natural fiber sources (Tomato pomace and sugar beet pulp) were prepared with replacement of corn flour and evaluated for physicochemical, dynamic rheological, pasting (RVA) and thermal properties (PTA). Pectin and sugar beet pulp showed highest water holding capacity of 6.37 g/g and 6.53 g/g respectively. Highest hydration capacity was observed with sugar beet (0.022 ml/g), lowest with corn flour. Highest oil holding was observed for cellulose (2.22 g/g) whereas lowest for pectin (0.84 g/g). From RVA, highest peak viscosity, breakdown and setback values of 5160, 747 and 7973.5 cP respectively were observed for 1% cellulose whereas lowest values of 2150, 121 and 3770.5 cP were observed with 2% pectin. Amplitude dependent behavior of pectin and amplitude-independent nature of insoluble fibers and control was revealed. *G'* was found decreased with fiber addition. Higher *Tf* values were observed for all fibers as compared to control corn flour (147.7°C) at 14% moisture conditions whereas no clear trend observed at higher moisture conditions. Soluble dietary fiber will be of better choice for snacks due to lower oil holding capacity, peak viscosity, breakdown, final viscosity and amplitude dependence nature of elastic modulus (*G'*) which will result in better expansion.

305-O

Hydrocolloids effect on rheological and baking properties of proso millet composite dough

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The evidence that gluten sensitivity is one of the increasing food intolerances is driving an increasing demand for gluten-free foods. However, gluten is a structure building protein essential for optimum dough development. Therefore, obtaining high-quality gluten-free bread (GFB) is a technological challenge. Millet grain has the potential to serve as an alternative to wheat based products due to its comparable nutritional composition except gluten. Addition of hydrocolloids can enhance the visco-elastic properties of millet dough and help build dough structure like gluten. In this study, we were interested in determining the rheological properties of millet-wheat composite dough with various proportions of millet flour (20, 40, 60, 80 and 100%), and its mixture with different hydrocolloids (Ticaloid GF 377 and Ticaloid GF 313 special blended gums from TIC gums for gluten

free doughs), and the quality attributes of bread made from them. Dough undergoes deformation during preparatory processes which was evaluated with the application of rheology. And the final baking parameters such as bread volume, texture, color will allow correlation between rheological and baking performance. Dough extensibility test showed promising effect of hydrocolloids in increasing the visco-elastic properties of dough with higher millet flour content. Sensory evaluation helped determine consumer acceptability of millet based bread. This study has helped us to better understand millet flour role in dough making and bread production, with potential use in non-gluten bread.

306-O

High speed Z-arm mixing improves agreement with mixograph results and discrimination of gluten strength of HRW wheats

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Z-arm and pin-mixers such as the farinograph and mixograph, respectively, are well established torque sensing technologies to evaluate dough mixing requirements, and when conventionally used, impart relatively low and high mixing intensity to dough development. In this study we evaluated a new version of a micro-Z-arm mixer capable of high-intensity mixing and integration of torque data as a function of time, i.e. work input to peak development (WIP), thus facilitating more direct comparison to mixograph results. Objectives were to evaluate effects of increasing Z-arm mixing speed on correlations between key parameters generated by the two mixers, and their prediction by protein fractions underlying gluten strength. Flours milled from a diverse set of 52 HRW genotypes, were analyzed at constant absorption using a 2-g mixograph at 88 rpm and a 4-g micro Z-arm mixer at 63, 100 and 140 rpm. Increasing speed of Z-arm significantly reduced analysis time, and improved relationships between Z-arm mixing (Z) and mixograph (M) parameters. Correlations between Z-dough development time (Z-DDT) and mixograph DDT were R=0.78, 0.81, and 0.85 at 63, 100 and 140 rpm, respectively. Similarly, correlations between Z-WIP and M-WIP were R=0.72, 0.80, and 0.87 at 63, 100 and 140 rpm, respectively. In contrast, Z-stability values at 63 and 100 rpm were poorly correlated to mixograph measures of gluten strength, but correlations improved considerably at 140 rpm for M-DDT (R=0.80) and M-WIP (R=0.74). The relationship between content of HMW glutenin and WIP were very similar for Z-WIP at 100 rpm (R=0.81) and M-WIP (R=0.80). The results indicated that high speed Z-arm mixing and mixograph results were equally effective in discriminating dough strength in a population of bread wheats and were comparably related to the key biochemical component of wheat flour underlying gluten strength.

307-O

Intermediate Wheatgrass (*Thinopyrum intermedium*) – a 360° evaluation

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Intermediate Wheatgrass (*Thinopyrum intermedium*), IWG, is a perennial grain currently being investigated for food uses. The benefits of perennial cultivation are manifold, including reduced nitrogen leaching and increased carbon sequestration. From a sustainability point of view, IWG seems like a perfect candidate for human food production, but for the food scientist, it does present certain challenges due to its composition. It does contain gliadins, and is thus not marketable as gluten-free, but it does not have the same profile or content of high-molecular weight glutenins and thus dough forming properties are poor compared to wheat. In addition, due to lower endosperm contents, the grain is lower in starch but higher in dietary fiber than more commonly cultivated grains. In recent years, researchers have investigated IWGs ability to form dough, its protein structures and interactions, as well as the effect of grain refinement on IWG dough rheology and bread-making performance. Starch gelatinization and retrogradation properties have also been investigated. Moreover, we are conducting storage studies evaluating rancidity due to autoxidation and enzymatic action, and phytochemical status. This presentation will provide an overview of the latest findings on IWG focusing on protein and starch features and their impact on final product quality. Improving the knowledge on IWG, its shelf life and its macromolecules will better define its application potential in human nutrition.

308-O

Starch-Gum Interactions in Gluten-free Sorghum Bread

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Sorghum is unique in terms of its resistance to drought, heat and insects and is grown and consumed around the globe. Moreover, sorghum does not contain gluten and has potential in the gluten-free market. A blend of non-wheat flour, starch and gum typically provide the structure of gluten-free products. Most research on sorghum bread uses a yeast leavened process, HPMC gum and corn, potato, rice or tapioca starch. Little is known about

the functionality or interactions of different starches and gums in sorghum batter. The objective of this study was to examine the starch-gum interaction in chemically leavened gluten free sorghum bread. Potato, rice and tapioca starches and HPMC, xanthan and locust bean gums were used. Bread was baked as pup loaves. Volume index was measured using AACCI Method 10-91.01 with a modified template, crumb grain was evaluated using the C-Cell Imaging System and texture was determined with the TA.XTPlus Texture Analyzer. The base formula was commercial sorghum flour, water, starch, gum, sugar, salt, shortening and double acting baking powder. Sorghum flour/starch ratios of 70:30, 80:20 and 90:10 were tested. Loaves containing all levels of rice starch had the same volume index (~165) as 100% sorghum flour (168) while all levels of tapioca starch and potato produced significantly smaller loaves (~150). The ratio of 90% sorghum flour and 10% starch was selected. The type and level of gum significantly impacted loaf volume, grain and texture. Starch-gum combinations which produced the best loaves were tapioca starch + 3% HPMC, rice starch + 3% xanthan and potato starch + 4% xanthan. Additional work is being conducted to evaluate the effect of the starch-gum combinations on sorghum batter viscosity profile using the RVA.

401-O

Role of extrusion in reducing anti-nutritional factors in cereal and legume based fortified blended foods

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The phytate, tannin and trypsin inhibitor content of raw and extruded cereal/legume binary blends, used to make the fortified blended foods by mixing with WPC, oil, sugar and vitamin/ mineral premix, were analyzed in this study. The raw sorghum/ cowpea binary blends (SCB) had phytate content ranging from 804.22–1138.50 mg/ 100 g, and the extruded SCB had phytate content ranging from 560–830 mg/100 g. The raw sorghum/soy (SSB) and corn/soy blends (CSB) had mean phytic acid content of 752.80 mg/100 g and 567.54 mg/100 g, respectively. The extruded sorghum/soy (SSB) and corn/soy blends (CSB) had mean phytic acid content of 556.60 mg/100 g and 317.64 mg/100 g, respectively. Extrusion helped in reducing phytic acid content by 16.92–29.26%, 26.06%, and 44.03% in SCBs, SSB, and CSB respectively. The control CSB+ had a mean phytic acid content of 1885 mg/ 100 g. Amongst the treatments, the SCBs showed highest phytate followed by SSB and CSB respectively. The CSB+ being just a physical blend of heat treated corn and soy showed highest level of phytic acid concentration. The mean tannin content in raw SCB ranged from 20.05–59.50 mg/100 g. The mean tannin content in extruded sorghum/cowpea binary blends ranged from 15.83–44.37 mg/100 g. The raw SSB and CSB blends had mean tannin content of 65.98 mg/100 g and 48.32 mg/100 g whereas the extruded SSB and CSB blends had mean tannin content of 53.64 mg/100 g and 36.73 mg/100 g, respectively causing a reduction of 20.09–26.67%, 18.69%, and 23.98% in SCB, SSB and CSB. The control CSB+ had a mean tannin content of 150.41 mg/100 g. Similarly, there was a reduction of 16.55–23.31%, 19.50%, and 28.26% inn trypsin inhibitors in SCBs, SSB and CSB respectively. Thus, it was found that extrusion was an effective processing method to improve the nutritional quality of fortified blended foods.

402-O

Impacts of extrusion with gum arabic and xanthan gum on physical properties and starch digestibility of dry bean powders

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Extrusion is a method that has been widely used to modify the functional properties of food ingredients. The objective of this study was to investigate the impacts of extrusion with gum arabic and xanthan gum on the physical properties and starch digestibility of bean powders of two varieties: Merlot Small Red and Fuji Otebo. The beans were ground to pass through a screen with an opening of 0.5 mm and properly blended with 1%, 3%, or 5% (db) gum arabic or xanthan gum. The bean powders and the blends were extruded (APV Baker MP 19T-25 twin-screw extruder) under the same conditions. The obtained extrudates were dried at 50°C overnight and then ground to pass through the same screen. The addition of the food gums increased the die pressure and specific mechanical energy during extrusion, and the increasing effect, dependent upon the gum concentration, was more obvious with xanthan gum. The extrusion, with and without the food gums, caused complete starch gelatinization and protein denaturation of the bean powders. Compared with the respective control bean powders before and after the extrusion, the presence of gum arabic decreased the viscosities of the bean powders, whereas xanthan gum increased the viscosities. The different effects could be attributed to the substantially higher viscosity of xanthan gum than gum arabic. The addition of food gums enhanced the water-holding capacity of the extruded bean powders of both varieties, and the increasing effect was slightly greater with xanthan gum at the same level of addition. The addition of gum arabic and xanthan gum did not show a remarkable effect on the starch digestibility of the bean powders before and after the extrusion. Extrusion with food gums can effectively alter different functional properties of bean powders but not their starch digestibility.

403-O

Multi-scale starch dissembling masks the effect of a highly branched structure on the digestion rate of extruded flour

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Extrusion is a widely used technique for cereal processing which combined with enzymatic action could offer extended possibilities for obtaining clean label modified flours. In this study, native and extruded maize flours were subjected to a branching enzyme (B) and a synergetic branching enzyme and maltogenic a-amylase (BMA) treatments in order to modulate their hydrolysis properties. The microstructure, pasting properties, *in vitro* starch hydrolysis and resistant starch content of flours were assessed. Starch granules were loosed from native flour particles during B and BMA treatments. However, only extruded flours displayed a much higher reactivity towards enzymes as seen by the increase of the roughness and the cavities in the surface of the particles. A reduction in the setback was observed for B and BMA native flours, in opposition to the flat pasting profile of their extruded counterparts. Regarding starch hydrolysis, extruded samples presented higher hydrolysis rates at the early stage than their native counterparts. The glucose release increased gradually for native flours with the time of reaction, whereas for extruded flours a fast glucose release was observed during the first minutes of reaction. However, the susceptibility of native and extruded flour to the pancreatic a-amylase hydrolysis did not change with any of the enzyme treatments, as the final asymptote and the digestion rate constant indicated. After 16 hours of hydrolysis, resistant starch content was lower for treated extruded samples. Results suggested that the negative effect of rapid starch digestion induced by extrusion could not be overcome by increasing the branching points and the proportion of short chains in treated extruded samples. This study shows that changes produced at larger hierarchical levels in the starch structure could mask changes produced in the primary starch structure.

404-O

Extruded corn soy binary blend: physicochemical and molecular characterization

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In order to better control the quality of extruded products and to further bridge the gap between extrusion conditions and physicochemical properties of fortified blended food (FBF) from the molecular level, corn soy binary blends (CSB) were produced using single and twin screw extruder (pilot scale) under various extrusion conditions (screw speed, in barrel moisture and feeding rate, specific mechanical energy SME). The physicochemical properties of CSB binary blends including pasting properties, water absorption index (WAI) and water soluble index (WSI), Bostwick flow (BF), and degree of starch gelatinization (DG) were investigated. Results indicated that over 93% of the starch was gelatinized for all the extruded CSB samples. Samples with higher SME showed higher WSI. This was due to the breakdown of the macromolecule which has been confirmed by HPSEC. The WAI showed an increasing trend at initial stage due to the breakdown of starch granule while decreasing when WSI reached a specific value because of the cleavage of both amylose and amylopectin molecule with the increase of SME. BF, which measures consistency and flow rate of FBF porridge, is affected mainly by gelling properties of polymer (mainly starch) in CSB instead of viscosity. Compared to the non-extruded raw material, BF of extruded CSB was significantly increased ($p<0.05$). Moreover, extruded Sorghum-cowpea (SCB as the positive control) binary blend showed much higher BF when compared to CSB, which was caused by the lower starch molecular weight. All in all, this research developed relationships between molecules and physicochemical properties and extrusion conditions of CSB, which provided theoretical support for the quality control and value added application of extruded FBF.

405-O

Physical and chemical changes experienced by waxy wheat flour inside a twin screw extruder

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Flour can undergo a variety of changes as it is subjected to the extreme pressure, shear, and heat within an extruder. The chemical changes that occur can lead to a vast difference in product quality, texture, and taste. While a majority of research has explored final product chemical qualities and starting material qualities, it is also important to understand the changes occurring within the extruder as the process variables change. In order to understand these changes, waxy wheat flour was extruded in a co-rotating twin screw extruder and brought to a dead stop under different extrusion conditions. By quickly opening the extruder, samples of starch were retrieved from the feed, transition, and cooking zones of the barrel. Through degree of gelatinization, viscometry, and HPLC results, it was shown that the starch components gelatinized and degraded quickly through the transition

zone and slowly through the cooking zone. Additionally, temperature and screw configuration played a significant role in altering the amount of degradation and gelatinization. Results were also correlated to water solubility and expansion measurements so that the amount of starch degradation could be linked to end product quality. By understanding the chemical changes occurring within the extruder and linking them to the end product quality, the process can be manipulated more accurately to achieve desired food products.

406-O

Sorghum-based extruded and pre-cooked bean analog – A solution for food security in Sub-Saharan Africa

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Despite the great strides in global hunger made in the last several years, Sub-Saharan Africa is still stricken with food insecurity and inadequate nutrition. Legumes, including beans, continue to be a major protein source and calorie contributor in the diet of this region. Beans require immense amounts of resources like fuel and water to cook. The purpose of this study is to create a micronutrient fortified and pre-cooked bean analog product, which requires lesser energy while delivering more nutrients than traditional navy beans. The bean analog is an extrusion cooked and shaped product comprising of sorghum, wheat and soybean flours, in addition to vitamin and mineral premixes and a few other process and product enhancers in minor amounts. The size and shape of the product was optimized for best cooking quality while minimizing drying costs during processing. Textural properties were measured using texture profile analysis and cooking quality attributes such as water absorption and solids loss (13-24%) were characterized and compared with navy beans. It was found that soak time of 1 hour and cooking time of 20 minutes led to a product with comparable texture to navy beans. Consumer study results indicated the bean analog would be acceptable product with potential applications commercially as well as in food aid programs.

501-O

QSorter: A fast and repeatable method for quality inspection and grading of rice

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Rice value in the marketplace is defined by quality grading standards. In addition to defining a classification system, the standards provide an assessment of soundness and quality factors, such as moisture content, infestation, and damage, including heat-damaged kernels, red rice, and chalky kernels. Rice grading according to the standards' guidelines is often implemented by visual inspection of rice samples, which brings subjective bias to the determination of the corresponding quality grade. Visual inspection of the rice samples is based on comparison with standard rice samples or images, however natural variability is extremely large. Often subtle changes in color, texture, or shape cannot be detected by inspectors and are challenging even for instrumentation using machine vision techniques. QualySense has developed a proprietary high-speed single kernel analyzer, the QSorter Explorer and investigated the possibility of developing an advanced Machine Vision system comprising adaptable illumination combined with an optical subsystem allowing the simultaneous imaging of multiple kernel projections. Color images were acquired, preprocessed and classified with various algorithms. As a result, a method for the reliable detection of chalky kernels has been developed enabling the QSorter Explorer to reach classification accuracies higher than 95% and very low repeatability errors. The method is being developed in collaboration with rice-grading inspection agencies and aims to provide a reliable and fast alternative to current quality inspection and grading methods.

502-O

Experimental simulation of cross-flow rice drying: moisture content and milling yield profiles

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After harvest, rough rice is generally dried to ~12% MC (wb) for safe storage. Drying is often conducted in cross-flow (CF) dryers using heated air. The objectives for this study were to experimentally simulate a CF drying column so as to measure MC and milling yield profiles throughout the column, as well as to quantify the impact of air-flow rate (Q) on these profiles. These data are intended to also serve to validate a mathematical model describing CF dryer operation. Drying runs were conducted using air at 60°C/12% RH, three Qs (0.36, 0.46, and 0.56 (m3/s)/m2) for three drying durations (Ds) (30, 60, and 90 min). The 39-cm tall bed of rice comprised an assembly of ten, fiber-mesh, hand-woven cylindrical baskets that were placed inside a Plexiglas® column to facilitate sampling at various distances from the hot-air plenum (HAP). After a drying run, the baskets were taken out from the column, each basket was placed into individual sealed bags and then the bags were tempered at 60°C for 4 h. After tempering, MC of rice in each basket was measured. Then, all samples were conditioned to ~12% MC, milled and separated, to determine milled rice yield (MRY) and head rice yield (HRY). Moisture

content and milling yield profiles throughout the drying column were reported. Across all Qs and Ds, both MC and HRY increased with increasing distance from the HAP. Increasing either Q or D resulted in reduced final MCs and HRYs, with D having a greater impact than Q. HRY reduction (HRYR) was more prominent in baskets closer to the HAP, especially at greater Qs and Ds. There were negligible HRYRs in the upper layers of the column. These profiles confirmed that rice near the HAP may often become over-dried and consequently, incur severe HRYRs, which ultimately may lower the economic value of the rice lot. These findings could be used to optimize the rice CF drying process.

503-O

Digestibility and physicochemical properties of rice being parboiled combined with heat moisture treatment

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Rice is a staple for Taiwanese as well as for Asian people. However, the consumption of white rice keeps declining recently in Taiwan due to high glycemic index. Brown rice is considered as one kind of whole grain, but is not favored by the market due to rough texture. Thus, there is a need for rice to develop a process for decreasing glycemic index, but maintaining good texture. Parboiling at 120°C combined with heat-moisture treatment was selected to explore the feasibility of reducing glycemic index by physical treatment. Sensory and texture profile analysis were employed to examine the texture of products. Scanning electron microscope was used to observe the morphology of rice after treatments. *In vitro* digestibility was utilized to understand the change in slow digestible starch and resistant starch of products. Some properties of the corresponding rice flours were measured by using differential scanning calorimeter, X-ray diffraction, and rheometers. The data showed that parboiling significantly increase the percentage of resistant starch from 1.95 (untreated rice) to 11% with slightly increase in slightly digestible starch. The heat-moisture treatment along with parboiling resulted in an increase in slow digestible starch from 37.08 (untreated rice) to 45.83%. The color of products is brown, but with a texture similar to white rice. The combination of parboiling and heat-moisture treatment appeared to be a potential method for making rice favorable by the market.

504-O

Effects of cooled storage conditions on milling yields and color properties of parboiled rice

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Two long-grain hybrid rice cultivars, XP 760 and CL XL745, both harvested in Arkansas in the fall of 2015, were stored as rough rice at moisture contents (MCs) of 21%, 19%, and 12.5% (wet basis) at temperatures of 10°C, 15°C , and 20°C (12.5% MC rice only stored at 20°C) for a total of 16 weeks. Samples were assessed at approximate 4, 8, 12, and 16-week storage durations, then parboiled using a pilot-scale parboiling unit. Rice was soaked for three hours at 67°C and steamed at 115°C for ten minutes. Soaking and steaming conditions were based on the onset gelatinization temperature of the cultivars, determined via differential scanning calorimetry (DSC). After drying, dehulling, and milling to a surface lipid content of approximately 0.4%, head rice was separated from broken kernels and assessed for color via colorimetry (L* a* b* scale) and imaging analysis. Milled rice yields and head rice yields for all storage temperature and MC treatment combinations were measured at each of the selected storage durations. Using a scanned image of approximately 100 kernels on a blue background, imaging software performed a pixel-by-pixel assessment of kernel area with color values established by a set of kernels of interest for the study—specifically representing burnt, red, chalky, and ideal parboiled rice color. Color analysis and imaging analyses showed minimal change in kernel color or degree of discoloration over storage duration. Milled and head rice yields showed little change over the storage period. This indicates that grain cooling may be a viable option for storing high-MC rough rice for durations up to 16 weeks without loss of parboiled rice color quality and yield. Utilization of these systems may reduce pressure on commercial dryers and eliminate pre-parboil drying for process efficiency.

505-O

Characterization of temperature and quality profiles of rice dried using microwaves for multiple bed thicknesses

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The volumetric heating phenomenon accorded by microwaves (MW) drying of rough rice may reduce inter-kernel temperature and moisture content (MC) gradients, thereby minimizing fissuring and reduction of the rice milling quality. The objective for this research was to determine the impacts of MW energy intensity and heating duration on temperature, MC and quality profiles for rough rice dried at different bed thicknesses. Medium-grain rough rice (cv. Jupiter) at initial MC of 23% (w.b.) was dried using a 915 MHz industrial microwave set to transmit energy at power levels 5, 10, and 15 kW for 4, 6, and 8 minutes and for rice bed thicknesses 5, 10 and 15 cm.

Rough rice temperature profiles, percentage points (%pts) MC reduction, pasting parameters, milling quality, microbial load, and sensory characteristics were investigated. Treatments at rice bed thicknesses >5 cm took longer to achieve surface temperatures (100°C to 112°C) necessary for adequate %pts of MC reduction in a single pass (i.e. to MC<13%); the %pts MC reduction increased with increasing specific energy. Rice beds that obtained = 600 kJ/kg-grain had MC=13.0% (w.b.), and the resulting head rice yield (HRY) was not significantly ($p>0.05$) different from control samples. Heating with energy input exceeding 750 kJ/kg-grain resulted in HRYs drastically lower than that of control samples. Microbial load on rough rice at 23% MC when dried to 14% MC were significantly ($p<0.05$) reduced compared to control samples. No impact was noted on dried product sensory attributes.

506-O

One-pass drying of rough rice with 915 mHz industrial microwave vs. degree of milling and milled rice quality

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Industrial milling practice for rough rice targets a degree of milling that results to milled rice surface lipid content (SLC) of 0.4% for optimal head rice yield (HRY) recovery and better storability. Equipment settings to achieve the said SLC is based on characteristics of rice dried using convective heated air or natural air drying operations which are typically performed in multiple passes of air. Volumetric heating which is associated with microwave (MW) drying could prevent intra-kernel moisture content and temperature gradients, which is likely to impact mechanical properties of the rice and may have an impact on the rice milling behavior. This study is the first to investigate, one-pass drying of rough rice with 915 mHz industrial MW and to report on implications of the process versus rice milling degree and milled rice quality characteristics. Medium grain rough rice (24% MC) at bed thicknesses of 0.01 and 0.05 m was dried in a one-pass, continuous drying operation for 8 minutes using pilot scale MW set at specific energy of 450, 600 and 750 kJ/kg. Samples from each treatment were milled for durations of 0, 15, 30, 45 and 60 s. The result shows that, as milling duration increased, surface lipid content (SLC) reduced by an average of 80%. Sample dried at 0.01 m bed thickness generally reached a SLC >0.32% in shorter milling durations (30 s) compared to at 0.05 m bed thickness which averaged 0.65% SLC in the same duration. Marginal reduction in protein content was observed with increase in milling duration ($p<0.05$). As the milling duration increased from 0 to 60 s, HRY and MRY reduced ($p<0.05$). The highest value of 77% HRY was obtained at 450 kJ/kg and 0.01 m bed thickness while the lowest value of 13% HRY was obtained at 750 kJ/kg and 0.05 m bed thickness. In general, HRY and MRY obtained after 30 s of milling were <60% and <70%, respectively.

601-O

A database of dietary fiber intervention studies: foundations for future research

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Dietary fiber is recognized as playing an important role in human health, and research in the field is moving at a fast pace. However, dietary fiber research is complex, and the literature embodies a large number of studies detailing a diverse range of fiber types. Using a systematic literature search and applying pre-defined inclusion/exclusion criteria, we created a database of human intervention studies linking dietary fiber to physiological health outcomes. The final database details 869 unique studies, capturing interventions on over 130 unique fiber types published in English from 1946 to May 2015. To demonstrate a first-hand application of this database, we used it to construct an evidence map on the literature relating dietary fiber to health outcomes on the human gut microbiome. We identified 158 publications in the database examining gut microbiome outcomes, and outcomes were grouped into four broad categories: fermentation (10% of publications with microbiome outcomes), fecal pH (19%), short-chain fatty acid production (31%), and bacterial composition (31%). Oligosaccharides (15%), resistant starch (15%), and cereal fiber (14%) were the most frequently examined fiber types. The majority of studies were crossover designs (65%) in adult populations (99%) with healthy baseline status (82%). Our work on this topic showed that well-controlled human interventions are needed to support associations being observed in animal studies linking fiber-induced changes in the microbiome to health benefits. This database is a valuable resource, allowing researchers to rapidly search the literature and identify research gaps. It may also be a useful starting point for systematic reviews and serve as a resource for food manufacturers, agencies defining fiber for food labeling, and researchers interested in evaluating the health benefits of different fiber sources.

602-O

Effect of consuming oat bran mixed in water before a meal on glycemic responses in healthy humans

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Viscous dietary fibers including oat β-glucan are one of the most effective classes of functional food ingredients for reducing postprandial blood glucose. The mechanism of action is thought to be via an increase in viscosity of the stomach contents that delays gastric emptying and reduces mixing of food with digestive enzymes, which, in turn, retards glucose absorption. Previous studies suggest that taking viscous fibers separate from a meal may not be effective in reducing postprandial glycemia. In this pilot investigation we aimed to re-assess the effect of consuming a preload of a commercially available oat-bran containing 22% of high molecular weight oat β-glucan mixed in water before a test-meal of white bread on glycemic responses in healthy humans. We found that there was a dose-dependent effect of oat-bran on glycemic response with each gram of oat β-glucan reducing glucose AUC by 4.4±2.0% ($p=0.0008$) and peak rise by 6.6±1.5% ($p<0.0001$). These data suggest the use of oat bran as nutritional preload strategy in the management of postprandial glycemia.

603-O

Sorghum and quinoa: health benefits and implications for future research

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Recent consumer trends have centred on gluten-free foods. This has provided commercial impetus to develop foods from gluten-free commodities with unique and/or novel properties. Examples include sorghum and quinoa, which despite being gluten-free, have had markedly different uptake within the food supply. The objective of this analysis was to explore and assess the evidence for health benefits associated with the consumption of sorghum and quinoa. Systematic reviews of health outcomes associated with the consumption of these commodities were performed. Studies investigating sorghum consumption in human cohorts were critically appraised using the Health Canada Quality Rating Tool. In contrast, the paucity of studies investigating quinoa consumption among humans culminated in a systematic review of animal studies investigating quinoa consumption to be performed. Quality appraisal was guided through the use of a previously validated quality-rating tool. The consumption of sorghum appeared to attenuate blood glucose responses and reduce the expression of markers of oxidative stress, which has implications for chronic disease management. Animals consuming quinoa appeared to experience decreased weight gain and an improvement in their lipid profile. It is however difficult to extrapolate these results beyond these animal studies into human cohorts. The broad implications are that these commodities may have properties superior to other staple grains. Future research should extend the current findings and explore the impact of processing on the maintenance of these health outcomes. In addition, more rigorously designed human studies are necessary to obtain a robust understanding of the health benefits. This could then be used to support the development of novel products from sorghum, which is currently underutilised, and quinoa, which continues to experience consumer demand.

604-O

Determination of protein quality assessed by both *in vivo* and *in vitro* methodology in soy and cereals

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The assessment of protein quality using an *in vitro* methodology may be a suitable replacement for *in vivo* models to generate digestibility in pulses and cereals. In this study, two varieties of soy, wheat and oat flour, that remained untreated or cooked, were investigated using a rat bioassay. Sprague Dawley rats (n=130, ~70g) were randomized to one of twelve diets corresponding to either variety of Etna/Amadeus soy (ES/AS), Carberry/Snowbird wheat (CW/SW), Turcotte/Navaro oat (TO/NO) flour, as well being untreated or cooked, with casein as a control. Protein quality *in vivo* was assessed using the protein efficiency ratio (PER), true protein digestibility (TPD) and protein digestibility corrected amino acid score (PDCAAS). A pH drop method was used to calculate *in vitro* protein digestibility (IVPD) and *in vitro* protein digestibility corrected amino acid score (IVPDCAAS). The PER of cooked ES (2.12), AS (2.06), CW (1.11) and SW (1.22) increased over their untreated equivalent, whereas the PER of untreated TO (2.03) and NO (2.23) increased over their cooked equivalent. The PDCAAS of AS was lower (56.9) than ES (75.0), due to a greater methionine and cysteine content (17.5, 21.9 mg/g protein; respectively) in the ES. Overall, ES, CW, SW, TO and NO had increased PDCAAS values when cooked over untreated. Analysis of correlation revealed an association between TPD and IVPD ($R2= 0.7013$; $p<0.0001$), while a significant correlation was found between PDCAAS and IVPDCAAS ($R2=0.9697$; $p<0.0001$). The strong correlation between *in vivo* and *in vitro* methodology suggests that it may be a sensitive, inexpensive and ethical replacement method for animal bioassays in evaluating protein quality.

605-O

Reduced protein digestibility of heated proso millet flour is prevented in the presence of urea

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Proso millet (*Panicum miliaceum*) contains about 12% protein with kaifirins being the major storage protein. Despite having numerous nutritional and agricultural advantages the crop has limited human consumption. In order to promote the edible uses of millet in US the protein digestibility was evaluated. De-hulled proso millet flour was subjected to wet heating (25-100°C) and oven heating (100°C) at various moisture contents (7%, 10%, 20% and 30%) and the pepsin digestibility was measured. It was found that heating the flour beyond 60°C with a moisture content above 10% resulted in reduction of digestibility from 80% to 35%. This trend was also apparent after sequential modelling of both gastric (pepsin) and intestinal (pancreatin) digestion. Further investigation ruled out the formation of intramolecular disulfide linkages and interactions of proteins with starch, lipids, and phenolics as the major causes for lower digestibility after heating. On the other hand, heating the flour with urea prevented the loss in digestibility, suggesting hydrophobic interactions among millet proteins on heating as the driver for lower digestibility. Exploring effect of non-thermal processing techniques and other chaotrops on digestibility of millets could help in understanding and possibly rectifying the observed problem.

606-O

Development of an industrial method for production of low phytic acid, high soluble fiber content whole wheat bread

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The objective of this study was to decrease the phytic acid content and increase the soluble dietary fiber content of whole wheat bread. For this purpose, wheat bran was fermented with fresh bakers' yeast and commercial endoxylanase enzyme prior to the laboratory-scale bread baking process. Fermented bran was used in the formulation of whole wheat bread production. The target values were to reach the 25% soluble fiber and to obtain 40% decrease in phytic acid content. After achieving the targeted reduction in phytic acid and increase in soluble fiber content in laboratory-scale baking trials, the method was used to design a new baking process for whole wheat and bran breads at large-scale. Two different fermentation procedures were applied. First, bran was fermented with fresh bakers' yeast and then with commercial endoxylanase enzyme. In the second procedure, enzymatic treatment was carried out before yeast fermentation. After the fermentation processes, bran together with fresh bakers' yeast was mixed to form developed dough and the dough was used in the industrial bread production process of the bakery. The decrease observed in phytic acid content of whole wheat bread was 85% and the increase in soluble fiber content was around 43%. The results indicated that, potential health problems can be minimized with the reduction of phytic acid content of whole wheat breads by the industrial method developed in the study. In addition, positive health effects of bran can be improved by producing whole wheat and bran bread with increased soluble fiber content.

621-O

Effect of deflavouring on the *in vitro* and *in vivo* protein quality of pea, lentil and faba bean protein concentrates

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Processing pulse flour can alter its protein quality through changes in amino acid composition, digestibility or both. In this study the effect of deflavouring on the protein quality of pea, lentil and faba bean concentrates was investigated in a rodent model. Rats (n=80, ~70g) were randomized to one of 8 diets: pea, lentil or faba bean concentrates or the corresponding deflavoured concentrate with casein and a commercial pea protein isolate acting as controls. The protein efficiency ratio (PER), protein digestibility corrected amino acid score (PDCAAS) and *in vitro* protein digestibility corrected amino acid score (IVPDCAAS) were calculated. The regular concentrates had PER values of 1.9 for pea, 1.1 for lentil and 1.2 for faba bean, whereas the PER values of deflavoured concentrates were 1.6 for pea, 1.1 for lentil and 0.9 for faba bean. The PDCAAS and IVPDCAAS values of faba bean concentrate were 61.2 and 52.2 respectively and 42.3 and 37.6 for the deflavoured faba bean concentrate. These measurements were relatively unchanged in pea and lentil concentrates/deflavoured concentrates (<7% difference). Correlational analysis was performed to determine the relationship between the *in vivo* and *in vitro* measurements of protein quality. Significant correlations were found between measurements of digestibility, ($R2=0.6080$, $p=0.0225$) and PDCAAS vs IVPDCAAS ($R2=0.9824$, $p<0.0001$). As a strong correlation was found between both digestibility and PDCAAS values generated from *in vitro* and *in vivo* methods, the use of *in vitro* digestibility analysis should be investigated as a potential replacement for the current rodent assay for nutrient content claim purposes.

622-O

The role of phytate in the antioxidant effect of cereal beta-glucans

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Cereal β-glucan is a water-soluble polysaccharide which is able to form highly viscous solutions even at low concentrations. Due to its health and technological functionalities it has been applied in various foods. Some polysaccharides are used to stabilize emulsions since they inhibit phase separation and oxidation. The proposed mechanisms include viscosity enhancement, metal binding ability and free radical scavenging. In this study, the lipid oxidation retardation and antioxidant effect of high and low molecular weight β-glucans from oat and barley were evaluated by measuring the production of lipid hydroperoxides and hexanal from lipid oxidation in an emulsion model containing β-glucans, iron binding capacity, and hydroxyl radical scavenging ability. The studied β-glucan samples showed various antioxidant activity and the difference was proved to be resulted from residual phytate content, a natural antioxidant, instead of molecular weight and origin of β-glucan. The β-glucan samples containing higher content of residual phytate showed higher antioxidant activity, and the antioxidant activity was significantly reduced when phytate was removed. Thus, the study indicated that the residual phytate played a major role in the antioxidant effect of cereal β-glucans, and the phytate content in plant polysaccharide extracts should be taken into consideration in the studies related to oxidation. In addition, the residual phytate may protect β-glucan from degradation and maintain its stability and functionality.

623-O

Dietary carotenoids of corn fractions do not seem to affect the development of atherosclerotic lesions in LDL-r-KO mice

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Carotenoid compounds are consistently shown to have potent antioxidant properties that play an essential role in preventing oxidative stress-induced diseases, like cardiovascular disease. Our previous study showed differential antioxidant potential of carotenoid extracts of hand-separated aleurone, germ and endosperm fractions of corn > wheat > barley in biochemical and *in vitro* models. In this study, protective effects of corn fractions (aleurone, endosperm and germ) against atherosclerosis and potential underlying mechanism in reducing oxidative stress were examined in low density lipoprotein receptor knockout (LDL-r-KO) mice. Four groups of male LDL-r-KO mice (n=32; 8 mice/group) were fed for 10 weeks with the experimental diets supplemented with (3 treated groups) or without (1 control group) 5% (w/w) of each of the hand-separated corn fractions. All diets were supplemented with 0.06% (w/w) dietary cholesterol. Blood samples, hearts, and livers were collected and used for biochemical and histological examination. Consumption of aleurone and germ fractions significantly reduced the size and severity of atherosclerotic lesions in the aortic roots (P=0.003) and improved the antioxidative status when compared to those in the control group. Incorporation of corn fractions boosted the total carotenoid contents (TCC (P=0.06), lutein (P=0.004) and zeaxanthin (P=0.002)) of the diets. However, the concentrations of TCC, lutein and zeaxanthin were comparable in the liver and plasma samples among all groups. Therefore, the antiatherogenic effects of germ and aleurone fractions might be due to synergistic effect of phytochemicals in these fractions. Additional studies are necessary to understand the exact mechanism of action.

624-O

Impact of dietary pattern of the fecal donor on *in vitro* fecal fermentation properties of whole grains and brans

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Fecal donor diet influences *in vitro* fermentation properties. The purpose of this study was to determine how diet influences *in vitro* fermentation properties of whole grains and brans. Whole grain flour and bran from corn, oats, rye, and wheat were subjected to *in vitro* digestion followed by fecal fermentation. Fecal inocula were from subjects with recommended dietary fiber intakes (RecDF: 31±5 g/d) or normal dietary fiber intakes (NormDF: 11±3 g/d; n=4/group). Short/branched chain fatty acids (S/BCFA), ammonia, and total carbohydrate were analyzed during fermentation. Samples inoculated with the fecal microbiota from the RecDF group showed higher fermentability of carbohydrates and higher production of butyrate, accompanied by reduced acetate, propionate, and BCFA compared to those from the NormDF group (68% vs 62%; 3.47 mM vs 2.40 mM; 10.4 vs 25.4 mM; 2.31 mM vs 3.90 mM; 0.25 vs 0.47 mM, respectively). Fecal microbiota were better able to break down carbohydrates in the whole grain flours compared to brans (67% vs 62%) regardless of diet group. In the RecDF group, rye and wheat showed the highest carbohydrate fermentability (73% and 71% vs 64% and 65% for corn

and oats); rye resulted in the highest butyrate production (5.53 mM compared with 2.19-3.12 mM for the other grains); and rye and oats resulted in the lowest ammonia production (11.7 mM and 12.6 mM compared with 19.4 mM and 19.9 mM for corn and wheat). In contrast, the microbiota from the NormDF group did not differ in their response to the grains. Thus, dietary fiber intake of the fecal donor has a dramatic influence on the ability of the gut microbiota to ferment the dietary fibers in grains, differentiate among grains, and produce metabolites that are beneficial to human health.

625-O

The good side of sprouting

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Sprouting has been widely exploited to improve the nutritional and sensory profile of cereal-based foods. Controlled sprouting of grains might lead to the development of specific enzymatic pattern (amylases, proteases, cellulases) that may improve cereals micronutrients bioavailability, color, taste and flavor. Nonetheless, the use of partially sprouted wheat as alternative to conventional flour improvers (e.g. xylanase, malt) has not been thoroughly investigated up to now. Xylanase and malt were added to the control flour at 0.5% level, as conventionally used in bakeries, whereas sprouted wheat flour was used up to 2%. Adding xylanase, malt or sprouted wheat to control flour (P/L > 1) significantly decreased dough stiffness, though best performances were observed in the presence of 1.5% sprouted wheat. Unlikely the mixtures containing xylanase or malt, the sprouted wheat blend showed gluten aggregation strength similar to that of the control, suggesting no worsening of the protein network characteristics. As for the leavening properties, dough development was increased from 52.8 mm to 70.4 mm, thanks to the enrichment with sprouted flour. In addition, presence of sprouted wheat improved the amount of gas production during leavening, resulting in dough with increased volume. As for the pasting properties, in the presence of sprouted wheat lower setback values were observed, thus indicating a lower starch retrogradation tendency, as demonstrated by analyzing the crumb texture after three days of storage. In conclusion, addition of 1.5% sprouted wheat may represent a valid alternative to xylanase or malt for improving the rheological properties and bread making performance of stiff flours.

626-O

In Vivo Digestibility of Cross-Linked Phosphorylated (RS4) Wheat Starch in Ileostomy Subjects

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For the first time, the *in vivo* digestibility of cross-linked (RS4) wheat starch (CLPWS) was determined in ileostomy subjects to resolve which *in vitro* fiber value obtained from AOAC Method 991.43/985.29 or AOAC Method 2009.01 is nearest to the *in vivo* level. This study conducted at the Department of Gastroenterology, Monash University (Melbourne, Australia) was a randomized, double-blinded, cross-over study (with one week washout) involving 11 volunteers with a well-established ileostomy and with no evidence of Crohn's disease or intolerance to carbohydrates. Following an overnight fast, the test meal (breakfast) containing either CLPWS or native wheat starch (both uncooked) is administered with the subjects collecting ileostomy effluents every 2 hours for the following 24 hours. Significant differences in both wet weight (P-value = 0.004) and dry weight (P-value = 0.008) of the ileostomy effluent was observed following treatment. When assayed by AOAC Method 985.29, the total dietary fiber content of CLPWS and native wheat starch was 85.8% and 0.3%, respectively. With the subjects, the total dietary fiber of pooled effluents were significantly different (P-value = 2.22 x 10-5). Selected effluent samples from the subjects were also analyzed for RS4 content using the Shukri Method. The average digestibility/effective total dietary fiber content of CLPWS in the upper gastrointestinal tract will be reported. Light and scanning electron micrographs showed surface erosion of the intact granules of CLPWS indicating its resistance to digestive enzymes. This study confirms that AOAC 991.43 and AOAC 985.29 rather than AOAC Method 2009.01 yield dietary fiber values on CLPWS nearest to *in vivo* fiber level.

701-O

Departure from current processes: Novel structure design approaches for cereal-based foods

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For the development of novel structure design approaches for cereal based foods the distinct knowledge about the material's structure and its derived functionality is crucial. The knowledge about these structure-function relationships enables the creation of specific nutritional, physical, and sensorial properties. A direct link to develop enhanced relationships is food's microstructure due to the availability of noninvasive analyzing systems. Thus, methodologies to quantify individual dough protein, starch, and even arabinoxylan microstructures were

developed and models of structure-function relationships established. Based on these results direct formation of dough functionalities was acquired in wheat and rye dough systems. Furthermore, current processes were critically evaluated, in different intensities adjusted or recombined with processes from other food industries. A practical example is engineering based forced hydration and foaming of gluten free materials. For process control, novel analyzing systems were developed to enable a higher automation level, especially visual monitoring systems for mixing, proofing, as well as baking step. However, not just the development and control of new processes but also the networking and automation of the processes and analyzing systems enables standardized high-quality or even individualized food structures and textures. In a last step, reverse engineering can be applied: requested product qualities are defined (such as a specific crumb texture) and relevant production processes (such as 3D printing of textures) are evaluated. Opportunities and current limits of own research done in these fields are presented. In summary, knowledge-based evaluations of current and development of novel processes enable new ways for textural food properties in future.

702-O

Mechanical flour modification and its effect on saccharide formation and dough functionality

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For mechanical flour modification, wheat flour (ground by a roller mill) with a mechanical starch modification (MSM) of 4.78% was re-ground by a ball mill for four more MSM levels. Grinding was performed by varying the rotational speed and retention time until a significantly higher MSM level was reached. The MSM level was determined during grinding using the amperometrically method provided by Chopin (SDmatic; AACC 76-33). The water holding capacity (WHC) showed a linear rise as a function of MSM (R2=0.82). Furthermore, the water absorption of the samples was measured according to AACCI Method 54.21.02. The saccharide concentration, which influences yeast activity as well as gelatinization properties of starch, was analyzed in a flour-water-suspension as a function of fermentation time (0, 5, 10, 20, 60, 120, 180 min) by using a HPAEC-ED. Changes in the maltose content during fermentation were primarily responsible for an increasing saccharide concentration with rising MSM due to better hydrolysis by amylolytic enzymes. Maltose concentration increased with enhanced MSM levels and fermentation time. From suspension up to dough a reduction of water leads to a higher saccharide concentration after fermentation at the same MSM level. A comparison of the maltose concentration of yeasted and non-yeasted dough produced with varying water addition showed a lower maltose metabolization with higher dough hydration. However, varying MSM levels at a constant water addition resulted in nearly the same maltose metabolization of yeast after fermentation, despite higher substrate availability. In dough-model-systems changes in maltose concentration had an effect on the rheological dough properties measured during microbaking tests in a rheometer. In this regard, maltose content had an effect on gelatinization properties during baking.

703-O

Evaluation of the suitability of heat treated flour in high ratio cakes

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The typical sweet and moist characteristics of high ratio cake formulations are well appreciated in markets all over the world. For these kinds of products it is necessary to change the functionality of the flour by processes like the dry heat treatment. Currently, a cake needs to be baked to assess the success of the treatment and the suitability of flour in these applications. The problem with testing flour with analytical methods is that a whole range of treatment conditions (e.g. time and temperature) will result in the same level of response, but only few will deliver a satisfactory cake. In this work, a method is developed that allows evaluating heat treated flour for its suitability in high ratio cakes in a cost- and time-saving way. Two response surfaces are created with treatment time and temperature as parameters. The two responses are the peak viscosities in the Rapid Visco Analyser (RVA) of the treated flour i) in water and ii) in 50% sucrose solution. The contour lines of both surfaces are not parallel and an area that produces satisfactory cakes may be established. Both responses are tested for an unknown, heat treated flour sample and the point is found where the two contour lines cross. The experienced treatment time and temperature can be determined and the unique treatment condition may be correlated with cake quality (e.g. volume, structure). A graph is created where contour lines of rva peak viscosities in water and 50% sucrose solution cross in an operating window of 110°C – 150°C and 0 – 30 min. It shows the principle of how a concrete treatment condition can be assigned to an unknown flour sample and how that sample performs in a high ratio cake. This method may result in it no longer being needed to bake a cake for quality assessment of flour.

704-O

Effects of wheat cultivar, water, NaCl and mixing on the rheological properties of bread dough

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Predicting breadmaking performance and bread quality based on dough's rheological properties is a common practice in cereal science. The roles of ingredients (i.e., wheat flour, water and NaCl) and mixing time, separately, on dough rheological properties have previously been studied. But how dough rheological properties are affected by the interactions of ingredients and mixing (i.e., optimal, under- and over-mixing) has not been reported yet. The objective of this research was to investigate the interactive effects of wheat cultivar (totally 4), water concentration, NaCl concentration and mixing time on the rheological properties of doughs using mixograph, oscillatory frequency sweep and creep recovery tests. From mixograph analyses, dough rheological properties were better discriminated according to wheat cultivar at the low-moisture and high-NaCl (2.0-3.0% flour weight) conditions. For optimally mixed doughs, the effect of water on mixograph parameters such as Energy to Peak (ETP) was more significant at high-NaCl conditions, whereas the effects of water on the complex modulus (G*) and maximum creep compliance (Jmax) were more significant at low-NaCl (0-1.1%) conditions. In terms of changes in Mixing Development Time (MDT) and ETP, the doughs made from cultivar Pembina, Roblin and Harvest were more tolerant to NaCl reduction. Based on Jmax and relative elasticity (Jel), Roblin doughs prepared at optimal mixing and water addition were less responsive to NaCl changes. Considering the interaction of mixing and NaCl on dough rheological properties, G* and Jmax were more significantly affected by NaCl for under-mixed doughs. In conclusion, wheat cultivar, water, NaCl and mixing time exert interactive effects on the rheological properties of bread dough. For optimal breadmaking, ingredients and mixing time all need to be taken into account when preparing bread dough.

705-O

Starch gelatinisation and texture effects during vacuum cooling

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Vacuum cooling is a batch process whereby products containing free water are cooled by evaporation of moisture under vacuum. The aim of the project was to study if vacuum cooling could be used to shorten baking and cooling time of 800g sandwich loaves. The impact of a reduction in bake time and vacuum cooling process on bread texture, structure, volume, starch gelatinisation and enzyme activity was studied. Sandwich loaves were cooled using a vacuum cooler and compared with those cooled at ambient conditions. Weight loss of vacuum cooled products was significantly higher than ambient cooled products, depending on the vacuum cooling program. The crust was thicker and harder in the vacuum cooled products. Reduced baking time was used to compensate for these changes by reducing moisture loss from the loaves. A baking time reduction of 20% resulted in greater moisture retention but the crumb texture was significantly less resilient. The effects on starch gelatinisation and retrogradation were studied, together with amylase activity. Differential scanning calorimetry (DSC) analysis of bread crumb showed that when baking time was reduced by 44–56% vacuum cooled samples had higher levels of enthalpy of amylopectin compared to their respective ambient cooled counterparts. Enzymatic activity of the loaves was studied by making a slurry from dried bread samples and the slurry viscosity measured using the Rapid Visco Analyser (RVA). Vacuum cooled samples were significantly less viscous after 30 minutes suggesting they had higher enzyme activity compared to ambient cooled counterparts. These results show the importance of the residual heat in early stages of ambient cooling finishes the gelatinising process and inactivates the enzymes.

706-O

Optimization of expansion of cakes by investigating the baking acids role in the presence of a physically modified starch

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The softness is an important quality criteria for bakery products defined by the soft texture and/or the crumb structure and alveolation related to the expansion during baking. The last one may be controlled by CO2 production from baking powders. Baking powders are extensively used in cake recipes. However, their impact on the final quality of the pastry (volume, structure, taste…) is minimally documented in the scientific studies. This work is based on i) a state of the art on baking powder mixes and ii) a case of study on cake softness and structure using different baking acids, which are key players in a baking powder mix. In addition, the impact of pregelatinized starch on texture in link with cake expansion during baking was highlighted. Baking powder study is based on two experimental designs using three baking acids: SAPP10, 40 (double action) and MCPM (simple action). An instrumented oven equipped with video and lasers displacement transducers were used to monitor

the expansion/collapse of cake during baking. Pastry quality was evaluated from texture profile analysis (force at 40% deformation) and porosity measurements. Results showed that the addition of pregelatinized starch yielded in denser cakes; the denser structure resulted in a harder texture due to the lack of oven rise. The experimental designs showed that the best expansion by a mix of acids of 50% SAPP10 and 50% SAPP40 in the presence of 12.6% of modified starch. This led toward more aerated (porosity of 63%) and therefore softer product (hardness of 4-5 N) than the one without acids combination. In conclusion, the softness of cakes could be controlled by their expansion during baking by using leavening acids and modified starches. However, more investigations are needed for cooling phase to study the structure collapse with the presence of these acids.

707-O

The impact of processing on dough rheology and bread quality using an Asian bread recipe

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Perten doughLab and Warburton's stickiness test (WST) have been used to examine dough rheology effects during mixing and in post mixing processing respectively. Using a speed/temperature combination of 100 rpm and 30°C to represent current mixing practices in South East Asia (SEA), the impact of flour quality on dough rheology during processing was assessed with 5 commercially milled Australian flours, without an improver addition, with ascorbic acid alone and with a combination of ascorbic acid (AA) and fungal *alpha*-amylase (FAA). Differences between flours and their interactions with improvers were observed for doughLab mixing parameters, some of which were significant. The general pattern of rheological change during dough processing was for an increase in compression values after each moulding stage and no increase or a slight decrease by the end of the resting period (8 minutes). There were some small differences between flours with no added improver and these were less evident when ascorbic acid was used. When a mixture of ascorbic acid and fungal *alpha*-amylase, was used the differences were only evident after the second moulding stage. On the whole, WST parameters associated with stickiness were poorly correlated with doughLab parameters. It is speculated that the occurrence of break points on WST compression curve is related to a transition from an elastic to a plastic state. The overall changes in dough rheology in the absence of an improver typically comprises of an increase in compression area as the result of the first moulding step, almost no change during the resting time and a further increase after second moulding. Dough stickiness did not appear to change significantly as a direct result of dough processing steps.

801-O

Pulse ingredients and their effects on texture and sensory properties in formulating for meat analogues

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An understanding of meat analogues is crucial to the food industry as the world looks for sustainably sourced proteins and as a means to help feed our growing global population. Pulses, known as a good source of protein, due to its naturally high protein content have been investigated for their ability to be used in high moisture meat analogues. Changes to the formulation were found to greatly affect the texture of the product. The moisture content was found to significantly affect the texture and fiber formation in these meat analogues. Typically, the final moisture content of these meat analogues ranges from 58% to 65%. These formulations require a feed temperature of 90°C whereas the product is mixed at 130°C and cooked at a range of 145 to 170°C. Fiber formation occurs after the product is cooked and extruded through a barrel where the final product exits the die at a temperature of approximately 145°C. The effect of the type of pulse (lentil, pea and faba bean) fractionation, addition of pea fiber as well as deflavoring of pulse ingredients will be discussed. These products have great potential to be included in a wide range of products and some applications for them will be discussed.

802-O

Assessment of chicory root by-product as a novel insoluble fiber in bread and cereal bars

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In the inulin production process, inulin depleted chicory root with a fiber content of 75% (on dry weight) remains as a by-product after inulin extraction. This novel insoluble Chicory Root Fiber (iCRF) fits the increasing market for natural food fibers, that is mainly driven by the growing consumer awareness of fiber intake and the food industry needs for improved ingredient functionality. The application potential of iCRF was benchmarked and tested on taste and texture functionality in bread and a cereal bar. In a comparative study with other fibers, the dried iCRF contained less fiber than wheat (93%) and oat (93%), but contained more fiber than potato fiber (56%). On technical performance, iCRF had the highest water holding capacity of all tested fibers

(7.0 ml/g vs. 3.7, 3.1 and 5.4 for wheat, oat and potato, respectively). In Farinograph measurements, this high water binding was conserved in bread. A 2.8% addition of iCRF enabled the addition of 72% of water, as compared to 64% water addition for dough with a similar oat or wheat fiber addition.

803-O

Millet and Teff-Based Gluten-Free Pasta Formulated with Corn Starch and Glycerol Mono-Stearate as Texture Enhancers

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Millets and teff are nutritionally superior to other grains especially rich in minerals, iron, dietary fibers, antioxidants, phytochemicals, and polyphenols, which contribute to broad-spectrum positive impacts on human health. White proso millet and ivory teff flour was used to produce precooked gluten-free pasta using twin-screw extrusion with corn starch and glycerol mono-stearate (GMS) formulation as texture enhancers. Effect of screw speed and barrel temperature on physio-chemical (firmness), Differential Scanning Calorimeter (DSC) based thermal analysis, and cooking properties (water absorption and solid loss) of precooked pasta were studied. Rice pasta as gluten-free control and wheat pasta as overall control was used for comparison. Wheat pasta was of superior quality characteristics such as firmness, higher cooked weight and low solid loss followed by rice-starch, teff-starch and millet starch pasta. Teff-starch pasta shown increase in cooking time (12.53 mins), cooked weight by 120.9% and decline of 16.4% in cooking loss against teff. In gluten-free categories rice-starch pasta shown low cooking loss (28.12%) followed by teff-starch (28.30%), and millet-starch (32.64%). There was 3.13% reduction in cooked weight of teff-starch and 54% reduction in cooked weight of millet starch in comparison to rice-starch. The use of high amylose starch and GMS reduced the stickiness of the product. Water absorption of teff-starch was significantly ($P<0.05$) higher than millet-starch. Low screw speed and high barrel temperature improved cooking weight and reduced cooking loss. Teff-starch pasta quality attributes were analogous to rice-starch in gluten-free pasta group.

804-O

Effect of Bran Reduction on Gluten Secondary Structure in Intermediate Wheatgrass (*Thinopyrum intermedium)* Dough

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Thinopyrum intermedium, commonly known as intermediate wheatgrass (IWG), is a perennial crop with favorable agronomic characteristics. In comparison to wheat, IWG has higher protein and dietary fiber contents. However, the protein distribution is significantly different from that of hard red winter wheat. The difference in protein distribution coupled with higher fiber content negatively affects the dough rheology in terms of protein network formation. Therefore, the goal of this study was to determine the effect of bran reduction on the gluten secondary structure in IWG dough using ATR-FTIR spectroscopy. IWG grains sample was milled and bran was separated. Bran was added back to refined IWG flour at 100%, 75%, 50%, 25% and 0% of original bran content. Different flour samples were evaluated for dough strength using farinograph following the AACC Method 54-21.02 at two temperatures 30°C and 21°C. Dough samples were collected at different time points during mixing: dough development time (DDT), stability departure, and overmixing, and were subjected to FTIR spectroscopy to determine changes in protein secondary structure. At 30°C, IWG bran reduction did not cause significant structural changes in the dough made at DDT. At 21°C, inclusion of bran caused partial dehydration of gluten giving more β-sheets at the expense of β-turns. Decrease of temperature in 100% IWG dough made at DDT resulted in more beta turns contributing to weaker dough. As mixing time increased, more β-sheets were formed at the expense of β-turns in the IWG dough possibly due to mechanical disruption of gluten network and formation of protein aggregates. Determining differences in gluten secondary structure as affected by bran content provides insights into gluten network formation and stability. This information leads to optimization of IWG grain processing in order to expand its market potential.

805-O

Chemical characterization, functionality, and baking quality of intermediate wheatgrass (*Thinopyrum intermedium*)

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Intermediate Wheatgrass (IWG) is a perennial crop with environmental benefits such as reduced soil and water erosion, and increased nitrogen fixation. However, farmers will be reluctant to plant this crop without an established market, which relies on the characterization of IWG grains for parameters relevant to food use. The objective of this study was to analyze IWG for the grains' chemical composition, functionality, and baking

properties. Sixteen IWG lines along with one bulk IWG sample and wheat controls were analyzed for proximate composition, dietary fiber, starch composition, and gluten forming proteins, following standard analytical procedures. Starch pasting properties were monitored using a rapid visco analyzer. Dough rheology was assessed using farinograph and Kieffer. Bread baking tests were also performed following AACCI method. Compared to wheat, IWG samples had higher protein, ash, and dietary fiber contents, yet were deficient in high molecular weight glutenins, an important protein component responsible for dough strength and elasticity. The fat content of IWG samples were similar to those of wheat, but total starch content was lower. Amylose/amylopectin ratio, however, was similar to that of wheat. Rheological data showed weaker IWG dough strength compared to that of wheat. These findings suggest that IWG has a superior nutritional profile, but poses challenges for baked products that require dough rising properties. These results can be explained by the lack of gluten network formation and the higher fiber content that competes with protein and starch for water. This data will assist in future breeding efforts for the development of IWG lines suitable for food applications. This project's success will also advance cereal science industry to provide highly nutritious products to address consumer's demand.

806-O

Effects of hydrocolloids on rheological and optical properties of proso millet dough

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Proso millet is recognized as a source of healthy carbohydrate due to low glycemic index, gluten-free, minerals and dietary fiber. It is becoming common ingredient of gluten-free diet for coeliac patients. However, commercial exploration on using whole proso millet flour is limited. The lack of gluten reduces the elastic characteristics of dough and hence it is a challenge to mimic the wheat dough properties by supplementing the formulation. The aim of this project was to study the rheological properties of proso millet (PM) dough containing different hydrocolloids that could be used to completely replace wheat flour. Rheological characteristics of PM dough with hydrocolloids including guar gum (GG), xanthan gum (XG) and sodium alginate (SA) at concentration of 0%, 1% and 2% (wet basis) and 37% moisture content were compared with the behavior of wheat dough using a controlled stress rheometer. Wheat dough showed higher apparent viscosity values than PM dough at all shear rates except for the zero-shear rate. An increase of apparent viscosity was observed by the addition of all three hydrocolloids. The largest improvement was achieved by 2% XG, reaching the same infinitive-shear viscosity of wheat dough. Wheat dough exhibited weak gel behavior, whereas PM formed a lumpy dough. SA and XG provoked the largest upward trend in both storage and loss moduli, resulting in increased dough consistency. The increase of SA and XG from 1% to 2% showed slight improvement on the viscoelastic behavior of millet dough. PM dough showed a lower lightness value and a higher yellowness value than wheat dough. Generally, the addition of hydrocolloids reduced the color difference between PM dough and wheat dough except for GG. SA showed the least color change, followed by XG. The capacity of hydrocolloids to improve the rheology and color of PM dough followed the order of XG>SA>GG.

901-O

Development of quantitative screening methods for feruloylated arabinoxylan side chain profiles in whole grains

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Feruloylated arabinoxylans are a major hemicellulosic component of whole grains' dietary fiber complex. Their xylan backbones are substituted with L-arabinose and oligosaccharides, and some of these substituents are ester-linked with monomeric *trans*-ferulic acid, forming feruloylated side chains (FSC). Both increased FSC quantity and complexity (degree of polymerization of sugar moiety) potentially reduce feruloylated arabinoxylans' enzymatic digestibility. FSC profile differences could therefore affect, among others, the prebiotic potential of feruloylated arabinoxylans from different wholegrain sources and outcomes of xylanase treatments during wholegrain bread baking. We have developed and validated two FSC-screening methods enabling quantitative FSC profile comparison of cereal grain materials. The three most abundant FSC in cereal grains were isolated in preparative quantities as standard compounds for method development. For application to cereal grain materials (insoluble fibers from whole grains), FSC were semi-selectively released (50 mM trifluoroacetic acid, 2 h, 100°C), and the hydrolysates were cleaned up with C18-SPE. Liberated FSC were either quantified via two-dimensional NMR (HSQC) or reduced to their sugar alcohols with $NaBH_4$ and separated and quantified with LC-DAD-MS/MS. The determined FSC concentrations showed good correlation between the two methods. Sample preparation time was shorter for the HSQC-NMR method, but the LC-DAD-MS/MS method was more sensitive. Up to 93% of the total esterified monomeric ferulates were captured in the FSC profiles, confirming the significance of these compounds to the global arabinoxylan structure. Unique profiles emerged for the different grains: for example, oats had low overall FSC concentrations but high profile complexity, while maize displayed both high FSC concentrations and profile complexity.

902-O

Development of a small-scale wheat testing regime for assessment of bread-making quality

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The desired quality for wheat as a raw material is dependent upon the end-product and the processes requirements. For bread-making wheat, an assessment of the quality is relevant to the stakeholders throughout the supply chain from plant breeders to bakers as it may allow the selection of potential bread-making varieties in the early stages of a wheat breeding programme for the former and informs the latter on the functionality and baking performance of new varieties. Currently an assessment is likely to involve a number of chemical and rheological tests followed by test baking at the 400 g or 800 g loaf scale. Although these tests provide a definitive measure of quality, a baking assessment requires the milling of 2 kg of grain minimum and this amount of material is not always available. AHDB-Cereals and Oilseeds funded the evaluation of a set of small-scale test methods which require a significantly smaller amount of material (around 100 g of grain). The approach involves a size exclusion HPLC method and a small-scale dough rheology method (using a reomixer). By combining the data generated using both methods it has been possible to predict the performance of experimental material (work previously carried out). Subsequently, Campden BRI has developed a small-scale baking method that reliably correlates baking performance with large-scale test bake. Combining both the small-scale testing and the small-scale baking has the potential to reliably predict bread-making quality with around 100 g of wheat.

903-O

Falling number: sliced and diced

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Sales agreements at first point of sale and downstream in the market chain often specify a minimum value for falling number (FN), typically 300, below which the consignment is discounted. Although extensively used throughout the grain trade, FN is sometimes criticized because of perceived imprecision. For two successive years, FN precision has been extensively studied at USDA Beltsville. In the first year, repeatability precision, as performed according to AACCI Method 56-81.03 and slight modifications thereof (control + 3 treatments), was evaluated under optimal laboratory conditions and operator practices. Best linear unbiased predictors (BLUPs) obtained from the mixed effects ANOVA yielded estimates of FN averages for each treatment and sample. Coefficients of variation (CV) were calculated using these BLUPs and variance estimates. The 2nd year was devoted to ascertaining the inherent variability (sampling error) of the grain within the truck bed using U.S. official inspection probe-sampling protocol. Results for the first year indicated that CVs between 1% and 4% were achieved for all treatments and samples. Small increases to the sample mass and water volume improved precision, whereas the addition of a wetting agent had a negligible effect. In the second year, with test samples consisting of individual probings of truck beds (7 probings per truck) in Washington (4 sites, 10 trucks/site) and Ohio (1 site, 11 trucks), results for Wash. indicate surprisingly low sampling error, with 3 distinct variance patterns depending on site, these being FN variances of 24 (15-46 95% confidence interval for one site), 10 (5-29 CI for a second site), and 0.06 (with no CI estimable due to closeness to zero for two sites pooled). Thus, results of the precision and sampling studies indicate reasonable performance of the FN procedure, from sampling through lab operations.

904-O

Process optimization for economic recovery of anthocyanins from colored corns

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Anthocyanins (ANCs) can be used as natural alternate to synthetic dyes in foods, beverages and cosmetics. Colored corns can be used for their economic recovery. Purple, blue and yellow corns were fractioned using 1 kg lab-scale wet-milling, dry-milling and dry-grind processes to compare coproduct yields. Total ANCs in colored corn coproduct stream were quantified using 2% aqueous formic acid for extraction and pH differential method for quantification. For purple corn, ANCs quantified in wet-milling were 4.91 g/kg with steeping water, gluten slurry, starch, fiber and germ containing 79, 17, 2, 1 and 1%, respectively. In dry-milling, total ANCs were 4.55 g/kg with pericarp, small grits, large grits, fines and germ containing 48, 21, 18, 9 and 4%, respectively. In dry-grind, minimum ANCs were quantified (1.36 g/kg). For blue corn, total ANCs quantified in wet-milling were 0.36 g/kg with gluten slurry, steeping water, starch, germ and fiber containing 70, 15, 8, 4 and 3%, respectively. In dry-milling, 0.29 g/kg ANCs were quantified with small grits, pericarp, large grits, fines and germ containing 37, 21, 20, 16 and 6%, respectively. Total ANCs quantified in dry-grind were 0.08 g/kg. Purple corn processing will involve pericarp recovery at the front end while remaining endosperm and germ fractions can be utilized either in dry-grind or dry-milling. For blue corn, recovery of ANCs from gluten slurry after wet-

milling will be the optimal. We propose optimized processes for recovering ANCs from colored corns with a potential to significantly reduce their recovery costs on account of lesser processing volumes for ANCs extraction and complete utilization of feedstock resulting in significantly improved process economics.

905-O

Vacuum-coupled High-Solid Fermentation of Corn for Bioethanol Production

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Bioethanol, an important renewable transportation fuel, can be produced in significant quantities from fermentation of sugars obtained from starch or cellulose. The solid loading during the simultaneous saccharification and fermentation (SSF) process directly affects the final ethanol concentrations. High ethanol concentrations in the fermentation beer can significantly reduce the energy requirements for subsequent ethanol recovery and improve the plant productivity. However, during ethanol production from corn, the solid loadings during the fermentation process are restricted to 32% w/w due to inhibition by high ethanol concentrations. Simultaneous stripping off of ethanol under vacuum during SSF process is one of the potential approaches to reduce this inhibition. The objective of this study is to investigate the feasibility of this vacuum-coupled SSF strategy for high solid SSF of corn. The approach was tested for 40% solid loading using the dry grind ethanol process. Various vacuum cycles (time for one stripping) and interval periods were investigated to identify the conditions for maximum ethanol yields. Application of vacuum for 1h at 12, 24, 36 and 48h during SSF process resulted in complete fermentation compared to 13.6% residual sugars in case of conventional process. The final ethanol yield was estimated as 0.414 L per kilogram dry corn, which was about 1.68 times that for conventional fermentation. To determine the commercial scale feasibility of the process, a detailed techno-economic analysis will be performed by developing a comprehensive process model for the dry grind ethanol with vacuum stripping system. The model will also help in identifying the optimum vacuum stripping conditions for maximum ethanol yields with least energy consumption.

906-O

Impact of superfine grinding on the multi-scale structures and pasting characteristics of starch in whole-wheat flour

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Starch, as one of the main components in whole-wheat flour (WWF), has a significant impact on the quality of whole grain products. In our previous studies, the reduction of WWF particle sizes by superfine grinding has been shown to enhance the quality of whole-wheat dough and its noodle products. However, the changes in the structures and pasting characteristics of starch in WWF remain unclear when subjected to superfine grinding. The objective of the study is to investigate the influences of superfine grinding on the microstructural, crystalline, molecular structures and pasting characteristics of starch in order to build a correlation between starch structures and its functionality in WWF. Five ranges of particle size distribution of WWF (median diameter: 107, 86, 62, 41, and 21μm) were obtained by superfine grinding. The surface roughness and breakage degree of starch granules were increased with the enhancement of grinding strength. There was a reduction in the intensities of A-type crystalline peaks on the X-ray diffraction patterns due to the alterations of starch crystallites. Small-angle X-ray scattering analysis indicated the disorganization in the semi-crystalline lamellae of starch with thinner lamellae thickness and decreased ordering degree. Additionally, the 13C CP/MAS Nuclear Magnetic Resonance spectra verified the alterations of starch structure by the altered peak shapes of starch carbons (C2, C3, and C5). Along with the structural changes, the pasting properties of starch showed substantial variations, demonstrating increased pasting viscosities and reduced pasting stability. The results suggest that the structures and pasting properties of starch were influenced by superfine grinding although in a non-separated state, the variations of structure and pasting properties could be combined to fully understand the changes of starch functionality in WWF.

1002-O

Colorimetric oligosaccharide substrates for the measurement of polysaccharide *endo*-hydrolases

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Specific and highly sensitive oligosaccharide-based chromogenic and fluorogenic substrates have been developed for the measurement of trace levels of polysaccharide *endo*-hydrolases in cereal grains and products. These substrates are used in the presence of saturating levels of specific glycosidases such as thermostable a- and b-glucosidases and b-xylosidase. For the measurement of pullulanase and limit-dextrinase, the substrate is either 4,6-*O*-benzylidene-2-chloro-4-nitrophenyl-b-maltotriosyl (1-6) a-maltotriose (BzCNPG3G3) as a chromogenic substrate, or 4,6-*O*-benzylidene-methylumbelliferyl-b-maltotriosyl (1-6) a-maltotriose (BzMUG3G3) as a

fluorogenic substrate. a-Amylase is assayed with 4,6-*O*-benzylidene-4-nitrophenyl-a-maltoheptaose (BzNPG7) and 4,6-*O*-ethylidene-4-nitrophenyl-a-maltoheptaose (EtNPG7). For assay of *endo*-cellulase, the substrate 4,6-*O*-(3-ketobutylidene-4-nitrophenyl-a-cellopentaose (CellG5); for assay of lichenase and 1,3:1,4-b-glucanase (malt b-glucanase) the substrate prepared was 4,6-*O*-benzylidene-2-chloro-4-nitrophenyl-b-cellotriosyl (1,3)-D-glucose (BzClNPG443); and for *endo*-xylanase the substrate is 4,6-*O*-(3-ketobutylidene-4-nitrophenyl-b-xylohexaose (XylX6). On hydrolysis of each of these substrates by the particular *endo*-hydrolase, 4-nitrophenyl or 2-chloro-4-nitrophenyl oligosaccharide is released and this is immediately hydrolysed by the relevant glycosidase in the reagent mixture, to release 4-nitrophenol or 2-chloro-4-nitrophenyl that produce a yellow color in the presence of an alkaline solution. Assay procedures using these modified oligosaccharides are simple to use, specific, accurate, robust and readily adapted to automation. These methods should find widespread application in the analysis of cereal products and in screening of microbial preparations for the relevant enzyme.

1003-O

Image analysis for objective measurement of grain defects and foreign material

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For millennia grain has been analysed for quality and foreign matter by visual means. While well accepted, these methods, used primarily for the determination of levels of defective grains and foreign matter, are highly subjective and are susceptible to human factors and even potentially manipulation as they are by their nature is neither accurate nor precise. There is strong demand for means of objective analysis to improve accuracy but also, arguably more importantly, to address the repeatability and reproducibility of the analysis. One such approach is the use of Image however, if we consider the objective basis for the calibration process for techniques such as NIR spectroscopy we see the challenges and the paradoxes inherent in the calibration and validation of image analysis instruments. These paradoxes largely stem from the subjectivity of the reference method which remains a human analysis, albeit with a highly experienced operator. This paper will explore advances in image analysis for objective analysis of grain defects and foreign matter and will explore the challenges of the calibration and validation process. It will present results of trails conducted in Australia, Europe and North America which demonstrate the potential of this technique. For example, analysis of barley samples contaminated with wheat resulted in correlations better than 0.99 when comparing a validation set analysed by Image Analysis against a trained analyst. Defects such as skinning in Barley achieved correlations greater than 0.81. Useful levels of repeatability were also found in these studies with repeatability (Pooled SD) being less than half the level of accuracy (measures as RMSEP). Finding of these studies demonstrate that this analytical technique can provide a useful alternative to current methods.

1004-O

A novel approach for structural analysis of high viscous starch based products during heating

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The main aim of this study is to obtain a global view of the desired components with connections to production parameters applied in food industry. In order to achieve this objective allowing to observe complex food systems exemplary on bread, new innovative methods were combined with well-known microscopic techniques. As starch is the main component of wheat based product such as bread it was chosen for further investigation. The study of analytical methods to investigate structural changes of starch during heating revealed that they are all working with water in excess. Considering that wheat dough has a limited water content no in situ analysis of starch gelatinization under actual condition is possible until now. The newly developed method enabling micrographic analyses for numerous structural features is based on confocal laser scanning microscopy (CLSM) combined with image analyzing techniques. Structural and morphological changes can be quantified and discussed in detail. The relationship between heat treatment and structural features was first proven with different starch suspensions by common thermo physical analytical techniques such as differential scanning calorimetry (DSC). The new method was used to investigate the onset of starch gelatinization by using threshold values, which are based on the first derivatives, where values of CLSM and DSC showed the highest correlation. The gelatinization temperature that is in micrographs obtained through the shape and size analysis of starch granules is highly depending on the water content. In summary, a visual online detection system to investigate changes in starch granules on a microstructural scale during heating was developed. This in situ system monitors the structural changes of starch granules such as starch gelatinization with the advantage of being unaffected by secondary factors.

1005-O

Application of NMR-spectroscopy for structural analysis of pseudocereal non-starch polysaccharides

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Most pseudocereal dietary fiber polysaccharides such as xyloglucans and pectins are composed of heterogeneous and complex structural elements. Arabinans, which are neutral side chains of pectins, are particularly important and represent up to 35% of the non-starch polysaccharides. Thus, the structures of these polysaccharides may greatly influence the physiological and technological properties of the fiber. The main structural elements of these polysaccharides are only accessible through time-intensive methods such as methylation analysis. These conventional methods of carbohydrate analysis are based on chemical cleavage of all glycosidic bonds, which results in a partial information loss of complex structural elements such as β-arabinose units. Thus, a time efficient NMR-spectroscopic approach was developed to analyze the structural composition of arabinans. Insoluble arabinans were partially solubilized by *endo*-arabinanase, which selectively cleaves the linear areas of the arabinan backbone. To analyze the portions of the different structural elements in solubilized and soluble arabinans, specific marker signals in the HSQC-spectra of the oligo- and polysaccharides were used. The marker signals were evaluated by using previously isolated and well-characterized standard compounds. To study the applicability of the method, the arabinan structures of amaranth, quinoa, and buckwheat dietary fiber were analyzed. The portions of the main structural elements obtained from the developed approach were comparable with methylation analysis data. In addition, complex structural elements such as β-arabinoses can be analyzed, thus combining an increased information content with a reduced analysis time. The NMR-spectroscopic approach was also successfully applied to analyze pectic galactans and could also be used to analyze other pseudocereal non-starch polysaccharides.

1101-O

Variation in the asparagine concentration in Nebraska wheat and other grains

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Asparagine can react with reducing sugars during heating to produce acrylamide, which has high oral and dermal toxicity along with mutagenic and carcinogenic activities. Thus, a key concern in the baking industry is to reduce asparagine in flour to minimize the potential for acrylamide formation in finished products. The primary purpose of this study was to determine the variation in asparagine concentration in Nebraska wheats and to identify environment factors that contribute to asparagine accumulation. A secondary objective of this study was to determine asparagine concentration in prominent gluten-free crops that are currently replacing wheat in many baked goods. In wheat, asparagine concentration varied from 110 mg/kg to 540 mg/kg among five locations and three cultivars. Data suggests that longer exposure to solar radiation and higher evapotranspiration leads to higher asparagine. We also speculate that high asparagine in wheat grown in some parts of the state was due to slight sulfur deficiency in the soil. Asparagine concentration and reducing sugars showed negative correlations with high molecular weight proteins ($p=0.0023$, $r=-0.315$ and $p=0.0146$, $r=-0.255$ respectively), which is desirable for gluten quality. In our second objective on gluten-free grains, preliminary data indicated that pearl millet and oats may have a higher asparagine (827 mg/kg and 332 mg/kg), while sorghum (141 mg/kg), proso millet (68 mg/kg), and buckwheat (57 mg/kg) may have lower asparagine compare to wheat (271 mg/kg average). Therefore, our study indicates the important role of environmental conditions in determining free asparagine concentration in wheat and suggests that replacing wheat with other grains in gluten free products can influence a food product's potential for acrylamide formation.

1102-O

Relationship between mycotoxin contamination of colored corn types and phenolic acid evolution during kernel development

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Corn is one of the most cultivated and consumed cereal in the world. There is renewed interest in the identification of naturally occurring mechanisms which can reduce deoxynivalenol (DON) and fumonisin (FB) accumulation. Phenolic acids could play a role in this type of resistance mechanism as suggested by their ability to reduce *in vitro* fungal growth and mycotoxin accumulation. In this investigation, total antioxidant activity (TAA), free and cell wall-bound phenolic acids were analyzed during kernel development of six maize genotypes characterized by a wide range of kernel traits (kernel color, size and hardness). Maize ears were handpicked from plants at four growth stages, namely: end of the silking stage, blister stage, dough stage and harvest maturity. TAA and phenolic acids were determined using QUENCHER and LC-MS/MS methods, respectively. Finally, an evaluation of the mycotoxin contamination at harvest maturity was employed by LC-MS/MS. TAA, free and cell wall-bound phenolic acids showed significant differences among corn types at different developmental stages. On

average, a significant decrease in TAA, free and cell wall-bound phenolic acid content was observed during kernel development. Ferulic, *p*-coumaric and caffeic acids were the main cell wall-bound phenolic acids, while chlorogenic acid was the main free phenolic acid. A significant negative correlation was observed between free phenolic acids and TAA at the beginning of kernel development and DON contamination at harvest maturity, while no significant correlation was observed with FB contamination. The findings on phenolic acids provide insight into their evolution during kernel development, evidence of their role in the resistance to *Fusarium* and to mycotoxin contamination and information about bioactive compound content of maize varieties and hybrids characterized by a wide range of color.

1103-O

Food safe validation and verification: applying industry-driven research to ensure log reduction

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Food processors want to achieve safe, validated food products without negatively affecting sensory and nutritional quality. Many food processors undergo a presumed kill step during production using time and temperature correlations, yet most lack the scientific proof that ensures consumer safety. This presentation introduces an emerging scientific-validation system based on thermal processing parameters established for the reduction of *Salmonella* surrogate *Enterococcus faecium* in runner type peanuts, first published in *Peanut Science* (2014) 41:72-84. Continuous monitoring with a dynamic control system combined with a series of processing profiles and parameters for nut roasters can achieve an approximate 5-log reduction. Currently, the almond industry has the only mandate for log reduction, a 4-log kill step. However, there is an industry-wide need to ensure log reduction for all nuts and seed processing based on retention time, product temperature, process air temperature, air velocity, product moisture content and process air humidity. The data modeling protocols developed and validated for the nut industry demonstrate new opportunities for applications in grain-based RTE products such as snacks and breakfast cereals.

1104-O

Time-dependent adhesion behaviour of dough – relation to surface structure, surface energy and microbial contamination

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In order to improve the safety and efficiency in bakeries it is essential to develop a better understanding of the interaction between cereal dough and material surfaces. Therefore, a new measurement rig for a texture analyzer was developed to determine the separation behavior of dough after different practically applied contact times (e.g. 60 minutes of fermentation time) and for a huge variety of materials. Using this method differences concerning the adhesion behavior for higher contact times have been shown in relation to material composition and structure. For some of the analyzed proofing trays, the factor of the adhesion force increased from 2.3 to 8.0, when varying the contact time from 1 minute to 30 minutes. To precisely elucidate these adhesion phenomena different influencing factors have been considered. In this context, especially the specific adhesion was analyzed by identifying the surface energy of the two contact partners. For trays with a low adhesion to dough, low surface energy values were observed (5.0-5.7 Nm/m). Contrary, trays with high adhesion to dough showed high surface energy values (58.0-70.5 Nm/m), which roughly matched the energy of the investigated dough surface, indicating strong interaction of the two contact partners. In order to identify the correlation between adhesion and microbial contamination an adjusted method was applied to determine the microbial contamination of three differentiating proofing trays during a 12 week practical application. Thereby, a higher increase of nearly one decimal power was observed for materials with higher adhesive behavior to dough. In consideration of hygienic safety, the elucidation of the relations enables a targeted selection of materials with low adhesion for industrial use.

1105-O

Influence of foliar fungicide treatment of wheat on lipolytic activity in whole wheat flour

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Lipolytic enzymes play a key role in the enzymatic degradation of whole wheat flour upon storage. These enzymes may also be involved in plant defense. Therefore, the objective of this study was to analyze differences in lipase (measured with olive oil or p-nitrophenyl palmitate as substrate), lipoxygenase, esterase (measured with p-nitrophenyl butyrate as substrate), and falling number (sprouting damage) in whole wheat flour from wheat that had been treated with and without foliar fungicide. Because different substrates can be used to quantify lipase activity, a secondary objective of this study was to determine if these substrates give similar results or not. Six hard red winter wheat genotypes grown in Nebraska with two treatments (foliar fungicide treated and untreated) for both (2014/15) years were analyzed. There was a significant treatment X year interaction for lipase,

esterase, and lipoxygenase activities most likely because of high disease pressure in 2015. Fungicide treatment had a significant effect on falling number, lipase, and esterase activities in 2015 only. A significant genotype X treatment interaction was observed in lipoxygenase activity for both years. Positive Pearson partial correlation (year as a partial variable) was observed between lipase (measured with p-nitrophenyl palmitate) and esterase activities ($r=0.63$, $p<0.001$). Lipase activities measured with olive oil and p-nitrophenyl palmitate as the substrate were negatively correlated ($r= -0.28$, $p<0.05$). Falling number and lipoxygenase were not correlated to other variables. Results from this study suggested that enzymatic activities in the whole wheat flour is highly affected by the presence of disease pressure, and lipase activity measured with different substrates gave different responses.

1106-O

New durum wheat with soft kernel texture: end-use quality analysis of the *Hardness* locus in *Triticum turgidum* ssp. *durum*

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Wheat kernel texture dictates U.S. wheat market class. Durum wheat has limited demand and culinary end-uses compared to bread wheat because of its extremely hard kernel texture which precludes conventional milling. 'Soft Svevo', a new durum cultivar with soft kernel texture comparable to a soft white wheat, was developed by the homologous transfer of the *Puroindoline* genes at the *Ha* locus from the D genome of *Triticum aestivum.* The objectives of this research were to change the kernel texture of CIMMYT's 42nd elite durum yield nursery from hard to soft using Soft Svevo as the donor line and to evaluate the impact of the introgression of the *Ha* locus in the new soft durum genotypes. In 2015, 48 derived F2:5 CIMMYT soft durum lines were grown in plots in two locations (Pullman and Lind, WA) and in two replications. Grain was tempered, milled, baked, and subjected to end-use quality analysis in the Western Wheat Quality Laboratory. Data were analyzed and significant differences ($p<0.05$) were detected amongst genotypes for test weight (60.5-63.5 lb/bushel), kernel hardness (2.0-25.7 SKCS), break flour yield (37.7-43.8%), flour yield (58.9-65.9%), SDS sedimentation (3.2-12.5 ml/g), loaf volume (633-863 cm3), and flour protein (11.5-13.5%). No differences were detected for flour ash. Orthogonal contrasts between full-sib groups were also significantly different ($p<0.05$) indicating great progress can be made to broaden durum's milling potential and culinary end-uses if Soft Svevo's crossing parent possesses favorable alleles for end-use quality. These results suggest that the kernel texture of virtually any durum cultivar may now be softened via introgression of the *Ha* locus. Doing so would potentially create a new U.S. wheat market class, soft durum, and suggests that a paradigm shift is in order for its new milling characteristics, baking potential and food products.

1201-O

Effect of heat processing on immunoreactivity and *in vitro* digestibility of wheat gluten

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Approximately 1% of the world population has an autoimmune response to gluten, such as celiac disease, gluten ataxia or dermatitis herpetiformis. Found in wheat, barley, rye and some oat varieties the gluten network is composed of multiple subunits of prolamin and glutelin. Formation of the gluten network is especially important in wheat based products as it confers viscoelasticity and enables dough to be processed into bread. The aim of our study was to investigate the influence of different heat treatments applied to wheat flour on the immunoreactivity and *in vitro* digestibility of wheat protein. Commercial wheat flour (*Triticum aestivum*) from Cooperativa AgráriaAgroindustrial, de Guarapuava, Paraná–Brazil, 2012 harvest underwent extrusion, dry heat oven, ultrasound, spray-drying and microwave treatments. After processing, the samples were lyophilized. Protein digestibility and total protein before and after processing was determined on all samples. Immunoreactivity potential to celiac disease was tested by ELISA R5 (Prolamins Kit - TRANSIA® Plate Prolamins - BioControl Systems, USA) and G12 analyses (AgraQuant® Gluten G12 ELISA kit - Romer Labs, USA). A decrease in protein digestibility was observed in samples subjected spray-drying, ultrasound and extrusion (17.8%, 8.6% and 3.0%, respectively). Immunoreactivity using the R5 antibody decreased with spray-drying (47.4%) but increased with other heat processing, especially with extrusion (36.8%). Using the G12 antibody all samples showed a decrease in immunoreactivity compared to untreated flour, with highest decrease with spray-dry (52.6%). Heat processing leads to unfolding of peptide chains, changes in hydrophobicity and susceptibility to the action of proteolytic enzymes, and could influence immunochemical reactivity.

1202-O

Selective inactivation of trypsin inhibitor in chickpea and soybean using L-cysteine as a reducing agent

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Trypsin inhibitor, a serine protease, is considered a major antinutritional factor in legumes. This naturally occurring protein is highly active over trypsin due to its stable structure, which depends mostly on its disulfide bonds. Several attempts have been carried out in order to inactivate trypsin inhibitor, being heat treatments the most effective ones. One of the problems when high temperatures are used is the reduction in the protein solubility, disabling legume isolates from being part of different food products. Herein a novel attempt for inactivation of trypsin inhibitor in soybean and chickpea is described where the use of L-cysteine is conceived to change the protein stability by altering it disulfide-bond integrity. Chickpea and soybean alkaline extracts were obtained from their respective defatted flours and over these extracts the effect of L-cysteine (3.6 mg/g sample) and thermal treatment (80° and 121°C for soy and chickpea respectively) were tested. For soybean it was observed that trypsin inhibitor activity was mostly affected by thermal treatment (up to 76% of reduction) while the effect of L-cysteine was practically nonexistent (-1.88%). For chickpea counterpart, it was observed that treatment with 121°C was not effective in reducing trypsin inhibitor activity, being thus more resistant to high temperatures compared with the soybean counterpart. On the other hand, the effect of L-cysteine on chickpea (at the same concentration mentioned above), significantly decreased its activity up to 60%. With this information differences in structure and activity of trypsin inhibitor from chickpea and soybean are devised but more tests will be required in order to fully understand dissimilarities. This information sets the possibility to develop new and selective strategies to reduce anti-nutritional activity according to legume source.

1203-O

Pilot study using wheat bran to mitigate malnutrition and enteric pathogens

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In 2015, 4.9 million children under the age of five died from infectious, neonatal, or nutritional conditions. Malnourished children have an increased susceptibility to enteric pathogens and diarrhea, which flush commensal bacteria from the intestines. Commensal bacteria in the intestines regulate nutrient absorption, development, and immune responses. Children who are malnourished often get caught in the malnutrition-enteric pathogen cycle. In healthy intestines, there is a barrier layer and mucosal layer, which help digestion, nutrient absorption, and protection from pathogens. The barrier and mucosal layers are destroyed by pathogens. Commensal, beneficial bacteria such as *Bifidobacteria* and *Lactobacillus* ferment dietary fiber into short-chain fatty acids. These short-chain fatty acids heal the intestines. This study used 130 rats to examine the effects of wheat bran pellets, rich in dietary fiber, on health. There were four treatment groups: control, bran, colitis, and colitis + bran. Colitis was induced in half of the rats using dextran sulfate sodium in their water. Disease Index Scores were taken daily. The rats with colitis consistently had greater Disease Index Scores than those rats with colitis + bran. Every two weeks for 12 weeks, five rats from each group were euthanized. Digestive material was collected for short-chain fatty acid analysis. Bacterial samples were taken and plated on selective and differential media. Rats with colitis alone had greater levels of the harmful bacteria *Clostridium* than any other treatment group. Rats with colitis + bran had greater levels of the beneficial bacteria *Bifidobacteria* and *Enterococcus* compared to the colitis group. The conclusion from this study was that adding bran to ready-to-use therapeutic foods given to malnourished children could help increase beneficial bacteria and decrease presence of disease symptoms.

1204-O

Effect of Ultrasound and Germination Time on Alpha-Amylase Activity in Wheat Grain

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Alpha-amylase as other amylases has multiple applications in the foods and brewing industry. It is a widely distributed enzyme in nature, with a higher activity in some germinated cereals. Nowadays, the food industry applies ultrasound (US) to improve the rate of different processes of germinated grains such as barley, lentils, and chickpea. However, not much is known about its effect on amylase activity and solid loss in germinated wheat grain. The aim of this study was to evaluate the effect of different intensities of US and germination times on the alpha-amylase activity in two wheat grains (Patronato and Onavas varieties). The US was applied to the stepped grains at 3 intensities (27, 81, and 108 W) during 3 min. Samples were germinated at 25°C and 90% RH up to 7 days, watering the samples 3 times/day. Germinated samples were collected at 0, 1, 3, 5, and 7 days. Then, they were dried at 50°C for 48 h and ground with a 0.5 mm sieve Cyclotec mill. Alpha-amylase activity was measured by the rapid viscoanalyzer (RVA) and the Ceralpha method. Alpha-amylase activity by Ceralpha was significantly affected by US application, germination time, wheat variety, and their double interactions. Additionally, the enzyme

activity by the RVA was significantly affected by the main factors, and the interaction US application*variety was not significant. Solid loss increased and RVA viscosity decreased with germination time. The smaller solid loss (2.4-2.6%) was to 1-day germination. Patronato had a lower ($p<0.05$) solid loss than Onavas. The US application to Onavas favored the synthesis of alpha-amylase; while did not enhance the activity of this enzyme of Patronato. Overall, the recommendation is 3 days germination for both varieties, to keep solid losses and significantly increase the alpha-amylase activity.

1205-O

New method – A single value for seed size variability or uniformity of a grain sample

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Seed size is an important quality trait for most grains with 1000 grain weight often used as a surrogate measure. However, individual seeds within a sample vary in size, the variation being more pronounced in plants that are indeterminate, such as pulses (grain legumes). A more uniform seed size is visually more attractive and leads to greater consistency in composition and in processing. The seed size distribution method is routinely used as a quality parameter of pulse samples, particularly in breeding programs. Using a sieve stack, percentage (by weight) of grain retained on each sieve is obtained and can be presented in a table or histogram. However comparing histograms across samples is problematic. A single value of within-sample variability would make comparison and analysis much easier. This study examined the seed size distributions of a large set of pulse samples and compared the fit of different methods capable of generating the two parameters of interest; a mean seed size and within-sample variability. The seeds within samples were found to be Normally distributed without skewness or kurtosis and our proposed new method had a good fit to the data. The new method allows calculation of a mean Seed Size (*SSnorm*) and within-sample Size Variability (*SVnorm*). The method is most reliable when sieves are chosen so that the sample is retained on at least 5 sieves and it can also be applied retrospectively on existing seed size distributions. In addition, *SSnorm* and *SVnorm* were found to be independent of each other; meaning breeding programs can aim to maximize size uniformity without affecting the seed size. This method is suitable for calculating the mean Seed Size and within-sample Seed Variability of any grains that are normally distributed.

1206-O

Combining metabolomics and genomics to provide robust and trait-relevant tools to rice breeders

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Aromatic rice commands the highest prices in both domestic and international markets because consumers prize both the mouth-watering aroma and delicate flavour of the rice. The major aromatic compound in fragrant rice is 2- acetyl 1-pyrroline (2AP). Using a panel of 380 diverse varieties of rice, metabolomics profiling of volatile compounds from the grain, and genome wide association with 33000 single nucleotide polymorphisms (SNPs), the objectives of this study were to identify (i) sensory traits that describe jasmine rice; (ii) the volatile compounds that define those sensory traits, and (iii) genetic markers for those compounds. The sensory descriptors fell into three clusters, with Cluster 1 describing high quality jasmine rice, Cluster 3 describing non-fragrant rice, and lower quality jasmine rices falling between the descriptors in Clusters 1 and 2. The compounds that most strongly discriminated the high quality jasmine rices from the other samples were 2AP and four other compounds, two of which required high resolution platforms to reveal their molecular structure and annotation. These five compounds associate with the same SNP on chromosome 8, several are fragrant with a low odour threshold, and they provide new information about the pathway of 2AP synthesis. Three QTL were found that associate with high or low amounts of the five compounds. Another 20 metabolites associated either positively or negatively with high quality jasmine fragrance. Significant genetic associations could be found for some of these compounds. By combining these platforms, we deliver new and valuable tools to breeders for fragrant compounds and 2AP. We also deliver information and germplasm for the development of new populations targeted to provide appropriate phenotype data to identify QTLs for the other important metabolites identified here.

101-P

Functional properties of improved high protein digestibility-hard endosperm sorghum lines

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Sorghum is a drought tolerant crop with known bioactive attributes, but normally underutilized due mainly to reduced endosperm protein functionality. Sorghum proteins cross-link during cooking and restrict starch swelling. On-going work attempts to generally improve sorghum protein functionality for better nutritional and food processing applications. Raw and cooked *in vitro* protein digestibility of 28 improved sorghum lines, with a combination of high protein digestibility (HD), hard endosperm, and waxy starch traits, were investigated using standard pepsin assay. The sorghum lines were also characterized for water solubility index (WSI) and starch pasting properties (RVA). Generally higher protein digestibility (%) (65.60-81.64, uncooked; 55.56-65.26, cooked) samples had higher peak (15,888-27,654 cP) and final (28,962-44,562 cP) viscosities, indicating better starch swelling. Sorghum lines with lower peak (average 10,017 cP) and final (average 14,220 cP) viscosities exhibited lower protein digestibility. The waxy and hetero-waxy lines had lower pasting temperatures and higher WSI. The combined high digestible protein, hard endosperm and waxy/hetero-waxy starch sorghum lines exhibited better functionality than the normal sorghum varieties in terms of protein digestibility and starch pasting properties. These properties are important for improved sorghum nutritional quality for populations in the major producing areas (Africa and Asia), and processing functionality as ingredients in commercial foods.

102-P

Compositional and structural characterization of buckwheat hulls and buckwheat hull dietary fiber

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Buckwheat seeds have a beneficial nutritional profile and are usually used as a whole grain. Thus, they may contribute to an increased intake of dietary fiber. However, comparatively low dietary fiber contents were obtained for dehulled buckwheat seeds. Buckwheat hulls may be added to whole buckwheat flours to influence the nutritional profile. To evaluate the potential of buckwheat hulls as a functional ingredient, their nutritional composition regarding dietary fiber and protein was analyzed. Dietary fiber analysis yielded very high amounts of insoluble fiber (about 90%) and only minor amounts of other components. The physiological and technological properties of the fiber strongly depend on the structures of the fiber polymers, which were characterized by multiple analytical approaches. Dietary fiber polysaccharides were analyzed by methylation analysis and monosaccharide analysis after acid hydrolysis. Cellulose and xylans were the quantitatively dominating fiber polysaccharides, whereas only minor amounts of pectins were observed. Analysis of the fiber-associated hydroxycinnamates showed only small amounts of *para*-coumaric acid and ferulic acid. Significant amounts of hydroxyproline were observed in the amino acid profile of the residual protein, which may indicate the presence of structural proteins. Because lignin might also be a quantitatively important part of the fiber, Klason lignin and acetyl bromide soluble lignin were determined. Very high lignin contents of over 25% were observed for buckwheat hull insoluble fiber. Characterization of the lignin monomers by 2D-NMR and by GC-MS after applying the Derivatization followed by Reductive Cleavage method indicated that guaiacyl units are quantitatively dominating besides smaller amounts of syringyl units. Thus, buckwheat hulls are highly suitable to increase the amount of slowly fermentable insoluble fiber.

103-P

Health-promoting effect of ancient and genetically modified barley lines

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New health-promoting grain can help combatting life-style related disease. Barley (*Hordeum vulgare*, *Hv*) has nutritional and health promoting effects due beta-glucan and other bioactive compounds (1). *Hordeum spontaneum (Hs)* is its wild ancestor and comparisons suggest that dietary fibers and other bioactives changed through crop domestication (2). *Hs* accessions differ from *Hv* by their higher levels of prebiotic carbohydrates. Predicted glycemic indices (pGI (3)) for grain from *H. spontaneum*, transgenic Amylose-Only (AO) barley (4) and normal barley using static and dynamic human gastro-intestinal *in vitro* models showed that *Hs* and AO were lower (17.5 and 15.8, respectively) than normal barley (35.0). The AO grain has low pGI due to resistant starch. For *Hs* lower pGI was hypothesized to be effects of 1. Inhibition of the salivary amylase by grain proteinous inhibitors and/or 2. mechanical inhibition by high viscosity. The viscosity of 10% grain flour in heated

in water, measured by Rapid Visco Analyzer (RVA) at 37°C. Higher viscosity was found for *Hs* than for *Hv* and AO. Addition of alpha-amylase resulted in a slower decrease for *Hv* than for *Hs* demonstrating the inhibition of amylolytic digestion. Protein extracts from flour decreased pancreatic amylolytic activity *in vitro*. Bread with 50% of AO or *Hs* flour and 50% wheat flour showed good alveolation. *In vitro* dynamic digestion of the breads revealed increased soluble and in-soluble fibers present in the digesta. Our work supports the potential to include health-promoting grain of both high/full amylose and ancient germplasm as health-promoting ingredients for a healthy future diets.

104-P

Nutritional properties of proso millet grown as a second crop in Minnesota

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Millet is a drought-tolerant, nutritious gluten-free grain high in resistant starch, thus well-suited for diabetics and people with celiac disease. As part of an ongoing evaluation of proso millet as a double crop in Minnesota, our aim was to characterize six varieties (Dawn, Earlybird, Horizon, Snowbird, Sunrise, Sunup) of decorticated proso millet grown in two locations in 2015 and compare them to a commercial proso millet. Proximate analysis was conducted using standard methods, and pasting profiles measured with a micro viscoamylograph. Total and digestible starch was determined enzymatically. Color was measured on a chromameter, in addition to carotenoid quantification via HPLC. Growing location influenced moisture and lipid contents more than variety did, and both parameters were positively correlated. Dietary fiber contents tended to be influenced by variety but not growing location. Sample color most notably differed in lightness and yellowness, due to differences in carotenoid (lutein and zeaxanthin) content. Proso millet grown in Minnesota had lower pasting temperature, similar peak viscosity, higher breakdown and lower setback values than the commercial millet. Earlybird had lower pasting temperature, lower final viscosity and setback than all other millets, regardless of growing location. This variety had similar starch, protein and fat contents than other samples; however, it contained more soluble dietary fiber. In vitro starch digestibility of cooked samples was affected by growing location and variety, with Horizon having the least rapidly digestible starch and Dawn and Snowbird having the most slowly digestible starch. Our characterization of proso millets will lead to the selection of specific varieties for breeding purposes that are best suited for the production of specific cereal-based goods such as wafers, cookies or bread.

105-P

Physical, rheological and baking properties of proso millet cultivars

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Nine different cultivars of proso millet namely Cope, Earlybird, Huntsman, Minco, Plateau, Sunrise, Rise, Dawn and Panhandle were obtained from Panhandle Research and Extension Center, University of Nebraska, Scottsbluff. Their protein content was determined to range from 10-12%, and starch content 43-55%. Results showed significant difference in physical properties such as moisture content, sphericity, volume, bulk density, porosity and angle of repose, which range in the values from 9.62-10.18%, 0.86-0.91, 3.94-5.141 (mm3), 765.49-809.67 (Kg/m3), 42.49-44.20%, and 22.98°-25.74°, respectively. Evaluation of postharvest properties of different proso millet cultivars are mandatory to obtain the knowledge of their physical and engineering properties in order to design appropriate machineries for process operations like sorting, drying, heating, cooling, and milling. Rheological and baking properties of dough made from different millet cultivars were evaluated. Small deformation, creep-recovery, dough extensibility and final baking parameters such as bread volume, texture, and color were determined and found significantly different by cultivar.

106-P

Use of *Aspergillus niger* peptidase for making reduced immunoreactive bread supplemented with an amaranth blend

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People with celiac disease and other-gluten related disorders are unable to intake gluten-containing foods, because their immune response. Baked goods for the gluten-free diet do not fulfill the expected sensorial characteristics; therefore, gluten proteins have been modified using enzyme technology to reduce or avoid their immunoreactivity, but keeping as much as possible their functionality to obtain good quality bread. The aim of this study was to enzymatically modify gluten proteins in wheat flour using the *Aspergillus niger* prolyl-endopeptidase (AnPEP) to elaborate bread supplemented with an amaranth blend (raw/popped, 80:20) evaluating its immunoreactivity and technological quality. AnPEP concentration (1:50, v/v), wheat flour ratio (20%, w/v), two temperatures (35 or 40°C), and 8 h incubation. For bread-making (modified breads), 60% of

wheat modified flour supplemented with 40% of the amaranth blend was used. Specific volume and immune-reactive gluten (by R5-ELISA) in modified wheat flour and breads were evaluated. The higher reduction of immunogenic gluten (98% as compared with the control) in the modified wheat flour was obtained using AnPEP (1:50, v/v) and wheat flour (20%, w/v) at 40°C, 8 h of incubation. Otherwise, no significant differences in the specific volume of control breads (wheat flour incubated without AnPEP + amaranth blend) (3-2.8 cc/g) and the modified breads (2.8-2.5 cc/g), at 35 and 40°C, neither in crust or crumb appearances, were found. The immune-reactive gluten was lower in modified bread at 40°C (60 ppm) than that at 35°C (1600 ppm). The supplementation with amaranth flour enabled to obtain breads with acceptable specific volume and appearance. Finally, the use of AnPEP allowed the production of bread with 60 ppm of immune-reactive gluten, considered as a "very low gluten" bread by the *Codex Alimentarius*.

107-P

Effect of Reducing Agents on Batter Consistency and Physical Characteristic of Bread from Sorghum Flour

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Sorghum is gaining recognition as a gluten-free grain and is a safe alternative for those suffering from gluten sensitivity or celiac disease. Still, the lack of gluten proteins does not allow sorghum to form a viscoelastic dough. In this study, reducing agents were added to improve the functional properties of sorghum kafirin proteins for bread baking. Study objectives were to determine the effect of reducing agents on kafirins, batter consistency and physical characteristics of sorghum bread. The reducing agents used were L-cysteine (2.5% fwb) and sodium metabisulfite (SMB) (500 ppm fwb). Following the method described by Bean et al (2011), RP-HPLC protein analysis showed that L-cysteine and SMB reduced protein structure, increasing RP-HPLC total peak area up to 747% and 681%, respectively. Batter consistency, obtained using RVA (AACCI Method 76-21.03) showed L-cysteine increased peak and breakdown viscosities and decreased final viscosity. Samples treated with SMB had increased peak viscosity, holding strength and final viscosity while breakdown viscosity decreased. Yeast activity, measured by Risograph using AACCI Method 89-01.01, revealed that L-cysteine reduced yeast activity after 20 min while SMB had no effect. Sorghum bread was baked using the method of Schober et al (2005). Loaf volume was measured by rapeseed displacement (AACCI Method 10-05.01) and bread firmness was evaluated using AACCI Method 74-10.02. In vitro pepsin digestibility (IVPD) was determined using the method of Mertz et al (1984). Loaf volume and crumb grain characteristics of bread containing SMB were equal to the control, while initial firmness and staling were improved. The addition of L-cysteine decreased loaf volume but produced softer initial crumb and improved IVPD digestibility by 19%.

108-P

Conformational insight of prolamin from proso millet: A fluorescence spectroscopy study

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Proso millet is rich in protein, minerals, dietary fiber, and vitamins, and its nutritive parameters are comparable to or better than other common cereals. Additionally, the gluten-free and non-GMO properties of millet make it desirable for human food. However, the structural changes of millet protein during cooking/processing is unclear, which plays a major role of the bioavailability of millet protein. The objective of this work was to study the conformational changes of prolamin from proso millet under different conditions mainly using fluorescence spectroscopy. The prolamin was extracted and purified in 70% ethanol solution. Fluorescence spectra of prolamin in ethanol-water solution from 80% to 20% were obtained. The emission maximum of prolamin was increased with decreased water content, which can be attributed to the exposure of the hydrophobic regions in the protein to solvent. Fluorescence intensity of prolamin in aqueous solution was decreased by both guanidine hydrochloride (Gdn·HCl) and heating due to the denaturation. The emission maximum of prolamin red shifted by 10 nm after heating at 90°C for 1 h, indicating that the tryptophans in prolamin were exposed to a more polar environment. The interaction of tannic acid with prolamin in aqueous solution containing 0.7%, 70% ethanol or 0.4 M Gdn·HCl was also studied by tryptophan fluorescence quenching. And the binding affinity of prolamin with tannic acid was decreased after partial denaturation. Findings from this study contributes to the understanding of millet protein chemistry, which may be useful in improving the bioavailability of millet protein.

109-P

Structural profiling of flavonoids in different cowpea and sorghum phenotypes for potential synergistic bioactivity

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The content and structural profile of polyphenols can have an important effect in their bioactivity and health benefits. Previous studies have shown that combination of structurally complementary flavonoids from cowpea and sorghum synergistically enhance bioactivity. The goal of this study was to identify the phenolic profile of potential sorghum and cowpea varieties that have the best synergistic activity. Three cowpea varieties (white, red, and black) and 3 sorghum varieties (white, lemon yellow, and red) were analyzed using normal and reverse phase HPLC and reverse phase UPLC-TQD-MS. The results showed different flavonoids as major compounds in sorghum and cowpea varieties. The red cowpea had the highest levels of flavonols (mainly quercetin-3-O-diglucoside) at 471 μg/g sample, followed by a white cowpea with dark brown eye whereas a white cowpea with no eye showed the lowest content at 47.1 μg/g. The lemon yellow sorghum showed highest content of flavanones (2393 μg/g, mainly eriodictyol-5-O-galactoside, eriodictyol-7-O-galactoside and naringenin-5-O-galactoside) and of flavones (667 μg/g, mainly luteolin-7-O-galactoside). Only the white sorghum variety showed the presence of the flavone, apigenin (5.02 μg/g of sample). Phenolic acid content ranged from 271-624 μg/g in cowpea (mainly protocatechuic aldehyde and trans-feruloylaldaric acid) and 66-2569 μg/g in sorghum (mainly caffeic acid esters). Further, the content of flavan-3-ols in cowpea ranged from 207-2155 μg/g of sample (mainly monomeric catechin-7-O-glucoside). Thus, the results indicate that different cowpea and sorghum varieties provide uniquely different profiles of flavonoids. This provides interesting opportunities for targeted combinations of the pulse and grain in food for enhanced health benefits.

201-P

Effects of pretreatments on removing the seed coat from the cotyledon of black bean

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Separation of seed coat from the cotyledon might result in additional black bean ingredients that could be used in food products. The objective of this study was to determine the effects of cooking and tempering pretreatments in combination with drying on the ability of removing the seed coat from the cotyledon of black bean using a burr mill. Black beans were cooked in boiling distilled water for 0, 5, 10, and 20 min and dried to the original moisture content in ambient air and at 90°C in a forced-air oven. Also black beans were tempered with distilled water to 'as is' and 10, 20, 30, 40 and 50% moisture, allowed to equilibrate for 24 hours and dried to the original moisture content in ambient air and at 90°C in a forced-air oven. Pretreated black beans were milled using a laboratory-type Burr mill and aspirated to remove the seed coat from the prebreak seed fraction. Seed coat yield after burr mill, seed size and seed hardness were significantly ($P<0.05$) affected by the boiling time and tempering moisture levels. The boiling time had no significant ($P<0.05$) effect on the cotyledon flour color but 30% temper moisture level had given the lightest cotyledon flour color. The results of this study indicate that cooking and tempering pretreatments enhanced seed coat removal during milling on a burr mill. In general, seed coat removal was greater with tempering than with boiling pretreatments. Seed coat removal was greatest with 10 min cooking or with 30% tempering pretreatments that were dried at 90°C.

202-P

Modification of whole flours of navy bean, pinto bean, black bean and chickpea by steam jet cooking and drum drying

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The health-promoting value of pulses is widely recognized, and utilization of them in food products could be expanded with new processing technologies. This study was undertaken to explore steam jet cooking as an approach to increase the level of pulse flour incorporation into food products by improving its properties. Whole bean flours of navy bean, pinto bean, black bean and chickpea were processed by excess steam jet cooking, drum drying, and milling to a state resembling the raw flours. Analysis of the structure and size of the particles, color, solubility and pasting characteristics, dietary fiber, and protein digestibility revealed differences that could provide advantages of this processing technique for certain food applications. Solubility in hot water and protein digestibility were increased by the processing, while average particle size, water absorption index, viscosity after pasting, and lightness of color were decreased. Color changes suggested slight Maillard browning and solubilization and redistribution of seed coat pigments. Starch granules were completely solubilized and the starch, along with fiber and denatured protein components, formed a uniform composite matrix with lower solubility at 25°C than raw flours. Fiber analysis revealed that jet cooking converted a portion of insoluble fiber to soluble fiber. Differences between the diverse pulse types were observed, but they were minor and reflected

composition differences between the bean types. These results suggest that further investigations to distinguish jet cooking from drum drying effects, as well as to characterize the functional performance and nutritional profile of the processed flours in various food systems, are warranted.

203-P

Characterization, functionality and *in vitro* digestion of refined starches from ten chickpea cultivars

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Chickpea (*Cicer arietinum* L) is an important legume crop in the world and its main carbohydrate is starch (38-50%). Viscous characteristics (analyzed by RVA) and digestibility properties (by the *in vitro* Englyst assay to determine the rapidly, slowly and resistant starch fractions) of wet milled isolated starch from eight pigmented and two cream chickpeas were investigated. The chickpeas studied had green (1 cv), black (3 cv), red (3 cv), brown (1 cv) and cream (2 cv) colored seed coat. The yield in chickpea starches ranged from 19-30%, in which starch and amylose content varied from 87-96% and 25-35%, respectively. The viscous characteristics of 13% (w/v) aqueous starch dispersions showed significant differences among the samples, their pasting temperatures ranged from 70-76°C, the highest for Br3512 and the lowest for C3421. The R5383 starch showed the highest viscosity values, compared with their counterparts; moreover, the peak and final viscosities showed strong positive correlations with amylose (r=0.8667, p=0.0012 and r=0.9213, p=0.0002). Resistant starch (RS) fraction was higher in R14782 starch (52%) and lower in R13124 starch (42%). The rapidly digestible starch (RDS) and slowly digestible starch (SDS) fractions varied from 17% (R14782) to 29% (R13124) and 27% (R13124) to 36% (R5383), respectively. The predicted glycemic index (pGI) in chickpea starches ranged from 48-49%, in which the R5383 starch showed the lowest pGI that could be associated with its higher amylose content (r=*-0.6860, p=0.0282*) and final viscosity (r=-0.6418, p=0.045). Overall, the results suggest that the isolated starches from pigmented chickpeas may hold a potential for the development of functional foods regarding their low glycemic index and viscous properties.

204-P

Impact of chickpea and plantain based gluten-free snacks on weight gain, serum lipid and insulin resistance of rats

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Ready to eat products, such as snacks, have become a normal part of the eating habits of the majority of the world population; however, they are considered high energy-dense products, and to promote weight gain and lead to obesity, metabolic syndrome and related diseases (cardiovascular events, hypertension, cancer). Incorporation of sources of non-digestible carbohydrates such as chickpea and unripe plantain flours may result in lower glycemic responses for the snacks and provide beneficial effects on postprandial insulin and satiety. Therefore, two gluten-free snacks containing chickpea, plantain and maize flours at different concentrations were prepared to evaluate the impact of chickpea or plantain flour level on weight gain, insulin resistance and serum lipid profile of rats fed with a high fructose diet. A dose of 0.93 g/kg was used in the experiments to simulate the snack consumption level by humans. Compared to high-fructose reference diet, consumption of both snacks decreased weight gain, fasting serum glucose and triglycerides. The effect was more pronounced for snack B, with higher chickpea content. Consumption of these snacks may have beneficial effects against obesity and cardiometabolic complications. Chickpea and plantain flours are promising functional ingredients for the development of anti-obesity foods.

205-P

Glycemic response of chickpea and food grade DDGS(FDDG) fortified pita breads

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The estimated cost of diabetes in the US is $245 billion. Consumption of low-glycemic index (GI) foods, have been shown to improve glucose tolerance. There is a need for more low cost and more diversified range of Low Glycemic Response (LGR) foods. Chickpea (CP) and newer ingredients such as food grade distillers grain (FDDG) are known for high fiber and protein content and may be helpful ingredients in new food formulations. Our objective was to compare the Glycemic Response (GR) of combinations of CP and FDDG fortified pita breads in test subjects. Pita breads were made employing the following blends All Purpose Flour (APF, Control), APF/garbanzo (90:10 and 80:20), APF/FDDG (90:10 and 80:20), APF/garbanzo/FDDG (70:20:10 and 70:10:20). The experiment design was a single blind, randomized controlled, cross over design with a convenience sample of twelve panelists. Following overnight fasting, subjects consumed each bread type. Blood samples were collected at 30 min intervals. Glycemic response curves were constructed. Area under the Curve (AUC) was calculated.

Control (APF) yielded an IAUC of 86.9mmol.min/L). Pita bread containing 10% CP yielded an IAUC of 84.23 mmol.min/L while the 20%CP showed IAUC of 67.3 mmol.min/L. Ten percent FDDG pita breads showed IAUC of 56.35 mmol.min/L while the 20% FDDG pita bread showed an IAUC of 48.53 mmol.min/L. Inclusion of CP and FDDG into APF, separately and in combinations (70:20 10 and 70:10: 20), resulted in improvements of the GR when compared to APF control Pita. Sensory analysis of the pita breads showed lower taste scores for 10% and 20% chickpea only formulations. The study demonstrated the efficacy of high fiber and high protein ingredients such as chickpeas and food grade distillers grains in the development of low glycemic response foods.

206-P

Effect of sodium selenite on isoflavonoid contents and antioxidant capacity of chickpea (*Cicer arietinum* L.) sprouts

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Isoflavonoids composition, antioxidant capacity and amino acid composition were evaluated in chickpea (*Cicer arietinum L.*) sprouts germinated under different sodium selenite concentrations (0, 0.5, 1 and 2 mg/100 g seeds). Chickpea seeds were germinated during four days at 24°C and the isoflavonoid profiles and concentrations evaluated daily during four days germination by HPLC-UV. Twelve isoflavones and two pterocarpan phytoalexins forms were identified in sprouts, being formononetin glycoside malonylated, formononetin, genistein, isoformononetin glycoside malonylated, biochanin A, biochanin A glycoside and pseudobagtigenin glycoside the major compounds. The highest isoflavonoid concentration was quantified in the fourth day of germination. Total isoflavonoid concentration increased 80% in sprouts obtained using high Se content (2 mg/ 100 g seeds) compared to counterparts without chemical Se stress. Antioxidant capacity increased only 30%. Germinated chickpea obtained with chemical stress elicited by the sodium selenite concentrations reduced the concentration of total amino acids. Ours results suggest that Se-enriched chickpea sprouts could represent a good source of dietary Se and serve as an excellent functional food rich especially in terms of isoflavonoids.

207-P

Effect of processing variables on the yield and composition of air-classified fractions from field peas

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Pulses are an important food source because of their nutritional values. As a way to increase their use in foods, separation techniques, such as dry (air-classification) or wet (isoelectric precipitation) milling processes, can be used to separate the pulses into protein and starch fractions. Air classification uses a stream of air to separate particles from finely-ground flours, according to their size and density. Protein and starch are the main constituents in pulses, and can be liberated through fine grinding. Finely ground pulses can be separated into protein-rich and starch-rich fractions through air-classification. A study was undertaken to investigate the effect of processing parameters (classifier speed and air flow rate) on the yield and composition of the air-classified fractions. In this study, a lab air classifier was used to separate pea flour into protein-rich and starch-rich fractions. Results indicates that increasing classifier speed increased yield and starch content of starch-rich fraction, and protein, ash and total dietary fiber (TDF) content of protein-rich fraction, but reduced yield and starch content of protein-rich fraction, and protein, ash and TDF content of starch-rich fraction. Increasing air flow rate reduced yield of starch-rich fraction, and protein, ash and TDF content in protein-rich fraction, but increased yield and starch content of protein-rich fraction, and TDF content in starch-rich fraction. These fractions would have potential for use in food manufacturing as ingredients.

208-P

Sensory Evaluation of Gluten-Free Cookies Made with Pinto Beans

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Flour mixes containing 40% of either milled raw pinto bean, cooked pinto bean, germinated pinto bean or germinated and blanched pinto bean were prepared and used to make gluten-free cookies. The sensory, chemical and physical properties were evaluated. Sensory evaluation was based on hedonic method using 31 panelists to determine likeability of cookies based on appearance, flavor, texture and overall acceptability. Sensory properties of the cookie were not significantly different across treatments. This demonstrated that cookies can be made from raw bean flour (BF) up to 40% level without the need for treatment such as cooking or germination to improve sensory properties. This will result in significant reduction in flour preparation and further processing cost. Total starch content of the BFs were comparable; however, raw and germinated BF had significantly higher resistant

starch (30%) than other BF (4-5%). Raw bean flour had the lowest protein content compared to the treated BFs. The flour from raw bean had a higher water solubility index (27.3%) compared to flours from treated beans. Flours from the cooked beans had the lowest (10.4%) water soluble index. The oil absorption index followed the same trend where the highest value (0.93) was in the raw flour and lowest (0.77) was in the cooked bean flour. The germinated and blanched pinto bean flour had a final viscosity (252 cP) value that was significantly lower than all other BFs. This resulted in a gluten free mix that also had a lower viscosity (1147 cP) than other treatments. Differences in composition and functional properties indicate the potential for new applications of pinto bean flours based on treatment.

209-P

Evaluation of characteristics and palatability of dog kibbles made with pea starch vs other starches

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Pea starch is a non-traditional carbohydrate source that has not been commonly used in extruded dog kibbles. A study was conducted to evaluate characteristics of extruded kibbles with pea starch for adult dogs and their palatability, comparing those made with rice, potato and corn starches which are commonly used in dog kibbles. Kibbles were made incorporating 30% of each starch into a nutritionally balanced formula (dry matter 92-92.5%, crude protein 26-29%, crude fat 15-16%, crude fiber 3-4.5%) while keeping all the extrusion parameters constant for each run. The products were evaluated for the color (Hunter, Miniscan XE Colorimeter), shape, density, hardness (texture analyzer TA HD plus with 30kg load cell) and for palatability (palatability study with adult dogs at Summit Ridge farms). Both potato and pea kibbles showed more radial expansion showing disc shapes whereas corn and rice kibbles showed spherical shapes. There was no difference in the color among the kibbles made with different starches. Density of the kibbles varied from 305-345g/L in which potato showing the highest density, whereas the hardness (by compression) varied from 6.54-14.35kgs in which pea kibbles having similar hardness to potato. The feeding trial showed that the average intake ratio for potato and pea diets were 0.506 and 0.494 respectively. Based on the Wilcoxon signed rank test results there was no significant difference in consumption of potato vs pea diets (P= 0.3803) by the adult dogs. With Chi2 probability P =0.7518 there was no significant difference in preference by first choice between potato and pea diets either. Overall results showed that pea starch can be successfully incorporated in the dry kibbles for dogs.

301-P

Using hot water pretreated corn stover liquor in dry grind ethanol process to improve ethanol yields

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Cellulosic ethanol plants have started operating at commercial scale; however, challenges related to high cost of pretreatment still exist. As an alternative to new cellulosic ethanol plants, mildly pretreated corn stover liquor can simply be incorporated into the existing dry grind process. Mild pretreatment, such as hot water pretreatment, does not require chemicals and special pretreatment reactors used for acid or alkali pretreatment processes, lowering capital costs for modification of the existing dry grind process. Hot water pretreatment produces a minimal amount of inhibitors (furfural, acetic acid, hydroxymethylfurfural and formic acid), which would not decrease enzyme activities or yeast viability of the existing dry grind process. C5 and C6 sugars hydrolyzed and released into the liquor during pretreatment could be fermented into ethanol by engineered yeasts and increase ethanol production per unit land. Corn stover has 22 to 28% hemicellulose and 39 to 42% cellulose. When corn stover was hot water pretreated at 180°C for 20 min with 20% solids, 50% of hemicellulose and 10% of cellulose were solubilized. To perform the dry grind process with 30% solids, 70% of harvested corn stover would need to be pretreated. Theoretically, this could result in an additional 0.4 to 0.5 gallons of ethanol from one bushel of corn.

302-P

Use of corn with high amino acid content for bioethanol production

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Amino acids, Lysine and Tryptophan, are limited in corn distillers dried grains with solubles (DDGS). These amino acids are currently added as supplements to enhance the nutritional value of DDGS. Corn with higher levels of these amino acids is of particular interest to the livestock and poultry community. The objectives of this study were to evaluate transgenic corn hybrids (with high Lys and Trp contents) for ethanol yields and nutritional value of DDGS. Two corn hybrids (I and II) and their transgenic (*TG*) isolines (I:*TG* and II:*TG*) were processed using laboratory scale procedures: conventional dry grind and modified dry grind process using granular starch hydrolyzing enzyme (GSHE). Crude protein contents of transgenic hybrids I:*TG* and II:*TG* (13.3 and 11.5%) were higher than their control isolines (9.70 and 10.8%). Total Lys and Trp contents in corn were 2.5 and 3.5 times higher in transgenic hybrids I and II than their control isolines, respectively. Final ethanol

yields for transgenic hybrid I:*TG* were 16.7 and 16.1% v/v with conventional dry grind and GSHE process, respectively. This was lower compared to its control isolines: 18.5 and 17.8% v/v with conventional and GSHE process, respectively. Final ethanol yield of transgenic hybrid II:*TG* was 16.3% and lower than the control isoline (17.4% v/v) with conventional process. However, with GSHE process, ethanol yield for transgenic hybrid (II: *TG*) (17.5% v/v) was similar to its control isoline (17.1% v/v). There were no differences in the amino acid profiles in the recovered DDGS from conventional and GSHE processes. Total Lys and Trp contents for transgenic hybrids were in the range of 1.35 to 1.53% w/w and 0.31 to 0.38% w/w, respectively and are higher than the amino acid levels in normal DDGS (an average of 0.7 to 0.8% Lys and 0.2% Trp) and meet the necessary nutritional requirements for broilers and egg layers.

303-P

Starch analysis of self-pollinated and open-pollinated common corn in Taiwan

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Recently, the common corn is promoted to be cultivated in Taiwan by Council of Agriculture (COA), Taiwan, under two chief considerations of adjusting farming system to revitalize farmland and elevating country's food security. In this study, the physicochemical properties of the self-pollinated and open-pollinated maize seeds of four most popular common corn varieties (Tainug No. 1 (TNG1), Tainan No. 24 (TNA24), Ming-Fong No. 3 (MF3) and Ming-Fong No. 103 (MF103) are analyzed. The results found that the self-pollinated TN1 and Tn24 have higher contents of amylose and crude fat than MF3 and MF103. The thermal and pasting properties of TNG1 are significantly different from the others but there is no specific relationship among the open-pollinated maize seeds. The highest peak and final viscosities of TNG1 starch suspension are attributed to it's the highest content of amylose and the largest of averaged molecular weight. The lower pasting temperatures (including onset, peak and conclusion temperatures) and enthalpy (deltaH) of TNG1 starch suspension are related to its fine structure of amylopectin; that is, the TN1 has more short chains and larger ratio of short chains (DP 6-24) to long chains (DP ≥25). As a result, the controlling and keeping the characteristic physicochemical properties of starch from the specific corn cultivar is very important and should be taken into consideration when the cultivation of common corn for food applications is promoted.

304-P

Microscale structure and thermal and pasting properties of sweet corn and cow cockle starches

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Small-granule starches are important models for studying the structure and function of starch, including the digestion, thermal, and rheological properties, as well as the interactions among individual starch granules and between starch granules and other food components. Small-granule starches were isolated from sweet corn and cow cockle (*Saponaria vaccaria*) by alkaline extraction method. The microscopic structure and the thermal and pasting properties of both starches were compared with those of rice and maize starches (waxy and normal). Sweet corn starch (SCS) granules showed high degree of heterogeneity and complexity, in which two populations of granules were identified. The larger population consisted of the polygonal or rounded granules, whereas the smaller population was composed of smaller granules that displayed compound structures. Cow cockle starch (CCS) granules were polygonal in shape and their size was around 500 nm. Based on the X-ray diffraction patterns, CCS was classified as A type, and SCS was in the transitional state between A and B type. The gelatinization temperature ranges of SCS and CCS were at 59.4-91.2°C and 58.9-87.2°C, respectively. Importantly, the enthalpy change for SCS gelatinization was only half of the values for the other five types of starch, suggesting much less interactions among the glucan chains of SCS granules. The pasting properties of both SCS and CCS were investigated using rapid viscosity analyzer. For SCS, its final viscosity was about 1/5 to 1/8 of those of various maize and rice starches. For CCS, its pasting performance was distinct from those of typical starches, showing no breakdown and setback. This study provides some basic information on the two small-granule starches, which may have potential for various industrial applications.

305-P

Distribution of acetyl group in acetylated maize starches synthesized in aqueous medium

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High degree of substitution (DS) starch acetate is a useful thermoplastic material interested by materials industry; however, conventional preparation of such involves heavy uses of organic media which lead to high cost and purification difficulties. In this study, waxy, normal, and high-amylose maize starches were acetylated to various

DS in aqueous medium catalyzed by concentrated NaOH and the substitution pattern of the acetyl group on glucose monomer was characterized for the first time. The DS values were in the order of high-amylose maize starch (DS 1.72) > waxy maize starch (DS 1.60) > normal maize starch (DS 1.03) when same amount of acetylating reagent was added. The acetylation efficiency was improved by a stepwise procedure, repeatedly filtering and resuspending the starch between each addition of acetic anhydride. Starch acetates were further fully esterified to DS 3.0 using acetic anhydride-d6 or propionic anhydride in pyridine. Complete substitution remarkably improved resolution for 1H NMR spectrum and allowed acetyl group at different hydroxyl positions to be quantitatively calculated. Because propionyl -CH2- signal overlapped the acetyl C6 proton signal at 2.1 ppm, we confirmed that deuterated acetyl group was a preferred secondary substituent over propionyl group. For starch acetates prepared in aqueous medium, C2 and C3 were preferred reaction sites at DS lower than 0.14. At DS 1, the distribution of acetyl groups was ca. 44%, 32%, and 24% at C2, C3, and C6 positions, respectively, regardless of the ratio of amylose to amylopectin in native starch. Future works involving applications and structure-function relations of starch acetates and other derivatives can be studied based upon these results.

306-P

Molecular size and shape changes in waxy maize starch during dextrinization

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The conformational properties of cold water-soluble pyrodextrin from insoluble native waxy starch were investigated using high performance size exclusion chromatography (HPSEC) coupled with multiple detectors for the first time. Pyrodextrin was prepared by adjusting waxy maize starch slurry pH to 2 or 3, filtering and drying at 40°C, and then heating at 150°C or 170°C for 0.5-4 h. The cold-water solubility of the pyrodextrin was from 64.7% to 100%. The gel permeation chromatography (GPC) results indicated that the molecular size was altered after dextrinization. At the end of dextrinization, the molecular weight was in the order of pyrodextrin at pH 3 and 150°C > pH 3 and 170°C > pH 2 and 150°C. The pyrodextrin with higher solubility in water had smaller molecular size, lower average molecular weight, lower intrinsic viscosity and lower hydrodynamic radius. The measured Mark-Houwink a (0-0.5) indicated a spherical conformation of pyrodextrin in aqueous solution.

307-P

Effects of pullulanase activity on debranching of waxy maize starch and digestibility of debranched products

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Resistant starch (RS) is notable for having several health benefits in humans, including glucose control and intestinal well-being. Pullulanase is able to debranch amylopectin and result in higher RS content in waxy maize starch. Different levels of pullulanase have been used to debranched waxy maize starch in the literature, but the changes of structure during debranching are unknown. In this study, waxy maize starch was cooked and debranched with 80, 160 and 240 NPUN/g starch pullulanase. One pullulanase unit (NPUN) was defined as the amount of enzyme, which, under standard conditions, hydrolyzes pullulan, liberating reducing carbohydrate with reducing power equivalent to 1 μmol glucose per minute, and crystallized at 25°C. The structure of waxy maize starch during debranching was investigated and the digestibility of the debranched products was measured. When pullulanase was increased from 80 to 240 NPUN/g, more amylopectin was debranched in same debranching time, and the degree of crystallinity and the RS content were increased. After the debranched starches were crystallized at room 25°C for 24 hours, the RS contents were greater than 63%.

308-P

Understanding the mycobiota of native maize from the highlands of Guatemala, and implications to its quality and safety

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Maize is considered a staple crop in Guatemala and is consumed in high amounts in the rural areas of the country. Given that traditional pre- and post-harvest practices lead to environmental exposure to pests and microorganisms, maize quality and safety can be compromised severely. In order to assess the potential degree of risk, maize from six farms from Huehuetenango, Guatemala were evaluated based on their mycobiota. For all of the farms, moisture levels during storage remained above 14% increasing the possibility of fungal colonization. Fungal load was estimated using DRBC agar. Moreover, DNA was extracted from the maize samples, and ITS1F-TW13 amplicons were subjected to Illumina sequencing. Overall, fungal counts from harvest and throughout storage were constant at approximately 5 log CFU/g. For the farms where the maize moisture content exceeded 20%, a high yeast content was observed which can reflect spoilage during storage. Findings showed a significant amount of *Fusarium*, a mycotoxin-producing mold, which could lead to mycotoxin contamination. This

indicates a potential for compromising the health of the inhabitants of the region where maize represents a significant portion of the diet. Moreover, fungal endophytes *Stenocarpella maydis* and *Acremonium* sp. were also found in significant amounts across farms, indicating damage of the maize plant. Insect damage is another indicator of risk as it may result not only in entry points for fungi but can also act as vectors for such microorganisms. An entomological analysis revealed an overall incidence of *Ephestia kuehniella* (flour moth) of 32%, *Sitophilus zeamais* (maize weevil) of 16% and *Tribolium* sp. (flour beetle) of 8% for the analyzed farms. Results from this study can help better understand the current health-risk scenario in the Highlands of Guatemala incurred by performing poor grain handling practices.

401-P

Variations in rice grain quality traits across locations in Africa

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Rice breeding efforts in sub-Saharan Africa have been largely skewed towards yield enhancement and stress tolerance to the detriment of grain quality traits, as such the quality of locally produced varieties remain variable. This study sought to assess variations in the grain quality traits of rice varieties including predominantly grown ones in this region and to identify those with both high grain quality and high yield that could serve as potential donors in breeding. Forty five (45) varieties were grown under irrigated lowland conditions in Benin and Senegal with two trials in each country. Wide variations in grain quality traits were observed among varieties. Cluster analysis was performed using, paddy yield, head rice yield (HRY) and chalkiness across the four trials. About 68% of total variation was explained by 5 groupings. One group having seven varieties (Sahel 108, WITA 10, IR64, Afrihikari, BG90-2, WAT339-TGR-5-2 and WAT311-WAS-B-B-23-7-1) was characterized by high HRY and low chalkiness across the trials. In this group, Sahel 108 generally had the highest paddy yield in the four trials, and IR64 and Afrihikari had intermediate and low amylose content respectively, with the rest being high amylose varieties. Another group of eight varieties consisting of B6144F-MR-6-0-0, C74, IR31851-96-2-3-2-1, ITA222, Jaya, Sahel 305, WITA 1 and WITA 2 was characterized by high paddy yield but poor grain quality. There is potential within existing varieties for improving quality of rice cultivated in West Africa.

402-P

Kernel and starch properties of United States and imported medium/short-grain rice

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The production of medium/short-grain rice in the mid-southern United States rice-growing region is increasing. This work aimed to identify the quality traits of importance to the markets for these grain types. Twenty-five medium/short-grain milled rice samples were collected and analyzed for physical, gelatinization, pasting, and starch structural properties. Six samples were from Arkansas (AR), five were from California (CA), and fourteen were imported (IM). Cluster and principal component analyses showed that the AR samples had greater gelatinization temperature, enthalpy, and percentages of amylopectin long chains (B2 and B3 chains) but lesser kernel whiteness, total setback viscosity, and percentage of amylopectin short chains (A chains) than the CA samples. With the exception of one sample from Taiwan, chemometrics indicated that the IM samples differed from the AR samples (Cluster A) in some properties and were grouped into three clusters (Clusters B, C, and D). Cluster B samples had properties that were similar to the CA samples; Cluster C samples had lesser gelatinization temperature and peak viscosity but greater percentages of amylose and A chains than the AR samples; Cluster D samples had lesser paste breakdown but greater final viscosity and percentage of B1 chains than the AR samples. Kernel width, color, and chalk were the primary sources of variation in milled rice appearance. In relation to structure and functionality, the percentages of amylopectin A and B3 chains, and amylose content were the major sources of variation.

404-P

The effects of rice flour and corn starch on estimated glycemic index of rice vermicelli

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Taiwanese rice vermicelli (mi-fen) is the traditional food in Taiwan, which is made with higher amylose long rice grain or rice flour and water. A glycemic index is considered to be one of the important objective indices for changes in blood sugar level in human body. The glycemic index of rice vermicelli would be affected by raw material and processing. Rice vermicelli is predominantly made with high amylose rice which inherently has a lower GI. Because of the cost and quality concerns, the main material rice which is made by Taiwanese traditional rice vermicelli was replaced by starch in recent years. As a result, less rice shall be added to this product. The objective of this study was to analyze the estimated glycemic index (eGI) and texture of rice vermicelli using corn starch, dry-milled rice flour and wet-milled rice flour. The results showed that vermicelli made with long rice

flour which has lower eGI (65~80). However, using corn starch on vermicelli making had higher TPA force value and lower cooking loss (3.5~5%), but there was no significant difference in cooking yield. Additionally, the vermicelli with dry-milled flour has lower eGI than wet-milled. To conclude, traditional Taiwanese rice vermicelli made with rice flour has more potential in lower GI and therefore, good for diabetic consumer.

405-P

A systematic review of the effects of sustainable production practices on rice quality and nutrient content

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Demand for rice labeled as sustainably or organically produced is growing globally. Consumers state that such rice is nutritionally superior to its conventionally produced equivalent, as well as being better for the environment. Organic rice farmers in the US report that the major challenges involved with increasing yields are weed control, nitrogen supply and stand establishment. There is no documented agreement on the influence of sustainable production practices on rice quality and nutrient content. A systematic review of research related to this gap in the literature was performed using the following search strategy. Scholarly articles published in the last 25 years were identified by searching five databases that house different journals, using the following terms: rice, organic, sustainable, nutrition, quality and various synonyms. After examining the titles and abstracts of the 12,757 articles first identified as being potentially relevant, 40 were selected for further evaluation. Four additional articles were added to this group by reviewing the reference lists of those 40 articles. For various reasons, 27 of the 44 articles were deleted. The nutritional characteristics studied were minerals, vitamins, and several phytochemical fractions such as gamma-oryzanol, tocols and phenolics. Amylose content, gelatinization temperature, kernel elongation and cooking loss were the traditional quality parameters evaluated. The impact of sustainable production practices on these traits will be discussed. The research materials and methods used in these studies included substantial variation in the cultivars studied, amendments added and analytical procedures used. Consequently, identifying conclusions across the studies was difficult. Recommendations for future work that will result in generalizable conclusions will be addressed.

407-P

Characterization of broken rice kernels caused by moisture-adsorption fissuring – an extended study

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Fissuring caused by rapid moisture adsorption generates appreciable amounts of broken kernels upon milling, thereby reducing the economic value of rice. This study investigated the extent of kernel fissuring and resultant milling yield in rice lots that had incurred various levels of moisture adsorption-induced fissuring, as well as the physical and functional characteristics of broken kernels that resulted from milling such lots. Roy J, CL XL745 and Jupiter cultivar lots were conditioned to 9, 11, 13, 15, and 17% initial moisture content (IMC) levels, rewetted in water at 30°C for 2 h, gently re-conditioned to 12% moisture content (MC), and then milled. Results showed that as IMC prior to rewetting decreased, the extent of fissuring increased, and hence, milling yield decreased. The mass-distribution of broken kernels was different between long-grain (LG) and medium-grain cultivar lots and also between the two LG cultivar lots. Peak and final viscosities were greatest for head rice, and decreased significantly with decreasing size of brokens. Although further investigation of the physical and functional characteristics of broken-kernel fractions is needed before conclusions on practical significance can be drawn, the paste viscosity-trends suggest that brokens of different sizes may have different functional properties and hence, may be best suited for different end-use applications.

408-P

The effects of nitrogen treatment on crack formation during wetting in rice

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Head rice yield is the most important quality measure in rice production. The presence of cracks in rice grains is a contributing factor to reduced head rice yield and altered functional properties. In the Australian rice breeding and quality program, cracks in dry, uncooked milled rice have been measured for many years; recently, measuring cracks in soaked rice has been identified as a better predictor of acceptable cooking properties, but this method is time consuming and very subjective. The main objective of this study was to develop an automated image analysis procedure using a digital camera and ImageJ to quickly quantify cracks in soaked grains to reduce operator error. The second objective was to understand the effect of nitrogen application on the wet cracking tendencies in rice grown in southeast Australia during 2014 and 2015. Koshihikari, a premium Japanese short grain variety, exhibited more cracks in wet grains than Opus, an Australian semi-dwarf short grain variety, for all treatments in 2014 and 2015. Nitrogen application showed lower wet cracking (37% and 40% compared to 47% for nil nitrogen) in Koshihikari whereas nitrogen application was similar for all treatments in Opus (38% and

42% compared to 39% for nil nitrogen). Our results indicated that Koshihikari is more susceptible to wet grain cracking than Opus and that nitrogen application and timing may be optimised to reduce cracking and thus improve consistent cooking quality.

409-P

Impact of parboiling feedstock in the simultaneous fortification of rice with iron and zinc

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Rice is the staple food of more than three billion people worldwide; hence, it is a valuable vehicle for nutrition improvement through micronutrient fortification. This work investigated the effect of parboiling on the simultaneous fortification of rice with iron (Fe) and zinc (Zn) using rough rice and brown rice as feedstocks. Ferrous sulfate and zinc sulfate were the sources of Fe and Zn, respectively. EDTA was added as an absorption enhancer at a fixed EDTA:Fe molar ratio of 1:1. Three fortificant concentrations (0, 100, and 200 mg/L for both Fe and Zn) were tested and two long-grain rice cultivars (CLXL745 and RoyJ) were used as test samples. Parboiling was accomplished by soaking rough rice or brown rice in the fortificant solution (1:2 ratio) at 70°C for 3 h, followed by autoclave-steaming at 115°C for 10 min, and then gentle drying to a constant weight at 26°C and 65% relative humidity. When rough rice was used as the parboiling feedstock, the Fe content of milled parboiled rice was 7.0-16.7 mg/kg for CLXL745 and 7.2-15.0 mg/kg for RoyJ. The Zn content of these lots was 21.7-32.9 mg/kg for CLXL745 and 22.0-35.0 mg/kg for RoyJ. With brown rice as the feedstock, the Fe and Zn content of milled parboiled rice from CLXL745 were 33.1-87.9 mg/kg and 46.2-72.1 mg/kg, respectively; that from RoyJ were 32.6-73.8 mg/kg and 48.2-88.4 mg/kg, respectively. Differences in head rice yield, color, and pasting characteristics were mainly attributed to cultivar and feedstock, and not fortificant concentration. Results indicated that brown rice is a better feedstock than rough rice for micronutrient fortification via parboiling.

410-P

Effect of soaking temperature on the healing of fissured rough rice kernels

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Internal stresses due to moisture and temperature gradients often result in the development of rice kernel fissures. Fissured rough rice kernels tend to break upon milling and potentially reduce the market value of rice. This work was conducted on the premise that kernel fissures may be healed by soaking in water at a specific temperature and duration. Fissured rough rice kernels of a long-grain cultivar, Wells (with a moisture content of ~12% and an onset gelatinization temperature of 73.0°C), were selected by X-ray imaging using a tabletop digital radiography system. Fissured kernels were soaked in a water bath at five soaking temperatures (60, 65, 70, 75, and 80°C) and three soaking durations (1, 2, and 3 h). Soaked kernels were then gently dried to a constant weight at 26°C and 65% relative humidity for characterization. Digital X-ray images revealed that soaking at 75°C for 3 h healed up to 70.0% of the fissured kernels. Soaking at 60°C did not result in healing; fissures even worsened on the lots soaked for 1-2 h. Soaking at 65 or 70°C for 3 h healed 17.5% of the fissures; healing did not occur on the lots soaked for 1-2 h. Soaking at 80°C for 2 h resulted in 35.0% healing; the lot soaked for 3 h turned mushy, hulls split, some particles leached into the soaking water, and was not subjected to X-ray imaging. Bending tests using a texture analyzer showed that brown rice kernel breaking force increased from 12.0 N of fissured kernels to 43.5 N of healed kernels. Soaking rough rice in water at a temperature slightly above its onset gelatinization temperature may potentially repair fissures.

411-P

Enhanced GABA Synthesis in Rice Bran by Anaerobic Incubation and Glutamate Addition

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Gamma-aminobutyric acid (GABA) is one of the bioactive amino acids found in grains and its biosynthesis may be accelerated by applying a physical stress. Rice bran (RB) which is one of the common source of GABA was treated by an anaerobic incubation with nitrogen gas at 40°C for 5 h after an adjustment of moisture content to 30% with an electrolyzed water. With the addition of electrolyzed water (pH 3), the anaerobic incubation increased the residual GABA content from 28.3 mg/100 g RB to 176.1 mg/100 g RB. A minor addition of glutamate (20 mM) to RB further raised the GABA content to 669.4 mg/100 g RB, which was approximately 24 times higher than that in native RB. The conversion rate of glutamate to GABA was 88.5%. The GABA was extracted from the treated RB in different solvents (distilled water or aqueous alcohols: 50% or 70% ethanol) under different conditions (20-70°C and 6-90 min). Extraction in 70% ethanol for 6 min at 20°C appeared most effective for GABA recovery, and the GABA content in the extract was 1013.5 mg/100 g RB. It was approximately 35.7 times higher than that in the native rice bran. The extract may be concentrated by vacuum evaporation to

remove residual alcohol and to raise the GABA content. The rice bran GABA extract prepared by the anaerobic incubation may be used as a bioactive ingredient for various food products.

501-P

Effect of controlled germination on the functionality of sprouted whole-wheat flour

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Germination is a natural and efficient approach to improve nutrients and bioactive compounds of seeds through activation of dormant enzymes during sprouting. Nevertheless, over-sprouting may reduce the mixing strength of wheat flour, resulting in sticky dough and smaller loaf volume. Controlled germination could be a solution to improve the nutritional benefits while maintaining the end-use performance of whole-wheat flour (WWF). This study was undertaken to investigate the effect of germination time on WWF functionality. Three classes of U.S. wheat were used in the controlled germination process, including hard red spring (HRS), hard white (HW), and soft white (SW) wheat. After germinating from 5 to 24 hours, the sprouted wheat was dried (800C, 3 hours) for WWF milling and quality analysis. Falling number (FN), glucose and protein content were determined by sampling hourly from 5 to 15 hours of germination. The Mixolab test was performed to assess dough mixing and starch pasting properties of selected WWF with FN values in the ranges of 100-200, 200-300, 300-400, and 400-500 s. Wheat FN values before germination were 478 (HRS), 519 (HW), and 381 s (SW), but they decreased from 435 to 56, 482 to 65, and 345 to 57 s, respectively, during 5 to 24 hours of germination. The glucose content increased by 4-37% and 227-357%, respectively, after 5 and 15 hours of germination. Protein content was not significantly changed during 15 hours of germination. The Mixolab test showed that C1 (development time), stability time, and C2 (protein weakening during heating) increased, whereas C3 (pasting viscosity peak), C4 (pasting viscosity minimum torque), and C5 (retrogradation final torque) decreased after germination. This study indicated that the controlled germination process could improve the end-use performance of WWF in bread and other products.

502-P

Nitrogen and fungicide management for improved field performance and flour functionality in Ontario hard wheats

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Nitrogen management is the most significant input cost to wheat producers. The recent surge in fungicide use on wheat in Ontario has impacted nitrogen management and response, but the extent of the impact on field performance and end-use quality is not known. The objective of this study was to identify optimal nitrogen (N) and fungicide (F) management strategies in Ontario for field performance and end-use flour functionality. First year field scale trials were conducted in 2014 to determine N response curves for hard winter (6 sites) and spring wheat (4 sites) at 5 N application rates with (F) and without fungicides (NF). Grain samples were collected for standard and advanced quality analyses including flour yield, protein and ash contents, Farinograph and gluten aggregation parameters, insoluble protein, secondary structure, and bake tests. N response curves showed the largest incremental yield gains between 0 and 60 lb N/ac. This amounted to 20.8 bu/ac and 16.2 bu/ac for F winter and spring wheat, respectively, but dropped to 18.0 bu/ac and 6.8 bu/ac for NF wheat. Cost analysis of the N response curves showed the most economical rate of N application (MER-N) to be 90 lb N/ac for spring wheat (F and NF), and 120 lb N/ac for NF and 150 lb N/ac for F winter wheat. Quality parameters including grain and flour protein, Farinograph parameters, and gluten aggregation were significantly affected by N rate but not F treatment. Insoluble protein content trended higher in F wheat, and secondary structure trends were apparent with F treatment. However, bread loaf volume did not reflect these trends. The first year results for F vs. NF wheat show N response curves and MER-N that deviate from current Ontario guidelines. Quality appears unaffected outside of the influence of N on protein content. Two more years of field trials are in progress to verify and refine these findings.

503-P

Solubilization and Structural Characterization of Arabinoxylans from Wheat Bran

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Wheat bran was dissolved using a novel solvent to elucidate structural and chemical composition information. This dissolution procedure was to dissolve a majority of the wheat bran and preserve the structural integrity of the dissolved polymers. Structural and chemical information from both the dissolved and undissolved fractions

were reported. The structure of the extracted non-starch polysaccharides were investigated using a 12% urea and 7% sodium hydroxide solvent. The extraction procedure involved the repeated cooling of the solvent bran mixture to -12.6°C and then agitating it at 25°C. When this procedure was applied to wheat bran, 84.14% was solubilized. Ethanol precipitated solubilized bran material, which was 43% of the bran, had an A/X ratio of 0.93. The undissolved fraction was constituted of 9% of the original bran arabinoxylan with an A/X ratio of 1.04 and 59% cellulose. These A/X ratios are similar to those found in the bran pericarp layer. The unextractable AX in the undissolved bran fraction was composed of highly branched arabinoxylan possibly physically and/or chemically linked to other cell wall components. The molecular weight range of the precipitated bran material was 3,420,267-43,495. The molecular weight was confirmed by using a pullulan standard. The average molecular weight of the precipitated bran material was 620,026. This procedure dissolved wheat bran while preserving high molecular weight polymers for structural characterization. Knowledge of wheat bran structure will increase our understanding of the factors that effect bran solubility, mechanical properties, and processing.

504-P

Understanding the genetics of wheat quality using MAGIC populations

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Wheat breeding requires assessment of both agronomic and quality parameters to ensure the varieties developed meet both farmers and end users requirements. Throughout the breeding process, grain and flour are valuable and scarce – a limiting resource. This limitation and the cost and complex nature of wheat based end-product evaluation mean quality assessment occurs late in the breeding cycle. This creates a bottle neck in wheat breeding programs and can result in agronomically advantageous lines being eliminated late in the breeding cycle. This represents a loss to breeders and growers, and thus robust genetic markers for end-product quality are required to mitigate against this. To identify robust markers of quality CSIRO undertook the development of Multi-parent Advanced Generation InterCross (MAGIC) populations capable of overcoming the limitations of bi-parental and association mapping populations. The resulting 4 and 8 parent MAGIC populations are presently being utilised in a multi-year, multi-site study to identify genetic markers of wheat quality. These assessments include test weight, grain protein, milling yield, water absorption, wet gluten content and straight dough baking. Three site years from the 4-parent, two from Eastern Australia, and one from Western Australia, and four site years (from both Eastern and Western Australia) from the 8-parent MAGIC population are being assessed. Here we present the results from the first analysis of this work and discuss the implications for enhancing breeding for quality traits.

505-P

Development of a mouse model of hypersensitivity to alcohol-soluble proteins isolated from Ambassador soft wheat

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Wheat protein-induced hypersensitivities (e.g., Celiac disease, wheat allergy, non-celiac gluten sensitivity, etc.) are growing at an alarming rate on a global scale for reasons that are largely unknown. To advance fundamental mechanisms underlying these disorders, we developed a mouse model of hypersensitivity to alcohol-soluble proteins (ASP) isolated from Ambassador soft wheat. Wheat flour was prepared and ASP were extracted using established methods. The ASP fraction was characterized by SDS-PAGE analysis. Groups of BALB/c mice were injected with the ASP along with alum five times, at ten-day intervals. Blood collected before and after injection was analyzed for specific IgE, IgG1, IgG2a and IgA antibody (Ab) responses using optimized ELISA methods. Mice received an i.p. challenge with the ASP and were evaluated for hypothermia shock response (HSR) by rectal thermometry. Blood collected after the challenge was analyzed for murine mucosal mast cell protease (mMCP)-1 elevation. The ASP fraction contained nine major proteins (8 with sizes from 12 to 38 kDa, 1 of >170 kDa, smear) and two minor proteins (70, 128 kDa). Upon injection, mice developed time-dependent robust specific IgE, IgG1 and IgG2a, but very little IgA Ab, responses. Systemic challenge resulted in significant HSR, but mice recovered by one hour. There was a significant elevation of mMCP-1 in the blood after challenge, confirming mast cell/IgE Ab mediated anaphylactic reaction. These data demonstrate that this mouse model may be used for basic and applied studies on soft wheat gluten-induced hypersensitivity disorders.

506-P

Wheat bran albumins as organic matrices for artificial bio-mineralization processes

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Proteins from cereal by-products are underutilized so that innovating regarding its use is an area of opportunity. The fraction of wheat bran albumins (WBA) is rich in the amino acids Asp and Glu, which makes them candidates as matrices for artificial bio-mineralization. In this work the abilities of WBA for retaining mineral salts and forming crystals were studied. WBA was reconstituted with water in a 1:10 ratio (w/v) and pH was adjusted to 8 or 10 in order to prepare 2 stock solutions (SS). The SS were subjected to thermal conditioning (TC) at 68.5°C for four time periods (1, 2, 3 and 4 h), after which two types of salt (NaCl and CaCl2), each at four concentrations (0.1, 0.25, 0.5, 0.75 and 1.0 M) were added. The salt gain index (SGI) was determined in the precipitates obtained in each treatment. Through a completely randomized design, factorial arrangement, ANOVA and analysis of means ($p = 0.05$) were performed to determine the effect of pH, type of salt, time of TC (TTC) and salt concentration (SC) on the IGS. The most significant interactions on the IGS were pH-type of salt and pH-SC, followed by pH-TTC and type of salt-SC. The conditions to which the largest SGI was obtained are pH 8, 3h TTC and addition of 0.5 M CaCl2. These latter conditions were reproduced to determine if there was formation of crystals in the process of salt gain. For this purpose the precipitates were lyophilized and analyzed by X-ray dispersive spectroscopy (EDS), scanning electron microscopy (SEM) and X-ray diffraction (XRD). Crystalline formations of nanometric thickness were observed, with an elemental composition in which predominated calcium and phosphorus. XRD analysis confirmed the presence of different polymorphs. It is concluded that the protein extracts of wheat bran can act as templates for biomineralization.

507-P

Does Mill Type Affect Ranking of Hard Red Spring Wheat Cultivars Based on End-Use Quality?

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Hard red spring (HRS) wheat constitutes about 25% of the wheat crop in the United States and is exclusively grown in the Northern Plains states of MN, MT, ND and SD. HRS wheat is known to have high protein content and excellent milling and baking performance. Domestic and overseas buyers pay top dollar for HRS wheat because of its high quality and unique characteristics. This research investigated the overall ranking of HRS wheat cultivars that were milled on Quad. Jr, Quad. Sr, Buhler MLU-202, and MIAG-Multomat roller mills. A cultivar scoring system was developed that considered their milling, flour, dough, and bread-baking qualities. A cultivar scoring system was designed to rank wheat cultivars for scores between 1 and 10, 1 being "average" and 10 being "most desirable". A total of twelve HRS wheat samples from 10 cultivars (Forefront, Elgin, Bolles, 817, Ingmar, Glenn, Dapps, Faller, Focus, and Prosper) were used in this study. Mill type and wheat cultivar had significant ($P<0.001$) effect on the milling, dough, and baking quality scores. Cultivar by mill type interaction did not appear to be so strong as to cause discrepancy in quality evaluation of wheat cultivars since ranking of twelve HRS cultivars was consistent for the overall quality score across different mill types. Based on the overall quality score Bolles, Glenn, and Ingmar cultivars were considered most desirable receiving overall scores of 7.1, 7.1, and 6.5, respectively. In contrast, Elgin, Focus, Forefront, and Prosper cultivars were considered to be average receiving overall scores of 6.0, 5.9, 5.8, and 5.5, respectively. The proposed overall wheat scoring system could assist farmers in selection of wheat cultivars considering the wheat end-use quality. Development of a comprehensive scoring system will also enable a more detailed scoring system for screening new lines for suitable end-use.

508-P

Novel tempering solutions to reduce the microbial load of soft wheat flour with minimal impact on flour functionality

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The initial microbial load of the grain is a safety concern for wheat-based products. The objective of this study were to (i) determine the impact of adding a combination of organic acid and NaCl to tempering water on the microbial load of soft wheat prior to milling, and (ii) to evaluate the impact on the microbial quality and functional properties of the resulting flour. Wheat was tempered to 15% moisture under controlled (18 h, 22-24°C, 60% RH), aseptic conditions by adding water (control) or tempering solutions containing acid (acetic or lactic; 2.5% and 5% v/v) and NaCl (26% w/v). Wheat was analyzed before and after tempering for Total Plate Counts (TPC), yeasts, molds, coliform, and *Enterobacteriaceae* (Eb). The microbial load of the tempered wheat was significantly reduced by all organic acid-NaCl treatments ($p<0.05$). The combination of lactic acid (5%) and NaCl was the most effective against TPC and Eb ($p<0.05$), with an average reduction of 3.1 and 4.5 log CFU/g,

respectively. After milling on a Quadrumat Jr, milled fractions were collected and sieved to separate the bran and germ from flour. Flour was evaluated by the same microbial analysis described for wheat. Additionally, flour functionality was evaluated by Rapid Visco Analyzer and Solvent Retention Capacity (SRC). The microbial load of the flour obtained from wheat tempered with lactic acid (5%)-NaCl was significantly lower ($p<0.05$) than the control flour and no significant differences in pasting properties among resulting flours were observed ($p>0.05$). In addition, there were no significant differences ($p>0.05$) in the SRC values among flours for the sodium carbonate solvent, which indicates that starch granules were not damaged by the tempering solutions. Addition of organic acids and NaCl in tempering water provides milled products with improved microbiological quality, without affecting functionality.

509-P

Validating the impact of particle size effect on the overall whole wheat flour (WWF) baking quality

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Commercial mills have implemented their own milling settings to obtain high quality Whole Wheat Flour (WWF). High quality WWF is influenced mainly by the wheat class and variety used, but also by the milling process. Quality testing was performed to demonstrate differences in WWF milled by different milling settings. Five California (CA) Hard Red Wheat (HRW) varieties were milled with a Osttiroler Stone Mill (Austrian Mill). Three HRW WWF obtained from three different mills were used, WWF1, WWF2, and WWF3. WWF protein content of CA wheat varied from 12.7-14.2%, and commercial WWF from 12.5-12.9%. WWF fine particle yield (FPY) of =150 μm was 40% higher for all CA wheat than commercial WWF. FPY for all samples ranged from 38-87%. Correlations between Water SRC (R2=0.83), Sodium Carbonate SRC (R2=0.90), and Farinograph Absorption (R2=0.87) with FPY were high. Dough rheology testing showed a positive correlation between Mixing Tolerance Index (MTI) with FPY was R2=0.60, and a negative correlation of Mixing Tolerance with FPY was R2=0.60. In addition, Mixograph Right Slope and FPY showed a positive correlation of R2=0.43. Bread loaf volumes for all WWF ranged from 630-710cc. No correlation was found for bread loaf volume and PFY. However, bread texture and appearance made with the high PFY had more open, softer and lighter crumb than the low PFY WWF. In conclusion, the overall dough strength, absorption, handling, and baking quality of WWF is not only affected by the wheat used, but also is highly impacted by the particle size distribution (PSD). The best overall baking quality performance was obtained with the high PFY WWF of CA wheat samples milled by Osttiroler Stone Mill.

510-P

Effects of geographical origin, genotype, and harvest year on stable isotope and multi-element fingerprints in wheat

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The stable isotope and multi-element are effective fingerprints for identifying geographic origin of foodstuff, but it is unclear that how the fingerprints information is affected by factors such as region, genotype, harvest year and so on. Wheat was selected as model plant in this study based on its wide distribution, diverse varieties and genetic uniformity. Experiments with ten genotypes of wheat were carried out in three different regions (Zhaoxian, Huixian, and Yangling) of China in three consecutive growing seasons (2010-2012), with totally 270 wheat kernel samples collected. The stable isotopes (d13C, d15N and dD) and multi-elemental compositions (Mg, Al, Ca, Mn, Fe, Cu, Zn, As, Sr, Mo, Cd, Ba, Pb) were analyzed to investigate the effects and contributions of wheat origin, genotype, harvest year and their interactions on fingerprints for wheat kernels. All the fingerprints were found to be significantly influenced by wheat origin, genotype, harvest year and their interactions using analysis of variances. Region accounted for the largest proportion of the total variation for d13C, d15N, dD, Mn, Sr, Mo, Cd in wheat, and genotypes showed the largest variation contribution for Ba, accounting for 27.34%. Error provided the most variation for Pb, representing 43.13%. Notably, the harvest year provided the most variation for other elements (Mg, Al, Ca, Fe, Cu, Zn and As), explaining 33.65, 29.70, 66.30, 56.88, 56.82, 36.55 and 51.51%, respectively. Geographical traceability of wheat can be successfully realized (100%) using a robust discrimination model with seven indicators (d13C, d15N, dD, Mn, Sr, Mo, Cd) even for wheat from different genotypes and harvest years. This research confirms the validity of geographical traceability using fingerprints and provides powerful theoretical proof for understanding the role of genotype, harvest year on geographical traceability.

511-P

Comparisons of Whole Wheat Bread Baking Methods for Evaluation of Bread Quality

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Whole-wheat bread quality, such as loaf volume and crumb texture, depends on whole-wheat flour characteristics, ingredients, and bread-making methods used. Sponge-and-dough (SpD) method is widely used commercially in the United States. Straight dough (StD) method offers an intermediate fermentation time and is the most widely used method for experimental baking in breeding programs. No-time dough (NoD) method offer process advantages of less space requirement and short processing and operation time, flavor development is poor and product formulation is stringent. This study used four different types of commercial whole-wheat flours with different physical and chemical characteristics to evaluate three different types of bread-baking methods (SpD, StD and NoD). Results showed that the StD and NoD methods required higher water absorption than the SpD method. Loaf volumes of whole-wheat bread made with the SpD method were higher than whole-wheat bread made with other baking methods. Whole-wheat bread made using the NoD method had the heaviest loaf weight, as due to the lack of fermentation in this method. The StD method resulted in the highest variation in baking mix time, baked weight, crumb grain score, and symmetry score. Higher variation is needed to identify differences among flour types as well as cultivars used. StD with an extra 10 min of proofing was found to be the best method for whole-wheat bread in order to see the differences between flour used, especially for different cultivars. This is important to help breeders for evaluation of whole-wheat bread quality. SpD method was not thought to be a suitable experimental bread-making method for quality evaluation of whole wheat flour since it is a great equalizer and showed no significant difference for crumb firmness and crumb grain and texture among whole-wheat bread made from different flour types.

512-P

Extraction efficiency of the wheat bran water-soluble proteins: a comparative study of two dialysis methods

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On a laboratory scale, the study of water-soluble proteins of wheat bran (WB) requires obtaining sufficient quantities of proteinaceous material, from which further purification can be carried out. The usual method of aqueous extraction involves membrane dialysis, which implies the use of large amounts of water, so it is desirable the search of alternatives. In this work, WB was subjected to aqueous extraction (1:10, w/v) and dialysis was performed into cellulose membranes (M1) or through a Sephadex-G75 column (M2); the latter explored as an alternative dialysis method. Both extractions were run at pH 8 because of a higher solubility of proteins at this pH. A third extraction (M3) was performed without adjustment of pH or dialysis, in order to compare the effect of these two variables on the extraction efficiency. The aqueous extracts were lyophilized, weighed and analyzed for protein content as well as subjected to SDS-PAGE for determining the MW profile. The efficiency of the methods was evaluated in terms of the yields of lyophilisate and protein. The lyophilisate yields (g/100 g WB) were 2.0, 1.0 and 6.0, whereas the protein yields (g/100 g lyophilisate) were 26, 6.4 and 7.0 for M1, M2 and M3, respectively. The pH resulting of mixing WB and water was 6.2, i.e. the pH at which M3 was run. The pH or the method of dialysis had no effect on the type of recovered proteins, since nine bands were observed in all the SDS-PAGE gels, with MW ranging from 14.4 to 66.2 kDa. The high protein content in the lyophilisate from M1 suggests that the membrane dialysis is the most effective method; however, the protein recovery in M2 and M3 were similar even when the yield of the M2 lyophilisate was 6-fold lower, so the dialysis through Sephadex on a major scale would be an attractive alternative considering that the water consumption for M1 was 24-fold higher than for M2 or M3.

513-P

Are salt and ascorbic acid needed to evaluate bread wheat flours for gluten strength using small-scale dough mixers?

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Salt and oxidizing agents such as ascorbic acid (AA) are essential ingredients in commercial breadmaking to improve dough handling properties and bread quality. Surprisingly these ingredients are typically not used in routine technological evaluation of dough strength by small-scale mixing. The aim of this study was to investigate the effects of salt and AA in mixograph analysis of gluten strength in a diverse set of 52 Canadian HRW genotypes. The effects of conventional and reduced salt concentrations (1.5% and 0.9%, respectively) and AA (72 ppm) were investigated individually and together at 60% absorption using a 2 g micro-mixograph and compared to a control. Mixing parameters of interest were dough development time (DDT), work input to peak development (WIP), bandwidth (BW) and peak height (PH). Significant 3-way interactions were found between genotype, salt

and AA for DDT, WIP, and PH indicating the complex and genotype-specific nature of interactions in dough mixing. Compared to control doughs, means and ranges of DDT and WIP increased significantly with individual addition of salt and AA, and together. Compared to salted doughs, salt+AA significantly increased means of DDT and WIP, and only increased DDT ranges. Salt but not AA increased PH and BW, and values significantly increased on average with increasing salt concentration. Strong relationships (R>0.96) were found between salted doughs and doughs mixed with salt+AA for all parameters suggesting the incorporation of AA may be unnecessary. Mixing parameters were more strongly correlated to HMW glutenin content (a key factor underlying gluten strength) when determined with salt and AA compared to control doughs. Results as a whole indicate that including salt, but likely not AA, in mixograph analysis enhances discrimination of flours for gluten strength and breadmaking potential.

514-P

Effect of temperature and precipitation on protein composition and baking performance of hard red spring wheat

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The objective of this study was to investigate the effects of temperature and precipitation during growing season on wheat protein composition and baking performance. Five Canadian Western Red Spring (CWRS) wheat varieties (Katepwa, Laura, Lillian, Carberry and CDC Kernen), representing a wide range of dough strength were grown in western Canada in 2010 (9 locations), 2011 (8 locations) and 2012 (9 locations). Flour proteins were extracted using SDS-phosphate buffer with and without sonication and analyzed by size-exclusion HPLC. The ratio of extractable monomeric protein (EMP) to total protein was positively correlated with variation from normal average temperature from the beginning of June to the end of July (r=0.797 to 0.445), though a single variety showed a weak positive relationship. The ratio of total polymeric to total monomeric protein (PP/MP) showed a generally negative relationship with variation from normal average temperature during this period above (r=-0.576 to -0.549). The ratio of unextractable polymeric protein to total polymeric protein (UPP/TPP) showed a generally negative relationship with variation from normal precipitation in July. In turn, EMP exhibited positive correlation with sponge and dough absorption, and energy in bread mixing. PP/MP showed negative correlation with sponge and dough absorption, and bread mixing energy, and positive correlation with bread mixing time. It was the period in anthesis from June to July. It appeared that the temperature and precipitation during this period affected on protein composition of wheat, consequently may have affected on bread making properties as bread absorption, mixing time and mixing energy.

515-P

Comparison of creep recovery test from gluten and dough: Effects of HMW-GS composition

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Effects of high molecular weight glutenin subunits (HMW-GS) on gluten and dough rheology, as well as mixing, extensibility and bread-making parameters of 19 hard red winter wheat flours were studied. Viscoelasticity was evaluated by creep recovery test using rheometer, with parallel plate geometry, 100 Pa of shear stress was imposed and holding by 100 sec, recovery also recorded by 100 sec. Data was fitted to a 6-element Kelvin-Voigt model ($R2$=0.99). *Glu-D1* 5+10 samples had higher loaf volume, resistance to extensibility and values of elastic moduli and viscosity coefficients compared with 2+12. Differences in elasticity *G1* or *G2* and viscosity *G″1* or *G″2* by glutenins attributed to entanglement of short-chain and large-chain sizes, respectively were correlated with quality. Also, *G″2* explained more the variability in loaf volume, as indicated by r=0.57; P<0.0001 compared to *G″1* r=0.45; P<0.01 in gluten. Elastic moduli *G1* and *G2* showed differences among poor and good quality samples. Gluten samples were on average 5.5, 3.1 and 1.6 times less stiff than their respective dough when comparing *G0*, *G1* and *G2*, respectively. These differences suggest that the non-gluten components have high influence in the instantaneous and first Kelvin elements of the model and they are manifested faster compared to gluten components.

516-P

Effect of sample preparation of wheat on Falling Number test

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The Falling Number (FN) test is a popular method to indirectly study the alpha-amylase activity of wheat samples. Uniformity of the sample is crucial due to the significant effect that a small amount of sprouted kernel will have on the test results. A sample size of about 250g is usually recommended for a uniform sample. Although

a smaller sample size would be preferable due to less processing time, it is not known if the sample uniformity would be preserved. Therefore, this study investigated the effect of a smaller sample size on the FN values of soft red winter wheat. Two different sample sizes of 250g (SS1) and 30g (SS2) were used for soft red winter wheat of three different reported FN values: 250sec (L), 325sec (M), and 350sec (H). Samples were first collected randomly by hand for the control (DW). The DW samples were then cleaned and discriminated into two groups: randomly collected by hand (CWC) and randomly collected with a divider (CWD). The samples were then grinded using Udy Grinder with different sieve screens (0.5-, 0.8-, 1.0-, and 2.0-mm). The FN values were measured using 7g of flour from each sample. Statistical analysis was performed using JMP. There were significant differences between CWC and CWD, suggesting that sampling by hand does not replicate the randomizing behavior of the divider. Significant differences were observed between SS1 and SS2 for the L and M samples, indicating that SS2 is not suitable for preparing uniform L and M samples. However, the FN test results for H wheat of sample size SS2 were comparable to the SS1 counterpart. Therefore, the SS2 sampling size can be used reliably for measuring the FN of wheat samples which have sufficiently high FN values.

517-P

Fractionation of wheat bran albumins through size exclusion chromatography (SEC)

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The wheat bran has significant amounts of underutilized proteins, representing areas of opportunity for innovation and added value. Traditionally these proteins are extracted in bulk by alkaline extraction, followed by acid and heat precipitation and occasionally assisted by cell wall enzymes, an expensive method and chemically aggressive. However, is possible obtaining concentrates of the water soluble proteins, or albumins, which after some fractionation step are susceptible of being used in sophisticated applications such as nanotechnology. In this work, by water extraction, dialysis and lyophilization, it has been obtained a concentrate of wheat bran albumins (CWBA) with 45% protein (d.b). Three bands of 15, 52 and 90 kDa were visible in electrophoresis native gels, whereas in SDS-PAGE gels there were 9 bands (7 to 84 kDa), indicating that the CWBA has 3 proteins conformed by several sub-units. The CWBA was fractionated by size exclusion chromatography (SEC), from which two non-protein fractions and 4 protein fractions were obtained. The protein fractions had molecular weights of 102, 58, 15 and 6.5 kDa, respectively, determined by comparing their elution volume with those of SEC protein standards. The analysis of the fractions for monomeric sugars (HPLC-PAD) and by UV-Vis and FTIR spectroscopies suggests that the non-protein fractions contain phenolics, arabinoxylans and/or arabinogalactans. On the other hand, in the 58 kDa fraction there was a significant activity of the enzyme polyphenol oxidase (PPO), an interesting fact because the current purification of PPO by chromatographic methods is a laborious process; here is demonstrated the possibility of being undertaken in a few steps, although deserves further studies. To the best of our knowledge, this is the first report on separation of wheat bran albumins by SEC.

518-P

Cluster analysis of historical and modern hard red spring wheat cultivars based on parentage and HPLC of gluten proteins

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There have been substantial breeding efforts in North Dakota to produce wheat cultivars that are well adapted to weather conditions and are disease resistant. In this study, 30 hard red spring (HRS) wheat cultivars released between 1910 and 2013 were analyzed with regard to how they cluster in terms of parentage and protein fraction composition. Protein fractions were analyzed by reverse-phase HPLC (RP-HPLC) for gliadin proteins and size-exclusion HPLC (SE-HPLC) for unreduced proteins. Differences between the clusters with respect to quality characteristics and the semi-dwarf characteristic were also analyzed. In terms of parentage, the clusters formed were grouped according to the release year of cultivar and semi-dwarf characteristics. Also, some farinograph characteristics showed significant ($P = 0.05$) differences between clusters, indicating improvement of mixing characteristics as a result of breeding efforts. In the dendrograms, based on binary data of gliadin RP-HPLC peaks, the clusters were not grouped according to release year and mixing characteristics. The clusters based on absorbance area data of RP-HPLC of gliadins and SE-HPLC of unreduced proteins showed significant ($P = 0.05$) differences for release year, semi-dwarf characteristics and some farinograph parameters. The cultivar "Granite", which is the only cultivar in the study with the *Rht-8* gene appeared as an anomaly in the dendrograms based on parentage as well as HPLC area data. Overall, the results indicated that the introduction of reduced height genes accompanied improvements in dough mixing and breadmaking quality traits in hard red spring wheat breeding. As per protein data, the results showed that the overall gliadin protein profile was not affected by the

reduced height genes, and that the quantity of certain fractions of gluten proteins changed over the last 100 years of wheat breeding.

519-P

Volatile organic compound profile of whole grain soft winter wheat

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Grain aroma, which is produced by volatile organic compounds (VOCs), is an indicator of grain soundness and a crucial quality attribute, especially for whole grain foods. The VOC profile of wheat grain is, however, either incomplete or has been determined from grain subjected to climatic and disease factors before harvest. To identify the intrinsic VOC profile of wheat grain, grain of nine soft winter wheat varieties was collected at 20, 25, 30, 35, and 40 days post-anthesis (DPA) and analyzed for VOCs using headspace solid-phase microextraction and gas chromatography. Ten compounds, including ethanol, 2-propanone, 2-butanol, 2-methyl-1-propanol, 3-methyl-1-butanol, 2-methyl-1-butanol, 1-pentanol, hexanal, 1-hexanol, and 2-ethyl-1-hexanol, were detected in all nine varieties at all of the DPAs. Five predominant compounds, including 3-methyl-1-butanol, 2-methyl-1-butanol, 1-pentanol, hexanal, and 1-hexanol were determined to be the major VOCs of soft winter wheat grain and quantified as the benchmark VOCs. The concentrations of VOCs were highest at 20 or 25 DPA and decreased with further maturation, except 1-hexanol. Hexanal was the most abundant VOC in five varieties, and 1-Hexanol in four varieties at 40 DPA. Both hexanal and 1-hexanol exhibited significant variation in concentration among wheat varieties, ranging from 1.30 to 2.99 and 1.21 to 5.46 μg/kg of wheat grain at 40 DPA, respectively. Wheat grain stored for a month, pre-harvest sprouted or infected with powdery mildew, scab, or sooty mold exhibited a prominent VOC peak of 2-ethyl-1-hexanol, 1-hexanol, 1-octen-3-ol, hexanal or 3-methylbutanal, respectively. The intrinsic VOC profile of wheat grain could be used as a reference in the determination of soundness for grain with undesirable odor, or that exposed to fungal infection, pre-harvest sprout damage or grain spoilage during storage.

520-P

Effect of damaged starch and NaCl content on dough properties of a Canadian Western Red Spring wheat

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The effect of damaged starch and NaCl content (1 and 2% w/w (flour weight)) on the dough handling properties of a Canadian Western Red Spring wheat cultivar (Roblin) was investigated using rheological methods and a texture analyzer. Three levels of increased damaged starch were produced by remilling the base flour using reduction rolls with decreasing gap sizes. Damaged starch levels of the base flour and remilled flours were 5.42%, 6.23%, 7.30%, and 8.43%, respectively. Rheological measurements showed that the dough complex modulus increased and the loss tangent (tan d) decreased with increasing damaged starch levels in the flour indicating that greater amounts of damaged starch produced stiffer dough. The base flour had the highest creep compliance value (Jmax) whereas the flour with the most damaged starch produced doughs that deformed the least, having the lowest Jmax values. The elasticity of the dough (Jel) was not affected by damaged starch content. Sodium chloride content did not significantly impact the rheological properties of the doughs. The stickiness of the doughs decreased as damaged starch content increased. Doughs produced with 1% NaCl had higher stickiness values than those containing 2% NaCl.

521-P

Relationship between kernel hardness and gluten proteins characteristics

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This study aimed at investigating gluten structural characteristics in dough from wheat cultivars with various kernel hardness. Flours from Branson, Emmit, and TW301020 *cvs.* (7, 24, and 69 SKCS, respectively) were analyzed for mixing properties, gluten aggregation kinetics, protein aggregates formation, thiols accessibility and protein conformation. Farinograph profiles were related to the kernel texture, with soft wheats (Branson and Emmit) having lower water absorption, development time, and stability than hard wheat (TW301020). Unlike the farinograph profile, Branson and Emmit exhibited different gluten aggregation kinetics, with Branson having longer aggregation time and higher aggregation energy, suggesting a stronger gluten network than Emmit. Protein structural characteristics highlighted that proteins in dough from Branson and TW301020 were more compact (low SDS-accessible thiols, low exposure of hydrophobic sites on the protein surface) and ordered (low levels in random coils) than in dough from Emmit. In addition, high levels of β-turns in Emmit dough may account for the fast gluten aggregation kinetics, compared to Branson. Interestingly, Branson resulted in bread with a higher specific volume than Emmit (3.6 and 2.9 ml/g, respectively), with TW301020 having the highest

value (5.0 ml/g). In conclusion, wheat samples showing similar mixing profile may have different protein interactions during mixing which will affect product performance. Not all soft wheat would form a weak dough; the ability of flour to produce a dough characterized by a compact protein network is independent of the kernel texture but it is rather related to the nature of inter-protein interactions.

522-P

Effect of genotype and growing location on grain and whole durum wheat flour and pasta quality

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The consumption of whole-wheat pasta is increasing due to its nutritional and health benefits. Improvement of whole-wheat pasta quality is essential for continued increase in market demand. Genotype and growing location affect grain quality, which results in differences in semolina and pasta qualities after milling and processing. Therefore, evaluation of genotype and growing location effects on grain, flour and pasta qualities of whole-durum wheat is needed. Six genotypes of durum wheat grown at Langdon, Williston and Minot, ND were selected. Grain, ground flour, textural and cooking qualities of pasta made from whole-durum wheat were evaluated. Results showed that falling number and gluten index both varied widely ranging from 358 to 479 s and 23 to 91 among genotypes, respectively. Mixogram peak height and break time for whole-wheat flour ranged from 4.7 to 5.3 cm and 5 to 9 min, respectively. Firmness of cooked whole-wheat pasta ranged from 3.7 to 4.2 gcm. Among growing locations, protein content and falling number of whole-wheat flour ranged from 13.5 to 14.5% and 323 to 508 s, respectively. Mixogram break time ranged from 6 to 8 min. Firmness and cooking loss of cooked whole-wheat pasta ranged from 3.9 to 4.2 gcm and 8.5 to 10.4%, respectively. Pearson correlation showed that firmness and cooking loss both were correlated with kernel protein content, falling number and whole-wheat flour mixogram properties.

523-P

Quality attributes of Chinese steamed bread made from soft red winter wheat flours with waxy wheat flour substitution

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An elevated amylopectin (AP) proportion of starch as observed in waxy and partial waxy wheat is known to have a substantial influence on the textural properties and shelf-life of many wheat-based products. Quality attributes of Chinese steamed bread (CSB) are presumed to be heavily affected by starch amylose (AM)/AP ratio, but much is yet to be verified. Two soft red winter wheat flours of normal starch endosperm were blended with 0-30% waxy wheat flour (WWF) of 5.1% starch AM content and tested for quality attributes of CSB, and moisture content, firmness, soluble starch content and thermal properties of CSB crumb, to determine the effects of starch AM content. The increased proportion of WWF in blends raised the mixograph absorption, probably due to the higher water affinity of AP as compared to AM. The incorporation of WWF increased the specific volume score of CSB from 15.7-16.1 to 18.4-18.4, and decreased crumb firmness from 22.0-21.7 to 11.2-13.3 N. Flour blends with 5-10% WWF, of which starch AM content is 22.4-24.7%, produced CSB of superior crumb structure (CS) without affecting surface smoothness (SS), stress relaxation (SR) and total score (TS). With more than 25% WWF in blends, negative changes in SR, CS, SS and TS of CSB were observed. The analysis of covariance indicated that CSB quality was little affected by protein content and dough strength parameters, indicating that starch AM/AP ratio was mainly responsible for the changes in CSB quality with the incorporation of WWF. Flour blends containing 15-20% WWF to produce a starch AM content of 20.5-22.7% exhibited reduced CSB staling (shown by decreased crumb firmness) and comparable TS to the control wheat flours. CSB prepared with more than 10% WWF exhibited a higher soluble starch content, indicative of reduced starch retrogradation, than that prepared with control flours during storage for 3 days.

524-P

Sensory and Instrumental Measurement of Crispness in the Crumb Texture of Toasted Pan Breads

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Pan bread is the most popular bread in Japan, and it is usually toasted before being eaten at home. Unfortunately, for bread bakers and cereal researchers, an objective test to evaluate the quality of toasted bread is not available. While it is difficult to make stable toasted slices of pan bread, still a quality test is needed to improve the overall quality of Japanese pan bread. To objectively measure, the texture of toasted bread, we chose to use the TA-XT2 Texture Analyzer. Crispness is one of the most important parameters in the evaluation of toasted pan bread. In this study, we focused on crispness of toasted Japanese pan breads, and we made both sensory and instrumental measurements. We found that instrumental crispness of toasted pan bread varied (1) with the openness of its crumb grain, (2) the type of toaster, be it a flat toaster, steam toaster or conventional toaster, (3) the bread making system, and (4) the variety of wheat (source of flour).

525-P

Effects of Whey Permeate on the Quality Attributes of Wheat Flour Dough and Its Pan Bread Products

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Whey permeate is a high-lactose dairy product solid produced through the removal of protein and other solids from whey, and it can offer many benefits to baked products. The objectives of this study were to evaluate the effects of different suppliers and levels of whey permeates on wheat flour dough and its pan bread products, and to identify specific components that may contribute to quality improvement. Two different suppliers and three levels (2%, 4%, and 6%) of whey permeate were investigated. Permeate and lactose products were used to replace sugar (100% and 33.3% substitutions), nonfat dry milk (100% substitution), and salt (100%, 50%, and 25% substitutions) to examine their effects on bread baking performance. Rheological characteristics of wheat flour dough were studied by Farinograph. Pan breads were evaluated for specific volume, texture, general appearance, crumb color, and structure. Replacing nonfat dry milk powder with whey permeate yielded better quality pan bread products (higher specific volume, softer texture, and higher rating scores). More specifically, 2% of whey permeate was an optimum level added in bread formula for a maximum improvement in bread quality with low cost. There was little difference in bread quality improvement between the two different suppliers of whey permeates. Furthermore, whey permeate could partially replace sugar (33.3%) and salt (25% or 50%) with equivalent bread quality to the control.

526-P

Reduction in microbial load of soft wheat by tempering with organic acid and saline solutions

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The microbial flora of wheat grains is the primary contamination source for milled products; therefore, reducing their load is desirable before or during processing. The objectives of this research were (i) to determine the efficacy of adding organic acids and NaCl to tempering water to reduce microbial load in soft wheat prior to milling, and (ii) to evaluate the effectiveness of combining organic acid and NaCl to reduce microbial counts. Wheat was tempered to 15% moisture under controlled (18h, 22-24°C 60% RH), aseptic conditions by adding water (control) or tempering solutions containing acid (acetic, lactic, propionic; 2.5% and 5% v/v) or NaCl (26.6% w/v). Wheat was analyzed before and after tempering for Total Plate Counts (TPC), yeasts, molds, coliforms, and *Enterobacteriaceae* (Eb). After tempering, the microbial load was significantly reduced by all treatments ($p<0.05$), when compared with initial levels. All acids at 5% concentration were able to reduce TPC counts, on average, by 1.9 log CFU/g. Lactic acid at 5% was the most effective against Eb ($p<0.05$), with an average reduction of 3.1 log CFU/g. In order to find a treatment that would further reduce the microbial counts, the tempering assay was repeated with combinations of antimicrobial agents. Wheat was tempered under the same conditions previously described by adding water (control) or tempering solutions containing acid (acetic or lactic; 2.5% and 5% v/v) and NaCl (26% w/v). The microbial load of the tempered wheat was significantly reduced by all organic acid-NaCl treatments ($p<0.05$). The combination of lactic acid (5%) and NaCl was the most effective against TPC and Eb ($p<0.05$), with an average reduction of 3.1 and 4.5 log CFU/g, respectively. Implementation of organic acids and NaCl in tempering water may have the potential to provide milled products with improved microbiological quality.

601-P

Observations on the influence of refinement on functional characteristics of intermediate wheatgrass

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Intermediate wheatgrass (IWG, *Thinopyrum intermedium*) is a perennial crop in the *Triticae* tribe which has received attention due to its potential for development as a grain crop which provides sustainable environmental and nutritional benefits. IWG kernels are smaller than conventional wheat resulting in greater bran and fiber contents on a weight basis. As fiber plays a critical role within the baked product matrix, an understanding of the role of refinement is essential to optimize the functionality of IWG in baked products. Therefore, gluten (Brabender Glutopeak), dough (Brabender Farinograph and Kieffer Dough Extensibility Rig) and starch (Brabender Micro Visco-amylo-graph) functionality of bulk IWG from two crop years and growing locations at varying levels of refinement (0, 25, 50, 75, and 100% bran content) were investigated with Hard Red Wheat (HRW) flour serving as a reference sample. IWG peak torque (PT) values determined by Glutopeak analysis varied by growing location, although uniformly decreased with increasing bran levels. HRW flour however displayed an opposite trend of increasing PT values with greater levels of bran addition. IWG and HRW exhibited greater Water Absorption values with increasing bran addition to attain optimal consistency, with IWG generally exhibiting greater water absorption, and lower development times and stability than HRW blends.

Kieffer Dough Extensibility analysis revealed that IWG doughs displayed considerably lower resistance to extension compared to HRW dough. Additionally, IWG experienced greater relative decreases in extensibility with increasing bran content than HRW. Starch pasting temperatures increased for both HRW and IWG with increasing levels of bran, whereas peak viscosity values decreased with increasing bran addition, with IWG exhibiting lower peak viscosities than HRW.

602-P

Molecular Weight Distribution of Flour Proteins in Intermediate Wheatgrass : Impact on End-Use Quality Parameters

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Thinopyrum intermedium, commonly known as intermediate wheatgrass (IWG) is a perennial crop shown to have both environmental and nutritional benefits. In comparison to wheat controls, IWG has higher protein and dietary fiber contents. However, a deficiency in high molecular weight glutenins (HMWG), an important component responsible for dough strength, was seen for all IWG lines. Therefore, the objective of this study was to understand the protein distribution of IWG lines and its relationship to bread-making quality parameters. Seventeen IWG lines and two wheat controls were analyzed for molecular weight distribution of flour proteins using size exclusion chromatography and subsequent evaluation of bread-making quality. MALDI-TOF and liquid chromatography coupled with tandem mass spectrometry were performed on extracted gluten from IWG sample and hard red winter wheat to determine molecular weight and identify the HMWG subunits. Dough rheological measurements were performed using farinograph and Kieffer following standard procedures. In contrast to wheat controls, IWG samples had lower percentage of SDS-unextractable high molecular weight polymeric proteins (uHMWPP). This fraction of proteins in IWG lines showed a significant and a positive correlation with farinograph stability and Kieffer-resistance to extension, but lower than that of wheat controls. Relative quantity of soluble albumins and globulins were higher in IWG samples than that of wheat. These findings suggest that lower uHMWPP content in IWG samples results in poor dough rheology due to lack of proper gluten network formation. The difference in protein distribution coupled with higher fiber content in IWG may negatively affect the end-product quality. Investigating the effect of fiber content on dough rheology may help identify ways to utilize IWG grain in commercial applications.

603-P

Using steam treatment to enhance storage stability of grains from perennial intermediate wheatgrass

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Thinopyrum intermedium, or intermediate wheatgrass (IWG), is a novel perennial crop with grains that have a competitive nutritional profile and advantageous environmental attributes. With strong agronomic and industrial appeal, IWG has potential to be marketed on a larger scale; however, such an effort requires more information about the grain, including its shelf life. Heat treatment has been shown to be an effective means of elongating storage life of grains by inactivating problematic enzymes responsible for hydrolytic and oxidative rancidity, namely lipase and lipoxygenase respectively. Preliminary studies indicated that these enzymes could be more problematic in IWG than in wheat. IWG and hard red wheat (HRW) control were subjected to six treatments consisting of two steam treatments (present/absent) and three incubation temperatures (4°C, 23°C, and 45°C). Antioxidant activity pre- and post-steam treatment was analyzed using 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) radical scavenging and leucomethylene blue (LMB) assays. Lipoxygenase activity was measured by the ferrous oxidation-xylenol orange (FOX) assay, and lipase activity was determined spectrophotometrically. Throughout storage, samples were analyzed for indicators of hydrolytic and oxidative rancidity, including free fatty acids, hydroperoxides, malondialdehydes, and hexanal. Lipoxygenase activity in IWG subjected to 60 min of steam treatment significantly decreased after two weeks of accelerated storage ($P<0.05$). The antioxidant activity was not significantly affected ($P>0.1$). Also, compared to our HRW control, IWG has a higher content of ferulic acid, an active antioxidant commonly found in wheat. The interruption of enzymatic activity by steam treatment coupled with the preservation of antioxidants could help prolong the shelf life of IWG, ultimately protecting its properties and rendering it marketable.

604-P

Physicochemical properties and *in vitro* starch digestibility of potato starch/protein blends

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In this study, starch-protein interaction, thermal properties, rheological behaviour, gel structure, texture profile and *in vitro* starch digestibility during processing (cooking, cooling and reheating) were investigated in a composite of potato starch/protein blends (0, 5, 10, or 15% potato protein isolate). The effect of protein on starch re-crystallization and short-range ordering in starch were further studied by differential scanning calorimetry (DSC) and Fourier transform infrared spectroscopy (FTIR). DSC and dynamic viscoelasticity showed that protein proportionally restricted starch granule swelling in the blends during cooking, while facilitating amylopectin retrogradation during cold-storage by heterogeneous nucleation and electrostatic complexing, resulting in a more complete overall crystallinity but a less perfect crystallization than in pure starch gel. However, the facilitating effect diminished with the increasing blend ratio of protein, attributed to its high molecular weight and more extended phase separation. FTIR readily detected the short-range ordering from slow retrogradation of amylopectin in processed samples, which proportionally increased with increasing ratio of protein within the concentration used in this study. Cooling of freshly cooked starch/protein blends built new short-range ordering in starch, which could not be completely reversed by reheating. Regardless of processing method (cooking, cooling or reheating), slowly digestible starch (SDS) and resistant starch (RS) contents were positively correlated to the increasing ratio of protein in the blend ($P < 0.05$). It is concluded that heterogeneous nucleation and electrostatic complexing contributed to the enhanced re-crystallization of amylopectin in the blends during starch gelation and retrogradation.

605-P

Effect of Yam Flour on Dough and Bread Quality

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Yam (*Dioscorea* spp) is a high moisture, monocot plant native to Africa and Asia. Yam contains starch, fiber, minerals, protein and lipids, as well as all essential amino acids and vitamin C, which are lacking in wheat. Processing of yam to flour is a necessary preservative measure to reduce economic loss and improve shelf life. This study was done to evaluate the quality of bread made from yam flour blends. Composite flours made from unfermented yam (UFY) flour or fermented yam (FY) flour and bread wheat flour were prepared. The yam flours were added at 5, 10, 15 and 20%. Dough quality of the refined wheat flour and the yam/wheat flour breads was measured using a farinograph. End product quality was evaluated by baking bread according to AACC-I method 10-09.01 and crumb quality was measured with a texture analyzer and C-Cell imaging system. The protein content of the flour blends ranged from 13.8-11.5% (14% MB) and were significantly ($p<0.05$) lower in yam/wheat flour blends. However, addition of the yam flours increases the mineral, vitamin and fiber content of the breads. The farinograph water absorption increased significantly ($p<0.05$) for blends prepared with UFY flour. The loaf volume of the breads ranged from 1092 to 925 cc, and the loaf volume of bread prepared with both types of yam flour remained fairly high. The crumb firmness of the bread with UFY flour was similar to the control bread, but bread with FY flour had significantly ($p<0.05$) higher crumb firmness. The C-Cell image analysis showed that the crumb quality of the breads with yam flours were similar to the control bread. Overall, yam flour appears to be a promising candidate in increasing the nutritional composition of bread, and incorporation of unfermented or fermented yam flour at up to10% appears to give acceptable quality traits in comparison to bread made with 100% wheat flour.

606-P

Soybean, whey and peanut protein isolates as thermal protective ingredients on microencapsulation of *L. plantarum* 299v

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Microencapsulation of probiotic bacteria in alginate, maltodextrin or other matrices helps to reduce the impact of heating process as spray drying, yielding a more stable presentation of the desired microorganism. Despite this protective effect, the microbial viability in final products is reduced up to 4 log cycles, making thus necessary the development of more efficient strategies to retain a higher rate of survival. Protein isolates on the other hand, are increasingly popular as a source of nutrients because of the perception that proteins increase energy levels and support overall health. The development of microparticles with a carbohydrate scaffold, prebiotics as inulin and proteins as thermal-protective agents of probiotic bacteria has not been fully explored and only some reports about the use of whey protein are found in literature. The objective of this work was to determine the thermo-

protective effect of soybean, whey and peanut protein isolates on microencapsulation of *Lactobacillus plantarum* 299v in terms of final viability. The experiments were made using an aqueous mix with alginate (1%), inulin (5%), maltodextrine (5%) and 2.5% of each tested proteins. Mixes were inoculated with *L. plantarum* (4x109 CFU/ml) before a spray drying stage at 130°C. Dry product was collected and diluted in PBS solution, inoculated on MRS agar plates and colony forming units were counted after incubation (48h at 37°C in aerobic conditions). Results show that after spray drying, the reduction of viable cells was roughly 2.5% (not even a log cycle: 1x109 CFU/mL final in the case of whey protein treatment). This study suggests that microencapsulation with 2.5% of protein isolates has a positive effect, making *Lactobacillus* more resistant to the harsh conditions of spray drying, an operation thoroughly used in food industry to produce ingredients at large-scale.

607-P

Relationship between viscosity of β-glucan and its content and molecular weight for developing functional food barleys

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The efficacy of β-glucan in a food in lowering blood cholesterol and glucose is largely related to its viscosity which is a function of its content and molecular structure. This study investigated viscosity of β-glucan in relation to its content and molecular properties in 147 barley samples. Preliminarily experiments were carried out to inactivate β-glucan degrading enzymes in barley in order to be able to measure viscosity of β-glucan. Dry heat, microwave heating and boiling in buffer were evaluated as a means to inactivate enzymes in barley with the use of pure β-glucan as a substrate. The viscosity of β-glucan significantly dropped over time (120 min) in the presence of unheated barley flour. Heating barley flour at 130°C for 120 min or microwaving for 20 min was not enough to avoid degradation of β-glucan. However, boiling barley flour for 10 min was effective in inactivating β-glucan degrading enzymes as indicated by preserving the viscosity of β-glucan. Viscosity of β-glucan in boiled barleys was measured based on the newly developed AACCI method 32-24.01. The sample weight of barley flour was adjusted to provide at least 1% β-glucan slurry in the RVA canister and therefore variations in viscosity among barley samples are related to content and molecular properties of β-glucan. Viscosity was measured at 37°C, monitored over the test time (120 min) and presented at three points (V10, V25 and V75) which represent the three stages of viscosity development (sharp, gradual and steady increase). The barley samples contained β-glucan ranging from 8.2-12.1% with an Mw range from 43,367 to 623,164 g/mol and a viscosity range 231-2191, 326-2575 and 394-2912 cP for V10, V25 and V75, respectively. The results indicate that β-glucan viscosity would be more effective in the development of functional food barleys.

609-P

Effects of defatted distillers' dried grains with solubles (DDGS) on dough and bread quality

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Defatted distillers' dried grains with solubles (DDGS) as a potential source of fiber and non-gluten protein could improve the quality characteristics of bread compared to whole wheat bread. This study was conducted to determine how the addition of different levels of DDGS to hard red spring wheat flour impacts dough rheology and bread quality parameters. Three DDGS samples were obtained from separate ethanol facilities in Minnesota and North Dakota which then were mixed, and milled on a Polymix Micro Hammer Mill at 6000 rpm through a 1.0 mm screen). Lipids were extracted by supercritical carbon dioxide (SC-CO2) using an ISCO SFX 210, and the defatted DDGS were collected. Treatments included 100% HRS wheat flour as a control, flour containing DDGS at (5%, 10% and 15% w/w), and 100% whole wheat flour. Dough rheology characteristics were evaluated by farinograph. Loaves of bread were baked and their quality determined. Results indicated that adding DDGS decreased the water absorption, while increased peak development time at all treatments. The addition of 5% and 10% DGGS increased stability, whereas 15% decreased it. Mixing time was greatest with whole wheat and 15% DDGS. The addition of 15% DDGS and whole wheat bread produced significantly lower loaf volume, symmetry and crumb scores compared to the control and bread containing 5% DDGS. Crumb texture characteristics were reduced with both 15% DDGS and whole wheat bread compared to those of control, 5% and 10% DDGS. Bread containing 10 % DDGS was similar to control bread and was better than whole wheat bread with regard to loaf volume, crust and crumb color, and texture.

610-P

Modified starch as fat replacement: effect on flour and dough characteristics

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Modification of starch with octenyl succinic anhydride (OSA) alters the starch properties in many ways that are beneficial to the food industry. Because of the dual, hydrophobic/hydrophilic, nature of OSA starches they have

applications as emulsifier or fat-replacement ingredients in bakery products. This research investigated changes in flour pasting and dough quality characteristics when octenyl succinate anhydride (OSA) modified starches were added as fat replacers. Dough was prepared with no fat, 2% vegetable shortening, and 2% and 4% OSA modified wheat and tapioca starches. Pasting properties were measured using a rapid visco analyzer (RVA). Gel firmness, dough stickiness and dough extensibility and resistance to extension were measured with a texture analyzer. The peak viscosity ranged from 213 to 252 rapid visco units (RVU). The control sample (shortening) had significantly ($p<0.05$) lower peak viscosity, breakdown and cold paste viscosity than samples with OSA starches. Fat replacers resulted in significantly ($p<0.05$) lower gel firmness and stickiness. Using OSA starches also had an influence on dough quality. Dough stickiness ranged from 215 to 279 mN and dough with OSA modified starches had significantly ($p<0.05$) lower stickiness than dough with vegetable shortening. The resistance to extension was significantly ($p<0.05$) lower for dough with no shortening (251 mN) and dough with vegetable shortening (268 mN) compared to dough prepared with OSA starches. OSA wheat starch dough had significantly ($p<0.05$) higher resistance to extension than the OSA tapioca starch dough. Overall, the OSA starches preformed well as fat replacers, in regards to pasting properties and dough quality. OSA starches reduced gel hardening during refrigerated storage and increased dough strength.

611-P

Modified starch as fat replacement: effect on bread quality

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Using fat in bread production is expensive, and from the diet point of view, fat counts as a high caloric food. Since obesity is a significant problem in the USA and many other countries, food industries are turning to fat replacers. Samples were prepared with no fat, 2% vegetable shortening and 2% and 4% octenyl succinic anhydride (OSA) wheat and tapioca starches. Dough quality was determined using a farinograph. Bread was baked according to AACC-I approved method 10-09.01 with 2 hour fermentation. Bread quality was also evaluated with a C-Cell imaging system and bread firmness was measured with a texture analyzer. Addition of OSA starches significantly ($p>0.05$) increased the farinograph water absorption, without greatly altering the other farinograph parameters. The bread loaf volumes ranged from 930.0 to 741.7 cc. The bread with no fat had the lowest loaf volume and bread with vegetable shortening had the highest loaf volume. Breads with OSA starches had significantly ($p<0.05$) lower loaf volume (746.7-823.3 cc) than bread with vegetable shortening, but significantly ($p<0.05$) higher than bread with no fat. Using OSA wheat and tapioca starches resulted in lower bread firmness during 7 days of storage than the bread with no fat and similar firmness to the bread with vegetable shortening. Bread firmness on day 1 for breads with no fat vegetable shortening was 2.14 N and 1.31 N, respectively. While the firmness for breads with OSA starches ranged from 1.55 N to 1.82 N on day 1. The crumb quality of the breads with OSA starches was similar to the bread with vegetable shortening. Results showed that samples with 4% OSA modified wheat and tapioca starch can be used as fat replacers in bread production. Dough and bread properties in comparison with control sample with 2% shortening had better or the same characteristics.

612-P

Sponge-dough bread quality: using *Kokja* as a fermentation starter

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Kokja, referred to *nuruk* (*Korean koji*), is a natural inoculator and source of amylolytic enzyme, which is used mainly for making Korean traditional wine "*makgeolli*". In this study, *Kokja* was used as a fermentation starter for sponge-dough bread making, and the microbial properties of sponge and the end-use bread quality were evaluated. Sponge prepared from wheat flour, water, and *kokja* (10%) was fermented at 8(FS8), 16(FS16), 24(FS24) hr, and optimally mixed with bread dough ingredients for wheat gluten development. Microbiological properties of fermented sponge were evaluated by lactic acid bacteria (LAB) and yeasts. Carbon dioxide (CO2) production during dough fermentation was determined using a Meissle fermenter. Bread quality determination was crumb moisture, loaf volume, bread crumb firmness and color. Consumer acceptance was evaluated on 6 sensory parameters using a 9-point hedonic scale. Dough fermentation capability was significantly higher in dough with FS16, showing consistently increased CO2 content up to 90 min fermentation. Loaf volume was the highest in bread with FS16 (624.3 ?), followed by FS8(596.7 ?) and FS24(580.0 ?). Addition of the sponge fermented longer time produced breads with blighter than other breads, and also reduced crumb firmness. Consumer ratings on most of the sensory parameters were higher for the breads with FS16. Although further experiment was needed, results indicated that 16 hr fermentation could be feasible to improve sponge-dough bread quality.

613-P

Influence of baking bread dough placed between electrodes of varying distances in an electrical resistance oven [ERO]

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The electric resistance oven [ERO] baking of bread is a well-established process in the manufacture of Panko [a flaky bread crumb used in Japanese cuisine]. Heating of the dough by means of an ERO is based on the principles of Joule's first law and Ohm's law. There is no standardization of ERO baking equipment. One such equipment attribute is the range of distances between electrodes in the bake chamber. This study focused on the effect distance between electrodes had on the rate of heating during baking. The distances between electrodes selected from Japanese literature are: 11 cm, 13 cm, and 15 cm. A Japanese patent bread formula was used in this study. We used constant voltage in this study. The results showed that the smaller the distance between electrodes the faster was the rate of baking. Baking with electrodes at 11 cm distance the dough reached 100°C in 14 minutes while at distance of 15 cm it took 27 minutes. The results showed a steady rise in current [amps] to an initial peak followed by a slight reduction and a second peak coinciding with reaching 100°C. Baking with the electrode at 11 cm distance achieved a first peak of 1.44 amps while at distance of 15 cm the current was peak was 1.06 amps. The electrical current is associated with the available free water and the electrolytes. The steady rise in current during baking would be associated with dough having increased conductivity and upon reaching a peak [near 52°C] began to decline associated with reduction of conductivity. The results showed an increase in dough resistance as the distance between electrodes increased. This study found that distance between electrodes in an ERO baking chamber had significant influences on the rate of heating, amount of current passing through dough, effect on baking time, and effect on changes in conductivity.

701-P

Understanding the digestion kinetic of amylopectin: supramolecular structural heterogeneity governs a-amylase hydrolysis

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Using combined analytical techniques (SEM, synchrotron-SAXS, XRD, DSC, FTIR, etc.), this work provides insights into how the structural heterogeneity on multiple length scales affects the digestion of granular amylopectin. Native amylopectin displayed a dual-phase digestion behavior, as the heterogeneous supramolecular structure of amylopectin endowed the starch molecules with different enzymatic susceptibilities. Alkali disrupted the amorphous matrix, as well as partial growth rings, blocklets, lamellae and crystallites, resulting in weakened amylopectin molecular packing and thus enhanced susceptibility of amylopectin molecular chains to a-amylase molecules. In particular, the stronger alkali (0.5% w/w) more prominently increased the multi-scale structural heterogeneity and even transformed the dual-phase digestion of amylopectin into a triple-phase pattern. These results confirms that the structural heterogeneity of amylopectin predominantly governs its enzymatic digestion, and treatments such as alkali may serve as simple methods to modulate starch supramolecular structural heterogeneity and thus to rationally develop starch-based foods with desired digestibility.

702-P

Interlaboratory evaluation of AACC Method 32-45.01 for the measurement of total dietary fiber

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AACC Method 32-45.01 (AOAC Method 2009.01; Codex Type I method) has been updated to allow for deficiencies identified in the method when it was employed across a diverse range of food materials. These limitations included; the fact that the incubation time with pancreatic a-amylase (PAA)/and amyloglucosidase (AMG) is 16 h whereas the likely time of residence of food in the small intestine is 3-5h; phosphate cross-linked starches (RS4) are underestimated; resistant maltodextrins are produced from non-resistant starch under the incubation conditions used in 32-45.01; fructo-oligosaccharides are underestimated using Sugar-Pak columns (F3 elutes after sucrose); sodium azide preservative is essential with incubation times of 16 h, but is undesirable; sample deionisation for HPLC is tedious; D-sorbitol is not considered to be the best internal standard. In the updated method, the incubation time with PAA/AMG was reduced to 4 h and levels of PAA (5 KCU/assay) and AMG (1.7 KU/assay) were increased. A simplified procedure for deionization of samples was developed and glycerol was introduced as internal standard. HPLC was performed on TOSOH TSK-GELR G2500PWXL gel permeation columns with in-line desalting. This method is currently under evaluation and results will be presented in this paper.

703-P

Assessment of capturing setting and threshold for digital image analysis of bread crumb structure

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In the last decades, the analysis of gas cells size, shape and their distribution in the crumb of baked products is acquiring great interest to assess the effect of process, ingredients and additives without using invasive techniques. In doing that, it is necessary to capture the image of the cross-section and then to use an image software to binarize images applying an algorithm. Nevertheless, capturing settings and the definition of the algorithm require a careful selection to obtain reliable results of gas cells distribution when study bread crumbs. The objective of this study was to determine the impact of the capturing settings and algorithm type in the analysis of gas cells distribution (number of cells, total cells area and circularity) in both wheat and gluten free breads. Crumbs from gluten and non-gluten breads were scanned full scale using different pixel levels per inch (600 ppi-150 ppi) and captured in tiff format. A 50x50 mm square field of view was evaluated for each image. Images analyzed by Image J software showed that the pixels level used significantly affected the number of crumb cells, and the impact was larger when compactness of crumb increased, independently of the type of bread, with or without gluten. Pertaining to the algorithm, cells count and size from digital analysis was dependent on the type of algorithm applied. Even with close thresholds, differences were observed in the number of cells per square cm and total cells area, but barely divergence was exhibited by circularity. Therefore, image digital analysis of bread crumb can be useful for understanding crumb structure, but attention must be payed when selecting capturing settings and algorithm to reproduce the accurate pattern of the baked products and also for comparing purposes.

704-P

Comparison of different nitrogen detection methods after Kjeldahl digestion of dietary fiber preparations

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Just as non-starch polysaccharides, lignin, and other polymers, proteins are part of the plant cell wall. However, they are not included in the definition of dietary fiber. Thus, it is necessary to adjust the dietary fiber fraction for its protein content in addition to its ash content. The official AOAC-Method (2009.01) for the determination of total dietary fiber by an enzymatic-gravimetric method and liquid chromatography recommends using either Kjeldahl analysis or a combustion method for protein determination. Approaches for nitrogen detection after Kjeldahl digestion are not further specified. Therefore, three different nitrogen detection methods were compared with regard to accuracy, precision, and practicability: the conventionally used titration with hydrochloric acid following steam distillation, a spectrophotometric determination based on a method of Willis et al. (1996), and the determination with an ammonia sensitive electrode. The spectrophotometric assay was tested using disposable cuvettes or 24 well plates for high throughput. It was demonstrated that all methods give very similar results, although the standard deviation of the high throughput spectrophotometric assay was slightly higher, probably due to smaller pipetting volumes. In terms of efficiency nitrogen detection by using the ammonia sensitive electrode was found to be a fast and easy to use approach. Finally, the methods were applied side-by-side on soluble and insoluble fiber fractions of several food samples (wheat, buckwheat, wild rice, pear, and asparagus) to demonstrate their applicability on different fiber types.

705-P

Impact of DNA extraction methods on digital and real-time PCR for assessment of genetically engineered traits

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Both real-time PCR and digital PCR are being used for quantitative analysis of genetically engineered (GE) traits. The quality and quantity of DNA varies according to the method used for DNA extraction. There is no information on the impact of different DNA extraction methods on digital PCR for absolute quantification of GE traits. Fast DNA extraction methods are preferred in terms of saving time and resources. Seven Commercially available and relatively fast DNA extraction kits were evaluated for their suitability to quantify GE traits using digital and real-time PCR. Ground seed samples spiked at 0.1% level were used for analysis of three GE events in canola, flax and soybean. RainDrop™ Digital PCR system and ABI 7500 were used for digital and real-time PCR, respectively. Sufficient amount of DNA was obtained for digital and real-time PCR use for most of the kits. One of the kits was not suitable for extraction of DNA from ground samples for all three crops. All DNA extracted using the commercial kits had low Abs260/230 ratios; while some of the DNA had acceptable Abs260/280 ratios. Canola and soybean DNA extracted with many of the kits was suitable for both digital and real-time PCR and the expected 0.1% percentage values were obtained. Flax DNA extracted with many of the kits was viscous and few and erratic target droplets were generated for digital PCR. The information is useful for laboratories involved in analysis of GE traits using digital and real-time PCR.

706-P

A review of *in vitro* methods for measuring glycemic response of foods

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Glycemic index (GI) is a definition used for ranking of foods according to their ability to increase blood glucose levels. High consumption of foods with high GI has a strong correlation with the development of type 2 diabetes, obesity and cardiovascular disease. The main purpose of this study was to review the available methods for measuring the GI of foods. Food GI can be measured using *in vivo* and *in vitro* methods. The *in vivo* method involves human blood testing after consumption of the food and was first introduced by Jenkins et al. (1981). For food labeling purposes, the *in vivo* method is recommended in many countries. However, it is inappropriate for research purposes, product development and quality assurance as it is costly, long, requires human intervention and lacks the necessary discriminatory power to distinguish minor differences in carbohydrate digestibility between foods. To overcome these limitations, various *in vitro* methods have been developed. The methods developed by Englyst et al. (1995) and Goni et al. (1997) are amongst the most cited methods; however recently these methods have been tailored for particular applications. They involve a series of incubations at physiological pH and temperature that imitate human digestion system. Carbohydrates are successively hydrolysed using hydrolytic enzymes including a-amylase and amyloglucosidase and then measuring the glucose content enzymatically or chemically. Recently the *in vitro* method has been automated by developing laboratory instruments but require optimization. The *in vitro* methods are criticized because they cannot mimic human digestion system in the lab and the measured GI values are only an indication of the actual glycemic response as high, low or intermediate. Further research is required to develop methods that are more suitable for measuring GI of foods for commercial purposes.

707-P

Triterpenoid Saponins Quantification from Quinoa (*Chenopodium Wild*) by UV-Vis/GC-MS

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Quinoa (*Chenopodium quinoa* Willd) is an Andean crop with high nutritional value. Saponins are the phytochemicals found in the external layers of quinoa seeds (between 2-5%), conferring bitter flavor that is not desirable by consumers. Quantification of saponins is challenging, since they are a complex mixture of triterpene glycosides that are derivatives from β-amyrin (*3*β-Olean-12-en-3-ol). An attempt was to quantify the total triterpenoid saponins in 28 varieties of quinoa, developing a rapid extraction protocol coupled with a UV-Vis/GC-MS quantification method. The total saponins were quantified using a calibration standard curve of oleanolic acid at ? = 527 nm. The total saponin content (expressed as % oleanolic acid equivalent) ranged from 0.67% (BBR variety) to 3.09% (Red Head variety). Seven varieties were classified as low-saponin content >0.11% whereas 21 varieties were classified as bitter genotypes. A commercial variety (Black) was used as reference (2.7%). Oleanolic acid (OA), hederagenin (HD), serjanic acid (SA) and pytoalaccagenic acid (PA) were identified by GC-MS. PA was the most abundant sapogenin in all samples ranged from 40 to 80% of total content, followed by HD with 15-30%. The formation of PA and the total sapogenin content had a positive correlation of *R2=0.88*. This method reduces time and costs associated with extraction steps. Organic solvent-assisted washing and analytical fractionation were substituted by a hydrolysis step, followed by a liquid/liquid partition, which dramatically decreased the amount of organic solvent used. In conclusion, this methodology presents a potential alternative for a high sensitive quantification of total saponin in quinoa.

801-P

Milling value and behavior during milling of wheat samples from around the world

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Milling Quality is associated with the extraction rate, which is the maximum amount of flour of a certain quality obtained. It is important as even a low yield gap has significant economic consequences. In the milling industry, it is also useful to know precisely the behavior of wheat during milling. Depending on the characteristics of the grain, most flour may be made during the breaking or reduction stage. Therefore, the industrial mill diagram should be perfectly suited to the type of grain used. The objective of this study is to create a map of the world's wheat quality. 150 wheat samples, coming from 17 countries distributed on the 5 continents, are tempered (16% / 24h) then milled on a laboratory mill (LabMill, Chopin Technologies). LabMill's milling diagram consists of 6 consecutive steps: 2 breaking steps (to make flour, fine middlings, coarse middlings, and bran), 1 sizing step (to reduce coarse middlings to flour, fine middlings, and fine bran) and 3 reduction steps (to reduce fine

middlings to flour). As expected, flour production is highly variable from one sample to other. Not only the global quantity of flour (extraction rate changes from 60% to 77%) varies, but also the distribution among the different milling steps (breaking step produces between 20% and 50% of the total flour, sizing step between 16% and 23% and reduction step between 27% and 64%). Consequently, this study confirms the strong variability of wheat quality and the necessity to have tools to predict and evaluate this quality.

802-P

Influence of pre-milling thermal treatment of pulses on end product quality of processed foods

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Pulse flours are an excellent source of nutrients and when incorporated as ingredients in processed food products can improve the nutritional profile. Interest from food processors to use these ingredients in food products is high, however undesirable off flavours found in pulses are a major obstacle to the wide spread adoption of these ingredients by food processors. Pre-treating pulses using various thermal technologies can effectively de-activate or minimize their off flavours, however the effects of these treatments on the end product quality of foods formulated with pulse flours is unknown. In this study whole yellow peas, red and green lentils, chickpeas and navy beans were treated using infrared thermal technology, pin milled into flour and incorporated into various processed food product formulations. Expansion ratio, bulk density and texture (crispness) of directly expanded extruded snacks made with flour milled from thermally treated pulses was assessed and compared to untreated samples. Expansion ratio and bulk density values for thermally treated samples ranged from 3.52–3.75 and 0.050–0.135 g/mL respectively. Significant differences in expansion ratios were detected for extruded snacks made with thermally treated yellow pea, green lentil and navy bean flours. Crispness of extruded snacks was assessed by measuring the number of force peaks determined by instrumental compression and ranged from 213–328 peaks. Significant differences in crispness were detected for snacks made with thermally treated green and red lentil flours. Thermal treatments of pulses prior to milling result in moderate effects on end product end quality of extruded snacks. Similar trends are expected in other processed foods including baked products.

803-P

Impact of rice varieties and milling processes on rice flour and final bakery products quality

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The way rice is consumed is changing constantly. Originally it was only as cooked grain but now rice is also consumed in many other forms. For example, in Japan, rice and wheat flours are combined to create breads with lighter and moister texture. The food industry must adapt to the evolving consumer tastes. It must create new methods for the selection and quality control of rice products. The objective of this study is to contribute to the development of new methods by evaluating the impact of the milling process on both rice flour quality (composition, particle size distribution and rheological properties) and the final bread product quality (volume and hardness). Six rice samples (representing different varieties) were milled using two different processes (roll mills and jet mills). Samples were both tempered and untampered. The flours were analyzed for amylose content, particle size distribution and rheological behavior (using a Mixolab) plus the bread making potential of the finished flours. Mixolab and bread making tests were made using mixtures of rice (30%) and wheat (70%) flours. Amylose content varied from 12% to 32% and was mainly impacted by variety. Particle size was strongly dependent on milling and tempering combinations with average particle sizes varying from 43 µm from untampered dry jet milling to 130 µm from untampered roll milling. Specific bread volume varied from 3.5 ml/g to 4.1 ml/g and presented good correlation (r2 = 0.61) with dough stability (Mixolab C1-Cs). Bread firmness varied from 3000 g to 6000 g and is correlated (r2 = 0.50) with starch gelatinization (Mixolab C3-C2). In the end, these results confirm the necessity to control the rice flour production process to control final bakery product quality. Laboratory analysis, using devices like the Mixolab, are essential to achieve this objective.

804-P

Effect of nitrogen fertilizer application rate on grain, milling and baking characteristics of soft red winter wheat

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The application of nitrogen (N) fertilizer to wheat crops is crucial for achieving maximum grain yield and increased protein content, especially for hard wheat. For soft wheat, on the other hand, relatively little is known about N rate effects on grain characteristics, possibly due to little interest in increased protein content. Two field

experiments, one with spring applications of 0 to 160 lb/acre N fertilizer at two locations for two years and the other with 0 to 160 lb/acre in one location for three years, were conducted and the obtained grain was tested for milling and baking quality characteristics. With the increased N rate from 0 to 160 lb/acre, increases in test weight by 1.3 and 1.7 lb/bu, grain protein content by 2.1 and 2.4% and kernel hardness by 8.6 and 14.3; decreases in kernel diameter by 0.2 and 0.1 mm and kernel weight by 3.5 and 1.3 mg; insignificant changes in flour yield; and a decrease in softness equivalent by 4.0 and 5.7% were observed in the respective field experiments. Lactic acid SRC and SDS sedimentation volume of flour increased from 97.8 to 113.2 % and 91.0 to 95.9%, and from 13.2 to 23.3 mL and 11.5 to 20.3 mL, respectively, in the respective experiments with the increase in N rate from 0 to 160 lb/acre. With increases in N rate from 0 to 160 lb/acre, water SRC significantly decreased by 3.0 and 2.6 mL in the respective experiments, while little to no changes in sodium carbonate SRC of flour was observed. With the increased N rate, harder, smaller and lighter grain with increased test weight, protein content, lactic acid SRC and SDS sedimentation volume was produced. Despite increases in protein content and kernel hardness of grain resulting from the increased N rate, water and sodium carbonate SRCs of flour exhibited either decreases or no changes, which would be desirable for baking soft wheat flour products.

805-P

A systematic analysis of roll speed combinations and resulting roll differentials

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The first break is the most important of the gradual reduction systems in flour milling. Size reduction process is affected by operational parameters of the break rolls as well as the physical properties of the wheat kernels. Roll differential, the difference between the speed of the fast and the slow rolls, is known to affect the granulation. Although there are several studies on the effect of roll differential, the effect of roll speed combinations resulting same differential has not been well studied. The objective of this work was to study the breakage behavior of wheat kernels at constant differentials of varying roll speeds. Experiments were carried out at (1) constant slow roll speed of 144 rpm and varying differentials (i.e. 360:144, 288:144, 216:144), (2) constant fast roll speed of 360 rpm and varying differentials (360:144, 360:180, 360:240), (3) constant differential of 1.5 at varying roll speed combinations (360:240, 288:192, 216:144), (4) constant differential of 2.0 at varying roll combinations (360:180, 288:144, 216:108), and (5) constant differential of 2.5 at varying roll speed combinations (360:144, 250:102, 200:80). Effectiveness of these first break operations were tested for break release, flour yield, particle size distribution, as well as ash and protein content. Both tests 1and 2created coarser particle size distributions at low differential of 1.5, while keeping the slow roll speed constant resulted in a wider distribution gap compared to keeping high roll speed constant. In tests 3-5, faster roll speed combinations at constant roll differentials resulted in production of higher percentage of fine particles.

807-P

Mitigation of rancidity in whole wheat flour through extrusion

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The development of rancidity is a major challenge in whole grain foods. Rancidity can develop in whole grain flour before processing as well as during storage of the finished products. The objective of this study was to determine the storage stability of whole wheat extrudates produced from flour stored in the freezer or at ambient conditions for 6 months. Two lots of whole wheat flour were divided into two portions. One portion was stored at ambient conditions (22°C and 65% relative humidity); the other portion was stored in a freezer (-20°C). After 6 months of storage the flours were extruded using a pilot scale Wenger twin screw extrusion system to produce a Ready-to-Eat puffed wheat crisp cereal. Cereals from each treatment were packaged in sealed foil laminate pouches and stored at ambient conditions up to 6 months. Flours and cereals were analyzed for free fatty acids and hexanal. After 6 months of storage, the whole wheat flour stored at ambient conditions contained significantly more free fatty acids (10.7 µmol/g) and hexanal (16.4 ppb) compared with the flour stored in the freezer (4.58 µmol/g and 1.9 ppb respectively); however, after extrusion the cereals were not significantly different for free fatty acids or hexanal (4.40 µmol/g vs 4.25 µmol/g and 3.47 ppb vs 3.47 ppb, respectively). After 6 months of storage the cereals were still not significantly different for these analytes (3.98 µmol/g vs 4.45 µmol/g; 9.77 ppb vs 10.1 ppb). Surprisingly, extrusion of "rancid" flour did not change the storage stability of extruded crisps compared with stored crisps from sound flour.

808-P

The effect of pea flour processing on the nutritional quality and end-product quality of extruded breakfast cereals

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Breakfast cereals are currently viewed by consumers to be low in nutritional density, formulated with starchy, low protein ingredients. The objective of this study was to examine the effect of adding different yellow pea ingredients on the nutritional differences of breakfast cereal formulations. Peas were roller milled into refined pea flour (RYPF), refined pea semolina (RYPS), whole pea flour (WYPF) and whole pea semolina (WYPS) and were incorporated at 56.7% of the breakfast cereal formulation along with corn meal, sugar, salt and pea fiber. A corn based control was also produced containing sugar, salt and pea fiber. Pea based breakfast cereals were analyzed for protein, dietary fiber, iron, potassium, folate, niacin, thiamine and riboflavin content. End-product quality characteristics of breakfast cereals including bulk density, number of air cells, and bowl life were also analyzed. Following roller milling, RYPS contained significantly greater (p<0.05) protein content as compared to WYPS, RYPF and WYPF. WYPS contained significantly greater dietary fiber content compared to the WYPF, RYPF and RYPS. Following processing, breakfast cereals made with RYPS and WYPS had significantly greater (p<0.05) protein and potassium contents. All pea based breakfast cereals contained greater amounts of protein, fiber, thiamine, niacin, iron and potassium as compared to the corn based control cereal. Statistical differences were observed in bulk density of the pea based breakfast cereals with the lowest bulk density observed for the refined yellow pea ingredients. These results indicate that pea ingredients can be used to improve the nutritional density of corn based breakfast cereal products without significantly affecting product quality. In addition, processing conditions of the pea ingredients can also affect nutrient content as well as end-product quality characteristics.

809-P

Use of Grain Sorghum as the Primary Grain Ingredient in Premium Extruded Foods Designed for Cats

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Grain sorghum is rarely used for pet foods due to the lack of scientific data on the nutritional quality and acceptability of sorghum-based products. Some previous studies showed that sorghum could provide nutritional benefits related to slower digestibility of starch or lower glycemic response, which can aid in premium products targeted towards obese, diabetic and geriatric pets. The aim of this study was to evaluate the effect of particle size on the extrusion of sorghum-based diets for cats. Two types of sorghum (White and Red) milled at three particle sizes (0.5 and 1.0 mm) were incorporated in a premium dog food formulation and compared to a rice-based dog food formulation. Formulas were extruded to achieve processing at two specific thermal energy: specific mechanical energy ratios (STE/SME), using different combinations of screw speed and preconditioning temperature (high STE/SME at 300RPM/85-90°C and low STE/SME at 400RPM/75-80°C). Water and steam flow in the preconditioner was varied to achieve the desired pre-conditioner temperature. The mean in-barrel moisture was 26% (wb). Thermodynamic analysis of the process was conducted to determine the thermal and mechanical energy input and energy losses. Bulk density and hardness of dry expanded cat food increased with particle size. The diets extruded at low STE/SME had higher bulk density and also hardness. Starch gelatinization increased as the particle size decreased. Process conditions did not influence the starch gelatinization. Results indicated that sorghum can be an effective alternative to rice as a carbohydrate source in extruded pet foods.

810-P

Effect of extruded germinated cotyledon bean flour on cereal bars' protein content and starch digestibility

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Cereal bars are ready to eat and long shelf life products and most of them are elaborated with simple sugars and do not supply an appropriate balance on their macro component composition. The aim of this research was to evaluate a cereal bar, mainly composed with oat flakes, elaborated with modified bean flour to increase protein intake, on the physical and nutritional characteristics of this product. In order to evaluate these effects, two different cereal bar systems were tested: Control (C) prepared with pre-gelatinized waxy maize starch due to its adhesive properties and Test (T) replacing this ingredient with modified bean flour, obtained from milling extruded germinated cotyledon bean. The formulation consisted on mixing the dry ingredients, adding agave syrup and water, molded in rectangular bars, baked and tested in terms of water activity, total dietary fiber,

protein, protein digestibility, fat, ashes, total starch, starch digestibility, texture, color and sensory evaluation. Protein value of T increased by 45% compared to C but protein digestibility values on the latter were not significantly higher than T values. Soluble and insoluble dietary fiber for T resulted 3.35% ± 0.34 and 5.24% ± 0.18, compared to C values 3.10% ± 0.04 and 5.10% ± 0.02, respectively. On the other hand, fat for C showed values significantly less than T with 10.27% ± 1.81 and 12.82% ± 3.52, respectively. Total starch content on C was higher than T and the estimation of starch 90-minute alpha amylolysis presented significantly higher values for C, 72.96% ± 6.21, than T, 49.69 ± 9.96. Untrained panelists performed a preference sensory test where T cereal bars were similarly evaluated as C. The substitution of starch with modified bean flour resulted in a product with similar features, sensory attributes and increased protein content with a reduction in starch digestibility profile.

811-P

Extrusion increases *in vitro* bioaccessibility of mineral elements in pinto bean (*Phaseolus Vulgaris* L) flour

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Pinto beans (*Phaseolus vulgaris*) are "good sources" (>10% of the US Daily Value per serving) of Fe, Mg, P, and K. However, previous reports have suggested low bioavailability, especially of the divalent cations, due to the chelating effects of phytic acid, tannins, and dietary fibers. Extrusion may be a strategy to improve the bioaccessibility of these elements. In this study, *in vitro* bioaccessibility of Fe, Mg, P, and K, as well as two heavy metals (Cd and Pb), were analyzed in unprocessed and extruded pinto bean flours. Physical properties (radial expansion, apparent bulk density, water solubility index and water absorption index) and chemical composition (dietary fiber, phytic acid, and tannins) were also determined. Extrusion parameters (temperature, moisture content, screw speed) significantly affected physical properties, but not element bioaccessibility or chemical properties, except in a few isolated cases. Extrusion did, however, increase the bioaccessibility of all essential elements (Fe, Mg, P, and K) by 1-5% without a comparable increased in toxic elements (<0.5% for Cd and Pb) compared to unprocessed flour. A significant reduction in phytic acid and tannins together with an increase in soluble dietary fiber was found after extrusion. Correlation analysis suggested that bioaccessibility of Fe is associated with phytic acid concentration, while Mg is associated with tannins and heavy metals are associated with soluble dietary fiber. The increase in element bioaccessibility by extrusion cooking is related to the changes in chemical components, whereas the severity of the extrusion process affected physical properties of pinto bean extrudates.

812-P

Effects of the extrusion processing variables on the physical properties of chickpea-barley extrudates

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The effects of extrusion processing variables [barrel temperature (120-150°C), moisture content (20-24% wet basis) and screw speed (260-340 rpm)] on the specific mechanical energy (SME) and physical properties (expansion ratio, bulk density and hardness) of chickpea-barley extrudates were estimated by using a response surface analysis. The extrudates were prepared from a 60:40 (w/w) blend of desi chickpea and hull less barley flours. The extrusion was performed using a co-rotating twin-screw extruder with a length: diameter ratio of 24:1. Barrel temperature and moisture content were the factors that affected the product responses the most. No interaction between the effects was observed. Significant correlation was found between the hardness and bulk density (positive), hardness and expansion ratio (negative), and the bulk density and expansion ratio (negative) of the extrudates. Desirable characteristics (high expansion, low bulk density and hardness) were obtained at relatively low moisture, high temperature and moderate to high screw speed.

813-P

Extrusion processing to develop snacks from garbanzo flour and distiller's dried grains developed for food applications

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Pulse flours, when combined with distillers grains, represent a novel blend as it is gluten-free and high in protein and fiber content. The present study investigated the effects of distiller's dried grains developed for food applications on the physical and nutritional characteristics, of garbanzo flour (GF)-corn grits (CG) based extruded products. The aim of the experiment was to optimize barrel temperature (100 to 140°C), screw speed (100 to 200 rpm), moisture content of blend (14 to 20% d.b.) and levels of distillers grain (0-20%) based on properties of extrudates such as water absorption index (WAI), water solubility index (WSI), bulk density (BD), radial expansion ratio (RER), textural properties and total dietary fiber using single screw extruder. Percentage of corn grits (60%) was kept constant for all the formulation. The study was carried out by central composite

rotatable design (CCRD) using Response surface methodology (RSM) which generated 27 experimental runs. Mathematical models for various responses were found to fit significantly ($P<0.05$) for prediction. Optimization of experimental conditions was carried out using numerical optimization technique and the optimum barrel temperature, moisture content, screw speed and distiller's grain percentage were 125°C, 15.8%, 175 rpm and 20% respectively with desirability value of 0.907. Experiments were carried out using predicted values and verified using t-test and coefficient of variation percentage. An extruded snack prepared with distiller's grain (20%) and garbanzo flour (20%) at optimized conditions was found to be acceptable by taste panelists.

814-P

Effects of extruded bleached nixtamalized maize pericarp on dry masa flour physicochemical properties

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Pericarp is a byproduct of the dry masa flour industry used for animal feed. Nixtamalized dried pericarp was ground and extruded with bleaching agents with the aim of supplementing dry masa flours (DMF) without affecting color, water solubility and absorption indexes (WSI and WAI), and RVA parameters. Testing was conducted through a randomized design established 7 treatments: T0 = extrusion without additives, T1 = enzymatic (*Lacasses from Pycnoporus sanguineus),* T2 = sodium metabisulfite, T3 = benzoyl peroxide, T4 = phosphoric acid, T5 = titanium dioxide 0.1% and T6 = titanium dioxide 0.2%. The treatments were extruded in a twin screw extruder Buhler® (BCTM-30). Flour blends were prepared as follows: 100% DMF and DMF substitution at 2, 5 and 10% by pericarp, generating a 7x3 factorial arrangement (treatment and substitutions, respectively). Extruded pericarp with the highest rate of expansion were T5 (1.39) and T6 (1.47). The T4 (1.57a, 11.58b), showed a decrease in a and b color in comparison to T0 (1.87a, 12.51 b). In case of DMF composite flours color (a, b) differed highly ($P< 0.01$) compared to the DMF control. Treatments with 10% replacement level presented the highest values of red (a) and yellow (b). Were not significant differences on the luminosity values (L) of flours. Higher values of WSI were presented as the level of substitution increased, T1 (1.95) presenting the highest. No significant differences for WAI were observed. Final viscosity values decreased as the percentage of pericarp increased, T1 (1377.3) was the smallest. In conclusion, the replacement of 2% of DMF with the extruded-ground pericarp treated with bleaching agents did not affect color, WSI, WAI and RVA properties. The use of extruded bleached pericarp to supplement dry masa flours represents an advantage in the industry because of the improvement in flour yield and dietary fiber content.

815-P

Cellular Antioxidant Activity of Tortilla Prepared by Nixtamalization and Extrusion-Cooking Process from Pigmented Maize

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Mexican pigmented maize (*Zea mays* L.) landrace kernels have been scantily evaluated regarding potential as functional food. In this study, two Mexican pigmented (yellow and red) maize accessions of Tuxpeño, Tabloncillo and Chapalote landraces collected in the northwestern region of Mexico were processed into tortilla to determinate total phenolic content, their Oxygen Radical Absorbance Capacity (ORAC) as well as the Cellular Antioxidant Activity (CAA) and Quality of phenolic compounds in the free and bound fraction of maize grains processed into tortilla by traditional nixtamalization and by extrusion cooking processes. Both the raw grain as nixtamalized and extruded tortillas, the bound fraction of phenolic extracts provided 64 to 90% and 71.6 to 92.8% of total phenols and ORAC-H levels, respectively. However, the traditional tortillas retained between 38.4 to 50.3% and 50.1 to 72.9% of total phenolics and ORAC-H levels, while the extruded tortillas retained 100% of the original content present in raw grain and even showed an increase. Nixtamalized tortilla had the highest Total Cellular Antioxidant Quality (TCAQ) (measure of cell antioxidant activity provided by 100 μmol of total phenols found in the extract), especially those made with red corn (R- 364) while extruded tortillas had a lower or equal TCAQ to their raw grain. These results indicate that the process of lime-cooking extrusion allows greater retention and release of phenolic phytochemicals content and antioxidant capacity in tortillas elaborated by this process, while the process of nixtamalization allows tortillas with lower CAA compared with the extrusion process but with higher TCAQ.

816-P

Efficacy of Carob Germ Flour in Processability of Gluten-Free Tortillas

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Production of gluten-free foods is on the rise due to increasing demands from consumer markets. Wheat-free tortillas are typically difficult to process, as batters and thick pastes lack the functional properties gained from gluten. Carob germ flour has been shown to form wheat-like dough and has the potential to improve processability of gluten-free tortillas. The objective of this research was to determine if carob germ flour addition to gluten-free tortilla systems could improve processing characteristics without forfeiting tortilla quality. Tortillas containing 0%, 5%, 10%, 15%, and 20% carob germ flour were prepared in water-optimized formulations containing xanthan gum (1.0%), salt (1.5%) and baking powder (2.0%). Flour was comprised of equal levels of cornstarch and sorghum flour plus the carob germ flour treatments. Tortillas were assessed for extensibility, toughness, color, thickness, diameter, and specific volume. Tortillas were assessed for extensibility, toughness, color, thickness, diameter, and specific volume. Results concluded the addition of carob germ flour decreased the L* values and pigments from the carob germ flour increased the tortilla's a* and b* values. Significant improvement in pressability was observed at 5% carob (p<0.05). This research shows the addition of carob germ flour increases processability without sacrificing functionality of the final product.

817-P

Changes in protein, dietary fiber and starch content in hot-press wheat tortillas with amaranth, quinoa and oat flour

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Amaranth is an important source of protein, which provides equilibrium of essential amino acids and with quinoa and oat could offer a nutraceutical food product. The aim of this research was to evaluate the effects of the amaranth, quinoa and oat flour on the chemical composition, starch and protein digestibility along with color and texture properties of wheat flour tortillas. Control (C) with 100% wheat flour and Treatment (T) 70% wheat flour, 20% amaranth flour, 5% quinoa flour and 5% oat flour were analyzed by producing tortillas following the hot press procedure and tested in terms of total dietary fiber (32-05.01), total starch (76-13.01), starch and protein digestibility (in vitro), protein (46-13.01), moisture (44-15.02), fat (30-10.01), ash (08-12.01), extensibility test (TA.XT2i Texture Analyzer), color (Minolta Chromameter CR-300), diameter, thickness, and sensory perception by an untrained panel. Results showed that T had 31.4%, 27.1% more soluble dietary fiber, and protein than C. The hydrolysis rate of starch digestibility (30%) was higher at 75 minutes and 4.8% more in protein digestibility in T. Otherwise, total starch and crude fat values reduced until 9.5 and 35.6%, respectively. In the extensibility test, T required 36.6% less force to rupture at day 6. T tortillas showed a lower L value (16.1%) and higher a and b (27.4 and 23.1%, respectively) values than C tortillas. The partial replacement of wheat flour with amaranth, quinoa, and oat flour positively influences protein, total dietary fiber, starch and in vitro digestibility.

818-P

Solvent Retention Capacity (SRC) application to analyze Korean-favorite noodle flour quality

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Korea imports most of the wheat it uses, predominantly from the United States, Australia and Canada, because wheat production in Korea is relatively small. Most of the imported flour is milled as all-purpose flour, but the production of stronger-gluten flour for bread and weaker-gluten flour for cookies and cakes is much smaller. More than fifty percent of total flour is used for noodle production. Flour quality contributes predominantly to noodle quality, and starch and protein content in the flour are known as key contributors. Rheological tests such as Farinograph and Amylograph, and noodle making test have been commonly used for evaluating noodle flour quality. However, Solvent Retention Capacity (SRC), which can predict flour quality contributed by individual functional component, has not been applied. In this study, three preferred and three non-preferred noodle flours were analyzed using SRC, proximate analysis, amylose and amylopectin content, and damaged starch content to evaluate Korean-favorite noodle flour quality. The SRC results showed noodle flours have relatively high values of water and sodium carbonate values compared to other flours. Amylose content of the noodle flours were lower than those of other flours. But, damaged starch content of all flour samples were not significantly different. Overall results indicated that higher SRC values with sodium carbonate solution were contributed by increased extents of solvent-accessible amylopectin due to higher amylopectin content, rather than by damaged starch content. Moreover, this study could help interpret obviously higher sodium carbonate SRC values (greater than 100%) correctly.

819-P

Prediction of Chinese commercial noodles flours processing quality

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Noodle making-cooking test has been shown to be one of the best methods to predict the suitability of flour samples for high quality noodles production. However, the test is time consuming and requires specialized personal and equipment. The development of quick and reliable instrumental methods to predict noodle flour quality is a clear progress. The objective of this study was to assess the ability of the Mixolab and the AlveoLab to predict the noodle processing quality of different commercial noodle flours. 80 commercial noodle flours were evaluated for their rheological properties using Mixolab and AlveoLab. Their resulted parameters were thereafter correlated with the technological tests using regression analysis method. The results showed a good prediction performance. With only Mixolab parameters used as model predictors, over 80% of samples have reached the acceptable risk for pre-noodles resting state score, taste score and total score. With the combination of Mixolab and Alveograph parameters, most of predicted values were improved, especially the percentage of samples predicted within the acceptable risk for dough sheet score and noodle color. They had improved from 75 and 74.4% to 87.3 and 89.9%, respectively. The results showed that using Mixolab and AlveoLab as instrumental methods to predict noodle flour quality was beneficial.

820-P

Water mobility for Chinese dried noodles with varied gluten and moisture content during drying

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The objective of this study was to investigate the water mobility in Chinese dried noodles with different gluten and moisture content during drying process. Reconstituted noodles were produced using gluten and wheat starch with gluten content of 10, 12.5, 15, 17.5, 20, 22.5 and 25% and noodle moisture content were set as 30, 32 and 34%. The fresh noodles were produced as square with the length of cross section of 2 mm after dough resting for 30 min, and then were dried at 40°C and relative humidity of 75% for 4 hours in a humidity chamber. Water status and distribution within noodles during drying were measured using NMR spectroscopy and MR imaging, and the microstructure of the dried noodles were examined by SEM. The results revealed that 80% of the moisture in dough and fresh noodles was strongly and less bound water with spin-spin relaxation time T22 of 4-8 ms. T22 increased with gluten and moisture content, but it was less affected by dough resting time. During drying, T22 decreased from 5-6 ms to 1-1.7 ms with increased drying time, indicating the moisture is more strongly bounded with the noodles. T23 peak was also found in the drying process, indicating that the moisture may be transferred as vapor during drying. The moisture transfer in noodles was slowed down with increased gluten content, which decreased the drying rate of the noodle for all different initial moisture contents. This was also confirmed by the denser noodle microstructure from SEM image. The drying rate was larger for noodles with lower gluten content and higher initial moisture content, but the final noodle moisture contents were approximately 15% and not significantly affected by the gluten and moisture content. Moreover, the drying front was found in cross sections of noodles during drying, and the high moisture gradient in this area may lead to noodle warping.

821-P

Effect of misformulation of dry mixes on texture properties and shelf life of cake

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Mistakes during bake mixes production are common, resulting in significant economic and product quality losses. The study aimed to evaluate the effect of ingredients on texture and shelf life of cakes (flour, sugar 80%, nonfat dry milk 12%, salt 3%, baking powder 3.5%; % flour basis) using a randomized complete block in factorial structure with 3 blocks. Three ingredients (milk, salt, baking powder) were evaluated at 3 concentrations (omission, normal and double dose). Analysis of variance and protected LSD (p?0.05) were conducted. Correlation with viscosity analysis of dry mixes was performed to detect patterns in quality control schemes. Milk or salt (omission or double dose addition) as main effects did not change the texture of the cakes (p>0.05). Interaction of ingredient vs days of storage were significant with milk omission affecting texture after 4 days of storage in resilience (-13.4%) and cohesion (-11.6%), and springiness (-2.6%) at 6 days. Omission of salt reduced resilience (-13.6%) and cohesion (-12.1%), and double dose reduced the springiness of cakes after day 6 (-3.2%). Omission of baking powder increased hardness (+309.1%), resilience (+19.4%), cohesion (+14.1%) and chewiness (+361.4%). Interaction baking powder vs days of storage changed the texture of cakes when the ingredient was omitted from the mix increasing hardness (+51.0%) and chewiness (+42.2%) at day 4. Baking powder misformulation resulted in a strong negative correlation ($r < -0.80$) between mix viscosity (trough, final viscosity and setback) and cake texture profile (hardness and chewiness), and a positive correlation with

springiness (r > 0.70). Comparing to baking powder, milk had a significant but lower correlation between the characteristics. The misformulation scenarios studied serve as a tool to relate information dry mixes quality control with viscosity and final product quality.

822-P

High-ratio cake baking with alternative carbohydrates for potential sucrose replacement

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Since 2014, when the World Health Organization and the U.S. Food and Drug Administration published their proposals on reduction of daily sugar intake and a Nutritional Panel update including a line for "added sugars", respectively, the baking industry has been actively searching for potential sucrose alternatives to reduce sugars, while maintaining excellent product quality. As alternative carbohydrates for potential sucrose replacement in high-ratio cake baking, two prebiotic, lower-glycemic-impact carbohydrate oligomers (i.e. isomaltulose monohydrate and Mylose syrup/Glucodry powder) were used to explore the effects of the sucrose alternatives on results from SRC, DSC, RVA, and cake baking, the latter including time-lapse photographic analysis. SRC values for chlorinated soft wheat flour in Glucodry and Mylose solutions were higher than those in sucrose and isomaltulose solutions. Starch gelatinization, observed from DSC, and pasting onset, from RVA results, were retarded by sucrose and the alternative sugars, compared to water alone. Cakes formulated with the sucrose alternatives produced equivalent or superior product geometry, including higher cake center height and shape factor, to those made with sucrose. Texture data showed that a cake formulated with "as is" isomaltulose was similar to that made with sucrose. Overall results suggested that isomaltulose could be used successfully to produce a high-ratio cake with lower glycemic impact and lower calorie content, and that Glucodry and Mylose also could be used to produce cakes with modified texture and decreased sugar. Time-lapse photographic analysis showed that pre-dissolution of isomaltulose was detrimental to cake baking, due to much earlier expansion and collapse, compared to "as is" isomaltulose.

823-P

Influence of different vegetal proteins on the physicochemical properties of both native and extruded maize flours

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Over the last years, interest in enrichment of starchy food products by incorporating proteins is increasing. There are already some research focused on a specific protein, but a broader study involving different proteins needs to be done. This research deals with the behavior of both native and extruded maize flour when interacting with different vegetal proteins (gluten hydrolysate, potato, rice and pea). Pasting, hydration, rheological and calorimetric properties of protein-flour mixtures were measured. RVA results showed that all proteins had a decreasing effect on the viscosity profile when comparing with their respective controls, being the pea protein the one that decreased the viscosity to a lesser extent while the decline was greater for gluten hydrolysate and rice proteins. For extruded flours, mixtures with pea protein were the only ones that showed a higher WBC and WHC value as compared with control extruded sample, while the other mixtures with extruded flour showed lower values. Both mixtures of pea protein-native flour and potato protein-native flour presented greater hydration properties when comparing with native flour, while the other mixtures showed lower values, which can be due to the different solubility index of the mixtures and the interaction between proteins and flours. DSC results showed that potato protein-native flour mixtures had a higher enthalpy than the control, while broader endothermic peaks were observed for most of the samples with proteins. Significant differences were also observed when comparing rheological behavior of the mixtures, indicating different viscoelastic behavior of the protein-flour mixtures. These results are of great interest for the future development of starchy food products enriched with proteins.

901-P

Relationship between pasting parameters and length of paste drop of various starches

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When starch paste be constantly stretched and breaking during under influence of gravity, one of flowing characteristics is the length of fully stretched paste. The length of pastes drop (LPD) often determines eating quality of the starch-containing foods. Typically, a long paste exhibiting high stringiness induces slimy mouthfeel, with a high tendency to coat a surface. However, a short paste generates cohesive drops that readily separate from each other, which is commonly favored for desserts, such as pie fillings and puddings. The relationship between pasting parameters measured using a rapid visco-analyzer (RVA) and LPD of various

starches from different botanical sources with different concentrations (5, 7, and 9%) was investigated. According to the viscositic analysis, some of the viscositic parameters were highly correlated with the flowing property (LPD). Starch content in the paste mainly affected the single pasting parameters, whereas source of starches such as genotype, botanical source, cereal/root and tuber, and variety affected the LPD. For cereal starches (especially rice and corn starches), the 2nd order pasting properties, such as breakdown (BD)/setback (SB), peak viscosity (PV)/final viscosity (FV), and PV-FV, exhibited significant correlations with LPD. The correlation between LPD and pasting parameters provides useful information on the application of starch paste in various food system.

903-P

Effect of soluble, insoluble and gel forming fibers on extensional properties of dough

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A low intake of dietary fiber has been linked with health problems including diverticular disease, diabetes, obesity, coronary heart disease, and colorectal cancer. By incorporating fiber into baked products, consumers would be able to meet the recommended daily fiber intake; however, the addition of fiber into dough systems changes the rheological properties which in turn affect the final quality. The purpose of this study was to understand the effects of soluble and insoluble fibers on dough development and functionality. Dough samples containing one of six different fibers (oat, inulin, dextrin, resistant starch, pectin, fiber gel) at 2, 5, or 10% replacement levels were tested. The MixoLab (Chopin) and Kieffer Dough Extensibility Rig (Texture Technologies) were used to assess the mixing and pasting behavior, and the extensional properties, respectively. Results indicated that insoluble fibers minimally affect water absorption, while soluble fibers decrease the water absorption, and gel forming fibers increase the water absorption. Both insoluble and gel forming fibers increased the peak viscosity while soluble fibers decreased it. The soluble fibers provided longer stability during mixing; however, they caused a decrease in the peak viscosity and delayed the point of gelatinization. The insoluble fibers caused a slightly early onset of gelatinization while the gel forming fibers caused a delay in gelatinization. Insoluble and soluble fibers displayed a wide extent of changes in their resistance (Rmax) and extensibility (Ext). Gel forming fibers caused development of short dough as indicated by low Ext values, while presence of soluble fibers created soft (low Rmax) and highly extensible (high Ext) dough.

904-P

Evaluating bread dough rheology using Warburton's Stickiness Rig and Texture Analyser (TA-XT2iPlus)

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The processing of flour, water and other ingredients to dough ready for baking involves subjecting the dough to significant stress and strain. Under these circumstances the behaviour of the gluten network is critical in delivering the final product quality. The measurements of dough rheology were undertaken using the DoughLab and the Warburton's stickiness test in a trial programme of 144 variables covering effects of mixing speed, final dough temperature and the effects of additions of ascorbic acid (AA) and fungal *alpha*-amylase (FAA) (common components of modern bread improvers). Dough rheology with the stickiness test was assessed ex-mixer, after 1st moulding, before 2nd moulding (resting) and after 2nd moulding. Changes in dough rheology as the result of processing stages were complex but broadly showed that dough resistance increased with moulding and decreased with resting time. Overall, the compression area from Warburton's stickiness test by the end of dough processing are significantly greater than when seen immediately after mixing. In contrast in the absence of an improver, dough stickiness did not appear to change significantly as a direct result of dough processing steps. Increasing the resting time between moulding steps increased dough firmness after final moulding. Longer resting time's slightly decreased stickiness during processing, however, stickiness did increase after final moulding. The addition of FAA alone had an impact on the rheological properties of the dough during mixing, indicating earlier activity. The impact on dough rheological properties during mixing when FAA was the sole improver addition confirmed the previous findings when FAA was used in conjunction with AA. Changes in dough rheology ex-mixer will have important consequence for dough processing.

905-P

Effect of hydrothermal treatment on rheological and functional properties of wheat flour

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The effects of hydrothermal treatment on rheological and functional properties of wheat flour were investigated in dough and flour matrices with Rheo F4, Mixolab, Alveolab and SRC-CHOPIN. Commercial European wheat flour T55 [moisture level: 13,5%; protein level: 11% (dm)] hydrated to 20% moisture was subjected to heat at different temperatures 50, 70 and 90°C for 5 min using a continuous thermal processing unit manufactured by REVTECH process systems (Loriol-sur-Drôme, France). Hydrothermal treatment affected the dough behavior as

well as the functionality of all flour components. It caused a decrease of the dough development parameters during fermentation, altered the dough strength and the solvent retention capacity profiles. As revealed from a decrease of the dough height [Hm], (from 66 to 19 mm), extensibility [L], (from 69 to 20 mm), deformation energy [W], (from 237 to 75 10E-4J) and lactic acid SRC values (from 119 to 117%), the reduced development of the dough was related to protein denaturation which resulted in a lack of gluten network formation and thus preventing the expansion of the dough and the retention of gas. Starch swelling properties were also affected by the hydrothermal treatment. The increase of both dough viscosity, as depicted from the Mixolab curves (from 2,1 to 2,6 Nm), and sodium carbonate SRC values (from 77 to 91%) reflected a partial gelatinization of the starch granules as well as an increase of the amount of damaged starch, respectively. These results show the potential applications of hydrothermally treated wheat flour in the preparation of bakery products, in particular where high dough viscosity and low proteins functionality are desired such as high ratio cake.

906-P
Evaluation of wheat flour quality using the MIXOLAB® and SRC
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The rheological properties of doughs made from different Australian wheat varieties have been evaluated using Chopin Technologies' MixoLab®' and Solvent Retention Capacity (SRC). Suitability of varieties for end products (noodles and pan bread) was evaluated by noodle sensory assessment and test baking. Quality of Japanese white salted (Udon) noodles can be largely attributed to the quality of the starch component and its effect on the eating characteristics of the boiled noodles, while the quality of Japanese yellow alkaline noodles (Ramen) can be largely attributed to protein quality and quantity. Protein quality and quantity also play an important role in determining the quality of baked goods. However, a range of other factors impact on final end product quality including interactions of wheat varieties with different ingredients and making processes. "MixoLab®" was used to measure both rheological properties of dough and starch gelatinisation characteristics of wheat flour. SRC was used to study glutenins and pentosans in different varieties of Australian wheat. Samples ranged in protein content from around eight to 15 percent. Outputs from both "MixoLab®" and SRC will be discussed in relation to the swelling properties of flour (FSV) and processing quality of wheat varieties as related to Udon and Ramen noodles and pan bread.

907-P
The Impact of Flour Storage Conditions on Dough Rheological Properties and Overall Baking Performance
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Flour storage conditions around the world can and will vary, influencing the raw material which can ultimately affect baking performance. Millers/bakers continually deliberate on what the optimum flour storage period is that will deliver the best baking performance. The aim of this study was to evaluate, at varying time intervals, changes in dough rheology and baking quality. The study took place over a 2-year period at both ambient and frozen storage conditions (ASC and FSC, respectively). Dough rheology was assessed using Farinograph and Extensograph. Baking performance was assessed on a laboratory/pilot scale. Over a 2-year period, strength increased for ASC and FSC but at a slower rate for FSC. It appears the impact of storage conditions on baking performance is more complex as there were fluctuations detected within 2 years of storage. For ASC there were 2 peaks in dough strength occurring at 8 and 21 months. Improvements in baking performance occurred after 3 weeks of ASC with minimal changes noticed until 10 months later. This finding was supported by greater loaf volume and brighter crumb colour (Minolta L*). It appears at 13 months, flour quality at ASC drastically deteriorated and resulted in a reduction of dough strength and baking performance. At 21 months, the dough was very resistant, resulting in lower loaf volume. Baking performance of flour stored at FSC was more stable (mixing time); however, there were fluctuations in loaf volume and crumb colour following the same pattern as for ASC but at a slower rate. Overall dough handling properties were more resistant on ASC and more extensible on FSC. It appears a minor reduction in flour moisture content resulted in a reduction in farinograph absorption (R2=0.72). Regression analysis was used to evaluate the impact of flour storage conditions over time on dough rheology and overall baking performance.

908-P
Rapid extensigraph protocol for measuring dough viscoelasticity and mixing requirement
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The extensigraph is particularly useful in characterizing the viscoelastic balance between dough strength and extensibility, which are directly related to the dough handling properties in the baking process. The standard

method requires milling to prepare large amounts of flour and testing throughput is minimal due to the prerequisite for farinograph water absorption and long dough resting time. This limits the use of the extensigraph in the milling and baking industry, as well as for the screening of breeding populations which are usually large in sample number but very limited in sample size. Therefore, a rapid extensigraph method was developed that reduced sample size (as low as 165 g wheat) for milling, and more than tripled sample throughput by using a pin mixer for dough preparation and reducing the dough resting time. Flour (100 g) prepared with a Quadrumat Junior mill was mixed with a Swanson type pin mixer to develop dough at constant water absorption of 67.5%. The dough was subsequently stretched by an extensigraph after 15 min of floor time and 30 min resting. Strong correlations were found for both R*max* ($r > 0.93$, $p < 0.001$) and extensibility ($r > 0.64$, $p < 0.001$) for the proposed rapid extensigraph method with the standard extensigraph method and a modified version currently used in the evaluation of dough properties of breeder lines in Canadian wheat registration trials. Additionally, the mixing parameters (time and energy) obtained during dough preparation provided further information about dough strength and mixing requirement. By significantly reducing sample size requirement and dramatically increasing testing throughput, this rapid extensigraph method can be widely adopted in the flour industry and meets the need for a fast evaluation of dough strength in breeding trials.

1001-P
Effects of beta-glucan on casted thermoplastic starch films
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Grain polysaccharides provide a major raw material for coming generations of advanced and environmental friendly materials. Thermoplastic starch (TPS) is processed using conventional plastic processing technology, such as casting, extrusion and molding (2). The adaptation for the daily use of TPS is achieved by chemical-modification or blending of starch with other polymers. For example mechanical performance of maize starch materials are improved by blending with polycaprolactone (Novamont, Mater-Bi; (1)). Alternatively, all-natural and fully compostable bioplastics can be generated by blending with other polysaccharides. maize starch (MSt) TPS prototypes were produced by casting with glycerol and different ratios of oat beta-glucan (BG) (100/0, 75/25, 50/50, 25/75 and 0/100 BG). Electron Paramagnetic Resonance tests using TEMPO (2,2,6,6-tetramethylpiperidine-1-oxyl) as a spin probe showed that EPR spectra of spin probe in the films containing BG but without glycerol had higher ratio between fast and slow rotation indicating looser chemical environment in BG containing films as compared to starch (3). This result was confirmed by high water vapor permeability at high BG concentration in the films. All films with BG but without glycerol showed a decreased brittleness and improved of cohesiveness as compared to 100% starch. The mechanical properties of blended films revealed an improvement of both stress and strain at break with increasing of BG content. Our data demonstrate that blending of starch with other natural polysaccharides is a leading path to improve functionality using all-natural polysaccharide systems.

1002-P
Effect of Chemical and Enzymatic Modifications on Starch and Naringenin Complexation
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Naringenin, the predominant flavanone in grapefruit, is a potent antioxidant, however its poor water solubility and bioavailability limit its clinical potential. The objective of this study was to improve naringenin solubility via inclusion complexation with starch. Potato starch was modified chemically (acetylation) and enzymatically (debranching), and various reaction conditions were evaluated to improve its complexation with naringenin. The soluble and insoluble complexes of naringenin were recovered and characterized. Acetylation decreased the formation of insoluble complex and increased the formation of the soluble complexes with a recovery total of approximately 0.88-0.93 g/g. The insoluble complexes contained a greater amount of complexed naringenin and displayed a mixture of B- and V-type X-ray pattern compared with the soluble complexes of a mixture of A- and V-type pattern. These results demonstrate that acetylation can improve starch-naringenin complexation.

1003-P
Effect of degree of pectin methoxylation on aqueous stability of sorghum 3-deoxyanthocyanins
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Sorghum 3-deoxyanthocyanin pigments are more stable than anthocyanins but readily associate and precipitate in aqueous systems due to reduced hydrophilicity. The objective of this study was to determine the effect of degree of methoxylation (DM) of pectin on the aqueous stability of sorghum 3-deoxyanthocyanins. Pigments were extracted from sorghum tissues (leaves, sheath, and grain) with differing 3-deoxyanthocyanin compositions

and solubilized with pectin (DM 6.7-85%) in pH 1-5 buffers for 14 days. Absorbance spectra were recorded with an UV-Vis spectrophotometer and pigment compositions were analyzed using HPLC-DAD. The 3-deoxyanthocyanin pigments were most stable in pH 1 buffer and tendency to aggregate increased with increasing pH. Pectin at a 0.1% generally prevented association of pigments at all pH but the stability depended on extract composition. At pH 5, 3-deoxyanthocyanins from tannin-containing sorghum grain showed 2.4-4% color loss compared to 3-deoxyanthocyanins from non-tannin sorghum grain (23.6-27% loss) and the controls (72-75% loss). As DM increased, the aqueous stability decreased with extracts higher in hydrophilic 3-deoxyanthocyanins; e.g., at pH 5, there was 61% color loss with high DM (85%) pectin compared to 29% color loss with low DM (6.7%) pectin. Increased apigeninidin content of the pigment extracts correlated with better stability in pectin, and the presence of tannins appears to enhance the effectiveness of pectin.

1004-P
Characterization of the low-molecular-weight glutenin subunit gene family members using a PCR-based marker approach
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Low-molecular-weight glutenin subunits (LMW-GS) are a class of seed storage proteins that play a major role in the determination of the processing quality of wheat flour. The LMW-GS are encoded by multi-gene families located on the short arms of the homologous group 1 chromosomes, at the *Glu-A3*, *Glu-B3* and *Glu-D3* loci. Generally, more than 15 genes are present in a single bread wheat cultivar. Because of the genic complexity of these loci and the lack of efficient methods for the LMW-GS protein allele identification, the role of each LMW-GS allele in the end-use quality has not been clearly established. In the present study a PCR-based molecular marker approach has been used to identify the LMW-GS gene alleles present in different hexaploid wheat cultivars. Analysis of a set of standard wheat cultivars with known LMW-GS alleles revealed the potential of this marker system for the unambiguous identification of the LMW-GS protein alleles. Moreover, the application of this system to three different populations segregating for the LMW-GS gene alleles showed the presence of intra-locus recombination suggesting a possible revision of the concept of a "single locus" for all the three *Glu-3* loci. The results of this study will help to define the LMW-GS profile of different hexaploid wheat cultivars and to clarify the contribution of each LMW-GS gene alleles in the control of the end-use quality.

1005-P
Interactions Involved in the Formation of Starch-Tannin Complexes
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Amylose–tannin interactions have promising potential to be utilized to modulate glucose metabolism and reduce the calorie density of starch-based foods. However, knowledge on the specific interaction mechanisms involved is lacking. Starch-tannin complexes were formed by incubating sorghum tannin extract with normal and waxy maize starch, in 30% (30E) and 50% (50E) ethanol solutions at 70°C/20 mins. The complexes were reacted with urea (2-6 M) and dioxane (10-15% v/v of water) to evaluate the contribution of H-bonding and hydrophobic interactions to starch-tannin complexes, respectively. The controls and treatments were analyzed for *in-vitro* digestibility (Rapidly Digestible Starch – RDS, Slowly Digestible Starch – SDS, Resistant Starch, RS) and Proanthocyanidins (PA) content and distribution. Urea reduced SDS by 58% and increased RDS by 55% in 30E normal maize. Dioxane showed a similar trend, but to a lesser extent (28% decrease in SDS and 20% increase in RDS). In 50E, urea increased RDS (mg/g starch) from 19–50 mg/g to 432–602, and decreased RS from 810–870 to 306–398 mg/ g. Dioxane also increased RDS to 91–197 mg/g of starch and decreased RS to 394–706 mg/g of starch. Amount of PA (mg/g of starch) released from the starch-tannin complex in 30E was slightly higher in urea (PA = 5.3–6.7) than dioxane (PA= 4.3–5.5). In 50E, however, dioxane released higher PA (~1.3–1.5) than urea (~0.8–1.0). H-bonding appears to be dominant in starch-tannin interactions, with hydrophobic interactions also playing an important role.

1006-P
Physicochemical, functional and digestion characteristics of thermally treated starches under acidic/alkaline conditions
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In this study we explore the combination of thermal treatments like annealing (ANN) and heat moisture treatment (HMT), under acidic/alkaline conditions on starches with different granular characteristics (rice, maize and potato) in a pilot scale plant with the aim to increase its nutraceutical potential. For this, ANN treatment consisted on starch dispersions (30% solids content), that where incubated at 50°C, at pH 7.0, 2.0, and 10.0 for

24 h. While the HMT starches were prepared at 70% solids content and incubated at 120°C, pH's were reached with either 2M HCl or 2M NaOH. After the time, both starches were neutralized (pH 7.0), air dried, grinded until pass 100 US mesh, and its proximal composition in terms of moisture, protein, ash and lipids were calculated, as well as water absorption index (WAI), water solubility index (WSI), oil absorption index (OAI). Additionally, the impact of the processing conditions on its digestion characteristics as the amounts of rapidly, slowly and resistant starch (RDS, SDS and RS) in gelatinized starch gels was estimated. We found that the proximate composition of the starches was not affected, WAI and WSI were higher on rice starch with ANN under acidic conditions compared with its native counterpart (4.3 g/g and 40% vs 2.5 g/g and 17%). The HMT treated starches showed the opposite trend in these characteristics. The OAI of native potato starch exhibits the lowest value (1.5 g/g), while ANN maize starch under acidic conditions retained the higher amount of oil (3.6 g/g). The highest SDS values were found on maize starch with ANN under acidic conditions (51.41%), the highest RS amount (57.53%) was found on native potato starch (pH 7.0). The outcome of this study can offer direction on the use of the analyzed starches in different food application, in order to be used as food ingredients without the introduction of chemical reagents.

1007-P

Commercial pea protein emulsifying, foaming, and gelling functionality at various pH levels

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Food proteins possess a number of functionalities important to food formulation, including foaming, emulsifying, and gelling properties. Egg albumin (EA) is the benchmark for many of these functionalities, but can be costly and is an allergen for some consumers. Previous studies have shown lab-produced pea protein isolate can be an effective functional alternative to EA under varying conditions; however, similar data for commercial pea protein (CPP) is limited. The study objective was to evaluate the capacity and stability of emulsions, foams, and gels created with CPP at pH 2.2, 2.7, 3.2, 4.0, 4.5, 5.1, 6.1, 7.2, and 8.3. Emulsion capacity (EC) was 248-354 g oil/g CPP at all pH levels except 2.2 and 3.2, at which it was >785 and 115 g oil/g CCP, respectively. Emulsion stability (ES) was 44-48% at all pH levels except 3.2 and 2.2, which had ES of 52% and 89%, respectively. Foaming capacity (FC) was 114-122% for most pH levels while 161% and 147% was observed at pH values of 2.7 and 3.2, respectively. Foam stability (FS) was 90-96% at all pH levels except 3.2 and 2.2, where values of 74% and 98% were observed, respectively. Weak gelation occurred at all pH levels except 2.7 and 3.2, with a stronger gel being formed at 2.2. The ES, EC, and FC of CPP was similar to values determined (in DI water) for EA of 52%, 370 g oil/g, and 115%, respectively. However, the FS of CPP was much lower than the 100% found for EA. These results indicate potential utility of pea protein as an emulsifier or foaming agent in foods of varying pH.

1008-P

The Amorphization of Vitamin B1 in Polymer Dispersions and Comparison of Stability in Amorphous and Crystalline States

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Thiamin (Vitamin B1) is an essential water soluble nutrient. For food fortification purposes, two synthetic salt forms of thiamin, thiamin hydrochloride (THC) and thiamin mononitrate, are extensively used. These are deliquescent crystalline solids. Thiamin is considered as one of the most unstable vitamins in food and is susceptible to heat, light, and neutral and alkaline pH conditions. It is hypothesized that thiamin becomes amorphous in some food (especially, cereal based) products due to formulation and processing treatments. The chemical stability of compounds is highly associated with their solid state (amorphous versus crystalline); however, there is no information available in the literature about the chemical stability of THC in both crystalline and amorphous forms. The objective of this study was to create amorphous forms of THC in the presence of a variety of polymers, which of majority are obtained from cereals, and then compare the chemical stability of crystalline and amorphous THC in different environmental conditions. THC was amorphized using select polymers (maltodextrin, pectin and PVP (polyvinylpyrrolidone) and lyophilization and stored in controlled temperature (25-60°C) and relative humidity (11-75% RH) conditions for up to 8 weeks. THC chemical degradation was tracked using HPLC, and samples were also analyzed using powder X-ray diffraction and differential scanning calorimetry. Color parameters were also monitored to correlate chemical degradation with change in color. Amorphous THC was successfully created in the presence, but not in the absence, of the polymers. Both %RH and temperature had significant impact on the degradation of THC in both forms, but moreso on the amorphous form. Degradation of THC was also affected by the Tg and pH of polymers, however, the Tg of the polymers was not directly related to the THC chemical stability.

1009-P

Control of physicochemical properties of leavened solid food and its bolus corresponding to dysphagia

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The aim of this study was to obtain an index for leavened solid foods that even an elderly person could chew and swallow. Physicochemical properties of the solid food prepared with polysaccharides (replaced 0.5 or 3.0% to soft wheat flour) and its artificial bolus were evaluated. The solid food and its artificial bolus had desirable physicochemical properties formulated with glucomannan, gum arabic or agar. However, the crumb softness of solid food could not be maintained by formulation of polysaccharide. Therefore, addition of emulsifier (formulated 1.0% for soft wheat flour) was considered. The solid foods prepared with glyceryl monostearate (GMS)+gum arabic (A) and sucrose esters of stearic acid with HLB of 3 (SES3)+glucomannan (G) were selected as the samples with different chewing and swallowing characteristics. The flow velocity of bolus was measured by an ultrasonic imaging device. The velocity was fast in order of water (0.48 m/s), yogurt (0.31 m/s), and solid foods (0.19–0.28 m/s). GMS+A sample with high softness and low saliva absorption, and SES3+G sample with low softness and high saliva absorption showed almost the same flow velocity of yogurt. Healthy person can form a bolus with desirable flow velocity for swallowing from the sample with low softness and high saliva absorption. Therefore, the sample with high softness and low saliva absorption was deduced to be suitable for an elderly person. Then artificial bolus which changed water contents was prepared, and mechanical properties (dynamic viscoelasticity, hardness, and friction coefficient) were measured. The property value decreased with the increase of the water content of the artificial bolus. From these results, it was speculated that bolus which had low storage modulus (< 0.5 Pa, 9.42 rad/s) and sufficiently coated layer with saliva might be desirable for deglutition easiness.

1010-P

Effects of Hydrocolloids on Shear-thickening Behavior of Starch Dispersions and Its Impacts on Gastric Emptying Rate

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Gelatinized waxy corn and potato dispersions had shear-thickening behavior at a shear rate around 20 s-1, a phenomenon that is not observed in gelatinized waxy wheat and rice starch dispersions and normal starches. Shear thickening behavior may have some implications on delaying gastric emptying time. Thus, in order to improve shear-thickening behavior of starch for potential nutrition advantages the shear thickening was enhanced with the use of hydrocolloids. Starches were mixed with various hydrocolloids following gelatinization and their rheological properties were studied. Both gelatinized waxy corn and potato starch dispersions showed increased viscosity with time. With addition of agar and xanthan gum, the viscosity of gelatinized waxy corn and potato starch dispersions decreased with increased shear rate with no shear-thickening behavior. The addition of pectin, sodium alginate or guar gum had no effects on shear-thickening behavior but altered the overall viscosity of the dispersions. However, upon addition of gum arabic, shear-thickening behavior was more obvious and moved to higher shear rates. In simulated gastric juice, waxy potato starch dispersions showed continuously increased viscosity to around 1 Pa.s over the test; whereas the viscosity of corn starch dispersions firstly increased to 0.1 Pa.s followed by a decrease of viscosity up to 0.05 Pa.s over the test. These studies indicated that gelatinized waxy potato starch dispersion has a potential to delay the gastric emptying rate compared to waxy corn starch. Results of this research should help to understand how rheological properties of starchy foods affect the digestion process in terms of gastric emptying.

1011-P

Porous starch performance to enzymatic hydrolysis and its relationship to their porous size distribution

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Enzymatic treatment of starches reveals as a powerful tool to modulate starch properties obtaining clean label ingredients. However, it could be envisaged further applications to obtain porous starches, which might have diverse physiological response. The aim of this study was to investigate the hydrolysis response, using *in vitro* assays, of porous starches obtained from different enzymatic treatments (fungal a-amylase – AM, amyloglucosidase-AMG and cyclodextrin glycosyltransferase-CGTase) and to identify possible impact of the porous size in the starch susceptibility to hydrolysis. Starch structure was captured using scanning electron microscopy and the porous size distribution was analyzed using Image J software. Microstructure analysis revealed that porous size was dependent on the enzyme used for producing the porous starch. The smallest pore size was obtained with CGTase, followed by AM and AMG. The enzymatic hydrolysis curves showed that porous corn starches had greater susceptibility to be digested due to the damage suffered by starch granules during the enzymatically treatment, and the extent of hydrolysis was dependent on the type of enzyme used for their

production. Overall, porous starch might be an alternative ingredient for satisfying needs when rapid levels of postprandial glucose are required.

1012-P

Nitrogen solubility index of pH and phosphate induced defatted soybean meals

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Defatted soybean meal is commonly used for producing extruded texturized-soybean-protein. Nitrogen solubility index (NSI) of soybean meal, which is vital for its application, is influenced by storage time and processing temperature. Changes of NSI of low-temperature defatted soybean meal (LSM), low-temperature defatted one-year-stored-soybean meal (LSSM) and high-temperature defatted soybean meal (HSM) induced by pH (5, 6, 7, 8, 9) with phosphate were investigated using the method of Lowry. Compared to the NSI of LSM and LSSM in deionized water, it decreases significantly in phosphate solution, which is 92.33, 96.10 and 85.4, 76.9%, respectively. Phosphate is considered to be a potential additive increasing the protein water holding capacity. The lower NSI in phosphate solution implies that phosphorylation or salting-out effect leads to less soluble protein. NSI of LSM in phosphate buffer solution increases from 35.72 to 88.28% when pH changes from 5 to 8, but it significantly decreases to 81.74% when pH is 9. NSI of LSSM shows a similar trend as LSM. Increased protein water binding capacity in weak alkaline conditions explains the increased NSI; whereas the formation of disulfide bonds might enhance the protein aggregation at pH 9, which decreased the NSI. Compared to LSM and LSSM, NSI of HSM is significantly lower. Interestingly, NSI of HSM shows a gradually increase from 10.39 to 35.63% while pH changes from 5 to 9, which is different from LSM and LSSM. Protein aggregation occurs in HSM during high temperature process and hydroxide ions may play a major role in protein dissociation rather than promoting aggregation. Different ratios of denatured protein for those three types of soybean meals might contribute to the different NSI values under varied pH conditions. The mechanism of NSI enhancement by pH for HSM will be further explored.

1013-P

Protein effects on heat transfer fouling using model thin stillage fluids

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Fouling is unwanted deposition of materials on surfaces of processing equipment, which leads to additional investment, lower processing efficiency and fluid contamination. In the corn ethanol industry, fouling occurs when thin stillage is concentrated into condensed distillers solubles. Several researchers have investigated operating conditions and constituents' influence on fouling characteristics. However, understanding protein effects on fouling is limited despite its high concentration in thin stillage (approximately 33% db). Protein contributions to fouling were investigated in the dairy industry. Whey proteins, together with phosphate-calcium, interact with each other or other proteins to form aggregates on heated surfaces. Maillard browning is another potential factor influencing fouling since amino acids in thin stillage are able to react with reducing sugars and form brown pigments. Proteins, as well as their hydrolyzed products amino acids, with accompanying sugars in thin stillage have been shown to contribute to fouling. Due to complex components in commercial thin stillage, it is difficult to study a single effect on fouling without interference from other factors. The objective was to investigate protein effects on fouling using various thin stillage models. Nitrogenous substances (urea, yeasts, glutamic acid, leucine and cysteine) were mixed with glucose. An annular probe was used to detect surface temperature and fouling resistance was obtained by using overall heat transfer coefficients of fouled and unfouled surfaces. Fouling was characterized by fouling resistance, induction period and fouling rate. Compared with a 1% starch model, no fouling occurred during test using glucose-urea fluids. Addition of urea reduced maximum fouling resistance by 29%. Molecular weight, structure of proteins as well as their properties may affect evaporator fouling.

1014-P

Extent of phosphorylation in peanut and soy proteins using sodium trimetaphosphate

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Peanut protein isolate (PPI) and soy protein isolate (SPI) were obtained by alkaline extraction from their respective defatted flours and phosphorylated with sodium trimetaphosphate (STMP) at three levels (1, 2 and 3% w/w) in order to find the best percentage in terms of extent of phosphorylation. The use of STMP in peanut protein has been not reported before and a good opportunity of new protein development is foreseen, mainly

because this reaction improves some of the most important functional properties when used as food ingredients: solubility, emulsifiability and whippability without detrimental effect in nutritional characteristics. The reactions were executed in an aqueous solution (pH 11.5) at 35°C during 3 h, and the extent of phosphorylation indirectly determined in the supernatant using two methods: titration with EDTA 0.01 M and inductively coupled plasma (ICP). When STMP is used, the reaction yields, by each serine transformed, an equivalent amount of pyrophosphate. The extent of reaction was expressed as pyrophosphate real/theoretical expressed as percentage and the two methods were compared. ICP was the technique with less variation over the titration counterpart, besides is faster and has not been tested before in vegetable protein phosphorylation. The highest extent of modified serine was reached with 2% of STMP (25.3%). These results were compared with phosphorylation in a soy protein isolate and similar results were obtained opening now the possibility to perform a complete functional evaluation of the obtained products in order to assess the improvement of vegetable protein properties.

1102-P

Quantification of peptides causing celiac disease in historical and modern hard red spring wheat cultivars

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Celiac disease (CD) is prevalent in 0.5 to 1.26% of adolescents and adults, and develops as a result of ingesting gluten forming proteins found in some cereals. Gluten is composed of glutenin and gliadin proteins. Gliadins are divided into α-/β-, γ- and ω-gliadins. Studies suggest that the majority of toxic/immunogenic peptides are produced by α-gliadin proteins. There are claims that breeding practices have changed wheat protein chemistry, resulting in modern wheat being more toxic as opposed to historical wheat. The aim of the study was to detect and quantify celiac-disease-initiating peptides of the gliadin proteins in historical and modern hard red spring wheat cultivars released during the last 110 years. For this purpose, gliadin proteins were extracted from wheat cultivars, and used in untargeted mass spectrometric analysis to determine the presence of 15 immunogenic peptides. For comparison of toxicity between historical and modern wheat cultivars, a targeted approach was used, where the relative amount of two toxic/ immunogenic peptides, PFPQPQLPY (DQ-α-I/ α9), RPQQPYPQ (glia-α20), and total α-gliadin, were determined using heavy labeled peptides. Three of the 15 peptides (RPQQPYPQ, PQQSFPQQQ and IQPQQPAQL) were detected in all cultivars. Ten other peptides were detected in various cultivars, while two peptides were not detected in any cultivar. The relative amount (unlabeled: heavy labeled ratio) determined for peptides PFPQPQLPY, RPQQPYPQ and total α-gliadin ranged from 1.8–18.3, 0.1–5.6 and 0.1–11.4 respectively. In conclusion, toxic/immunogenic peptides causing CD were found in both historical and modern cultivars irrespective of release year. Also, the relative amount of toxic/immunogenic peptides showed that there may not be a difference in terms of CD toxicity between historical and modern hard red spring wheat cultivars.

1103-P

Consumption pattern of selected retail flour-based products among pre-school children in Lagos, Nigeria

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Vitamin A fortification of flour is one of long-term strategies for eradication of vitamin A deficiency in pre-school children, pregnant and lactating mothers. Adequate consumption of flour-based products will contribute to their required daily allowance. Flour has been fortified with vitamin A in Nigeria but consumption pattern of its products have not been determined. This study aims at assessing consumption pattern of selected retail flour-based products among pre-school children (23-59 months) in Lagos, Nigeria. A three-stage sampling technique was used to select five out of 20 Local Government Areas, 22 wards out of 107, and 1,600 households with under-5 children. Pre-tested, semi-structured, interviewer-administered questionnaire was used to collect socio-demographic information, food consumption pattern and 24-hour dietary recall from mothers of the children. Data were analysed using descriptive statistics, t-test, and ANOVA at $p = 0.05$. Age of children was 31.4±5.3 months. Bread and biscuits were consumed by 44.0% and 67.9% of pre-school children respectively. While bread was consumed 1-2 times/week biscuits were consumed 4-7 times/week. Mean dietary intake of bread and biscuits per day was 117.6 g and 59.8 g respectively. Significant differences existed in consumption pattern between bread and biscuits (P=.000). There was also a significant difference in consumption of commonly consumed brands of retail bread (F=107.163; P=.000) and biscuits (F=3.605; P=.000) by pre-school children. Pre-school children consumed biscuits more frequently than bread. Adequate consumption of fortified products is essential to maximize gains of fortification programs. Subsidizing cost of bread would encourage increased consumption especially among the poor vulnerable groups.

1104-P

New Commercial Omega-3 Oil with High Oxidative Stability in Various Food Applications

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Long chain omega-3 polyunsaturated fatty acids (n-3 PUFAs) have attracted much attention for use in food products due to their beneficial health effects. However, n-3 PUFAs are underused ingredients in the food industry due to their low oxidative stability as well as off-flavor generated from oxidation. Therefore, there is a crucial need for developing new omega-3 oils with high oxidative stability for use in various food applications. Cargill has developed a new omega-3 oil, IngreVita™, containing a natural antioxidant that has high oxidative stability and does not require refrigeration. This new omega-3 oil showed high oxidative stability in various food matrices e.g. bakery products and dairy beverages. Great sensory performance of this omega-3 oil was also demonstrated in cookies and meal replacement beverage applications during shelf life (12 month) studies. Therefore, this new omega-3 oil with high oxidative stability developed by Cargill has great potential to increase the level of n-3 PUFAs in various food products without compromising their oxidative stability and sensory attributes.

1105-P

Protein quantity versus protein quality: where are we standing with predicting wheat baking quality?

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In wheat, grain protein quantity is often inadequate for explaining flour quality, which is critical for determining sustainability of the milling and baking industry. Protein quality, referring to the concentrations and ratios of glutenin, gliadin and albumin protein fractions, is proving to be as important as protein quantity. South Africa has three production regions with specific cultivars developed for each region. Size exclusion high performance liquid chromatography was used to separate protein fractions in commercial wheat cultivars for each of the three regions. Two locations and two seasons for each region were analysed. The highest concentration of glutenin was seen in wheat from the rainfed winter rainfall region, α/β, γ gliadin in wheat from the rainfed summer rainfall region and albumin/globulin in irrigated wheat. No consistent trends for concentrations and ratios of protein fractions could be established, nor consistent correlations with major baking quality parameters in the three production regions. Large insoluble glutenins of irrigated and rainfed summer rainfall wheat cultivars only correlated highly positively with flour protein, whereas in rainfed wheat of the winter rainfall region large insoluble glutenin correlated highly positively with flour protein, grain protein and loaf volume. Insoluble small glutenin proteins of irrigated wheat correlated highly positively with low loaf volume, whereas in the rainfed summer rainfall cultivars small soluble and insoluble glutenin correlated negatively with low loaf volume. In rainfed wheat from the winter rainfall region, small insoluble glutenin in total protein correlated negatively with grain protein, but positively with loaf volume. Protein fractions were therefore not consistent predictors of good baking quality, as both environment and genotype largely influenced this relationship.

1106-P

Zein as a texture modifier for high-protein extruded products

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Finding inexpensive and sustainable protein sources is crucial to feeding a growing world population. POET has developed a cost effective process to extract zein from the ethanol process. The zein product is light in color making it easy to use in foods. Extruded products are popular but their low protein content is a concern for health conscious consumers. Producing high-protein extrudates can be challenging. Adding protein typically reduces expansion, increases product hardness and density making it less enjoyable for consumers. Previous work showed that zein behaved differently from other proteins. It increased expansion and decreased product hardness and density. It was hypothesized that zein could be used to improve the quality attributes of high-protein extrudates. A recipe for a 25% soy protein isolate (SPI) extrudate was modified to include 5, 10 or 15% zein. The blends were extruded using an experimental extruder using the optimum extrusion conditions for a 25% SPI extrudate. The zein/SPI extrudates were characterized. The expansion ratio increased linearly with the zein content. The addition of 5, 10 and 15% zein increased the expansion by 9.4, 13.7, and 19.2% respectively. It decreased the product hardness by 15.1, 18.2, and 36.5% respectively. The addition of 5% zein decreased the bulk density by 31% and the increased the product crispiness by 36%. The extrusion conditions were further optimized for the zein/SPI blends. Optimizing the extrusion condition had the greatest effect on the expansion ratio. The addition of 5, 10 or 15% zein increased expansion by 19.9, 34.3, and 57.6% respectively. The addition of zein increased crispiness and decreased product hardness and density. The results suggest that zein can be used a texture modifier and could be used to produce high-protein products such as breakfast cereals and snacks.

1108-P

Pound cake quality as a function of storage conditions

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Pound cake is one of the most consumed fine pastries all over the world. Especially for cake manufacturing, the rate of cake firming is a key factor which, along with microbiological considerations, dictates shelf life. Next to the ingredients, it is assumed that the rate of cake firming is mainly determined by the storage conditions, as well as the resultant effect on the microstructural orientation of the ingredients. However, detailed knowledge is still missing concerning changes in the major structural components of cakes (proteins, starch and lipids) during storage (e.g., molecular mobility, recrystallization) and their relation to cake firming rate. To characterize the influence of storage conditions on the structural components of cake, rheological and microstructural investigations at different storage temperatures (7; 14; 21; 28; 35°C) were performed over 21 days. Lipid drop size distribution was visualized by confocal laser scanning microscope and analyzed with image processing software ImageJ. Crumb hardness measurements during storage were performed by TPA. In contrast to bread crumb, an increase in temperature leads to an increase in crumb hardness by more than 65% after 21 days. Inter alia, this effect accounts to starch recrystallization. Furthermore, area fraction analysis of lipids shows differences between the top (28%) and bottom (32%) of a cake cross section stored at 37°C of about 4%, whereas no significant differences are observed at a storage temperature of 5°C. The results reveal structural differences on cake firming and prove the influence of temperature and time on the major structural components. This study examined structural and textural changes in pound cakes stored at different temperatures, paying particular attention to the role of especially starch and lipids in cake firming.

1109-P

The effect of sourdough fermentation on the phenolic profile of ivory and brown tef varieties

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Tef (*Eragrostis tef)* is an endemic Ethiopian cereal grain. Due to its small size it is milled whole, and therefore tef flour retains the phenolic compounds present mostly in the bran layer of the grain. These phenolic compounds are found in three forms: free, conjugated (esterified to soluble fibre/sugars) and bound (esterified to insoluble fibre). In cereals, bound phenolic compounds make up the largest portion of total phenolics and can be released by hydrolyzing the ester bonds with strong alkali or acid. Fermentation of other grains, such as oats and barley, has resulted in increases of free phenolic compounds. Two varieties of tef, one ivory and one brown, were subject to a 72-hour fermentation using a sourdough culture (Cultures for Health). Phenolic acids were extracted before and after the process to determine the effects of fermentation on the phenolic acid distribution among the three forms (free/conjugated/bound). Extracts were analyzed by HPLC-DAD, and phenolic acids were identified and quantified by matching peak elution times to external standards and standard calibration curves respectively. The abundance of individual phenolic acids between the three fractions did not change over the course of the 72-hour fermentation in either the ivory or brown tef. However, there were visible color changes of the free-form extract, which was yellow for both ivory and brown tef before fermentation and became purple-green after the fermentation was completed. This result suggests that fermentation is potentially affecting another class of phenolic compounds that are responsible for the colors observed.

1111-P

Rheological characterization of new cereal: Tritordeum

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The Tritordeum cereal is a new cereal on the market. It was first commercialized in 2006. The rheological properties of Tritordeum are not fully understood yet which makes the quality control of this cereal very complicated. Thus, this study aims to evaluate the rheological properties of Tritordeum flour. 3 Tritordeum flours with various baking quality were tested according to both the AACC 54-30.08 standard protocol and a new testing protocol called “Tritordeum protocol”. This protocol is conducted at 45 % hydration with a slower mixing speed (40 rpm instead of 60). All analyses were made in duplicate to evaluate the repeatability of the new method. The results showed that both protocols allowed the assessment of Tritordeum flour. However, the Tritordeum protocol gave results closer to the baking performance: • Since Tritordeum flour contains less gluten protein, reducing the mixing speed allows to less damage the weaker gluten network (W values are between 107 and 227 instead of 38 and 135). Consequently, the results are more representative of the quality of the tested flour. • The new protocol allows obtaining a better repeatability: the means standard deviations between 2 runs of the same flour are in average 3 times lower: 2.6 with the Tritordeum protocol instead of 8 with the standard protocol

(W value). • Finally, the results are more discriminated and so more consistent with the baking quality of the flours. For example, the higher the "I.e." parameter is, the better the behavior of the flour during process is (7.6% for unacceptable baking quality flour, 37.6% for excellent baking quality flour). Rheological properties of Tritordeum doughs can be evaluated and the baking quality of such products can be predicted thanks to the new "Tritordeum protocol". Key words: Tritordeum, Alveograph, Rheology, Baking performance

1113-P

Reducing sodium in baked goods by control of bubble size distributions in dough

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Although numerous strategies have been developed to combat the deteriorative effects of salt reduction in bread, no one approach has shown sufficient promise to meet sodium reduction targets while maintaining good loaf quality. Simply reducing salt content in bread is not straightforward since salt reduction disrupts gas bubble structure, and thereby impairs bread quality. X-rays from a synchrotron source (Canadian Light Source) were employed to non-destructively monitor the rapid dynamics of bubbles in bread doughs in order to investigate how bubble size distribution (BSD) and gas retention are altered by salt reduction. Doughs were prepared using flours from two different wheat cultivars, made either with or without yeast and either with and without salt. All dough formulations were monitored for two hours to obtain time-dependent microtomography data. Complementary dough density measurements were performed to determine overall gas content. The high contrast X-ray images permitted the rapid changes in the bubbly structure of dough to be followed in 3D and within very short acquisition times (less than 1 min). A high number density of bubbles was found which was attributed to the very high resolution (6.5 microns/pixel) of the X-ray images. Using flours from two contrasting wheat cultivars and manipulating salt and yeast concentrations in doughs made from these flours altered the BSD in the dough at the end of mixing and how these BSDs evolved with time (especially for yeasted doughs). This study is the first to investigate the effect of salt on the evolution of the cellular structure of dough during breadmaking using X-rays from a synchrotron source. The results will enable breadmaking formula or process changes that mitigate poor loaf quality while meeting sodium reduction targets.

1115-P

Effect of *Lactobacillus plantarum* fermentation on the functional properties of pea protein concentrate

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Proteins show different functional properties due to nature of the interactions with the other components in the foods. Hydrolysis of proteins during fermentation can be a powerful tool to improve protein functionality through the modification of the protein's surface properties and also their size. Therefore, overarching aim of this study was to evaluate the effects of both fermentation with *Lactobacillus plantarum* and medium pH (pH 4 and pH 7) on the functional properties of pea protein concentrate (PPC). Samples were collected at different fermentation times (corresponding to different levels of hydrolysis), freeze dried and analyzed. As fermentation progressed (0-11 hr, 37°C), results showed an increased degree of hydrolysis up to 13%. Moreover, the nitrogen solubility index (NSI) of the PPC was found to be independent of time at pH 4.0 (~3.5%); whereas at pH 7.0, the NSI decreased gradually with time from 13.5 to 10.8% after 11 h of fermentation. Emulsification capacity (EC) at pH 4.0 increased (~43%) between 0 and 5 h, then decreased sharply to ~6%. However, at pH 7.0, EC was relatively independent of fermentation time. Emulsion stability (ES) was independent of time at pH 4.0 (ES ~22%); but at pH 7.0, ES increased from 36% to 56% after 5 h of fermentation, and then declined to 20% after 11 h. Foam capacity (FC) at pH 4.0 was found to increase from 74% to 89% after 5 h, then a decline to 68% after 11 h. In contrast, at pH 7.0, FC was relatively constant with fermentation time (~70%). At pH 4.0, foam stability (FS) decreased from 22% to 11% after 11 h of fermentation, whereas FS remained relatively constant with fermentation time at pH 7.0 (17%). In the case of water holding capacity (WHC) at both pH 4.0, values decreased from 1.0g/g to 0.9g/g after 5 h of fermentation, then increased to 158g/g after 11 h. A similar trend was observed for WHC values at pH 7.0.

1116-P

Prevention of product loss through the use of methoprene-treated packaging

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The insect growth regulator methoprene can be incorporated into the matrix of food packaging as a treatment to protect the contents from insects. Methoprene is exempt from food tolerance requirements under 40-CFR 180.1033, and is currently registered as an insecticide for use on stored raw grains, as a residual surface treatment, and as an aerosol. It is labeled by the US-EPA for use as a packaging treatment. The objective of this study was to

determine the effect of methoprene-treated packaging on egg hatch and penetration ability of larvae of *Tribolium variabile* Ballion, the warehouse beetle, and *Plodia interpunctella* (Hübner), the Indian meal moth. Treatment arenas were constructed with packaging treated with different concentrations of methoprene, and eggs of both species were exposed in the arenas. In addition, heat-sealed foil packages were created either with or without pinholes, placed in vials, and larvae introduced into the vials to assess penetration and survival of exposed larvae. There was no significant effect on egg hatch of either species when placed on treated or untreated arenas. *T. variabile* were unable to penetrate any foil packages. *P. interpunctella* penetrated all packaging containing pinholes. Methoprene-treated foil packages adversely affected *T. variabile* development, and deformed pupae and adults were observed at all levels of methoprene. The methoprene-treated packaging reduced adult emergence of larvae of *P. interpunctella* compared to untreated controls. Methoprene-treated packaging can potentially be used as part of management plans to protect the contents of packaged goods from infestations by stored-product insects.

1117-P

The USDA Starch Research Method: An Analytical Tool for Total, Soluble, and Insoluble Starch in Agricultural Crops

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Several analytical methods have been developed to characterize starch properties and concentration in products and by-products before and after processing. In sugar manufacture, starch is considered an impurity and is, therefore, quantified so that processing aids can be added or processors can be modified if necessary. Current sugar industry starch methods use extensive heating to completely solubilize starch and iodine to measure soluble polysaccharides since enzymes are too expensive and labor intensive. These methods are simple, rapid, and selective, use a soluble potato starch standard (which is not an ideal model for sugarcane starch), but are unable to effectively solubilize or accurately quantify starch amounts in various factory products like juices, massecuites, molasses, syrups, or raw and refined sugars. The newly developed USDA Starch Research method, based on microwave-assisted probe ultrasonication, offers the ability to solubilize <40 g/L insoluble starch in 6 mins while extrapolating results to a corn starch (which corn and sugarcane are both grasses and very similar) standard curve and incorporating a color correction step. This is the only method that quantifies total, insoluble, and soluble starch in various products. The method was validated following the International Commission for Uniform Methods of Sugar Analysis and found to be applicable to sugarcane and sweet sorghum bagasse (3% CV), mixed juices (2%), massecuites (4%), molasses (7%), and raw sugars (12%) and, 100% satisfactory performance z-scores were also obtained. Total starch values obtained with the USDA Starch Research method were significantly higher than those measured using other sugar industry methods. Future work includes expanding the utility of this method to other starch industries.

1118-P

Commercial mill operational efficiency expressed as endosperm purity via quantitative chemical imaging

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Quantitative chemical imaging with appropriate pixel size relative to the granular particle size enhances the localized sensitivity to reveal the molecular structural composition of wheat millstreams. Simultaneous microspectroscopic scanning of individual pixels in an array of detectors is performed with the objective of determining the endosperm analyte (product) concentration in a heterogeneous matrix of solids that includes nonproduct. The spectral organic chemical features of the isolated endosperm analyte (primarily starch and protein) are defined using a robust spectral library and compared to those of the nonendosperm components. Rather than a binary scheme, each pixel in the image is assigned a % endosperm score based on a partial least squares data treatment. Quantitation is achieved by summation of % endosperm concentration scores for all pixels in the field of view. Replicate fields of view are interrogated and coadded. In the industrial commodity processing scheme, the weighted combination of product concentrations are determined and cited in order of descending purity. Because endosperm purity is determined rather than focusing on nonendosperm (impurity), a sequential cumulative millers' curve reveals the streams that need to be included to meet the contract purity specifications. This enables informed product stream selectivity following refinement via a series of processing separation steps. The increased sensitivity of the endosperm purity method described is anticipated to be useful in assessing the effects of equipment installation or changes in operational settings on the commercial milling process. Application of quantitative chemical imaging to a newly constructed mill with design for a unique function is cited to exemplify the utility of this approach to optimize individual unit processes. The preliminary results are presented in this report.

1119-P

Effect of heat processing on immunoreactivity and *in vitro* digestibility of wheat gluten

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Approximately 1% of the world population has an autoimmune response to gluten, such as celiac disease, gluten ataxia or dermatitis herpetiformis. Found in wheat, barley, rye and some oat varieties the gluten network is composed of multiple subunits of prolamin and glutelin. Formation of the gluten network is especially important in wheat based products as it confers viscoelasticity and enables dough to be processed into bread. The aim of our study was to investigate the influence of different heat treatments applied to wheat flour on the immunoreactivity and *in vitro* digestibility of wheat protein. Commercial wheat flour (*Triticum aestivium*) from Cooperativa AgráriaAgroindustrial, de Guarapuava, Paraná – Brazil, 2012 harvest underwent extrusion, dry heat oven, ultrasound, spray-drying and microwave treatments. After processing, the samples were lyophilized. Protein digestibility and total protein before and after processing was determined on all samples. Immunoreactivity potential to celiac disease was tested by ELISA R5 (Prolamins Kit - TRANSIA® Plate Prolamins - BioControl Systems, USA) and G12 analyses (AgraQuant® Gluten G12 ELISA kit - Romer Labs, USA). A decrease in protein digestibility was observed in samples subjected spray-drying, ultrasound and extrusion (17.8%, 8.6% and 3.0%, respectively). Immunoreactivity using the R5 antibody decreased with spray-drying (47.4%) but increased with other heat processing, especially with extrusion (36.8%). Using the G12 antibody all samples showed a decrease in immunoreactivity compared to untreated flour, with highest decrease with spray-dry (52.6%). Heat processing leads to unfolding of peptide chains, changes in hydrophobicity and susceptibility to the action of proteolytic enzymes, and could influence immunochemical reactivity.