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Compositional characterization of hairless canary seed oil and starch associated lipids

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

Characterization and stability of short chain fatty acids modified starch pickering emulsions

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Rice and quinoa starch modified with short chain fatty acids (SCFA) (acetate, propionate, and butyrate) at different levels of modification and starch concentration, were used in the preparation of oil-in-water starch Pickering emulsions (SPEs) at 10% oil fraction. This works aimed to study feasibility of the utilization of SCFA-starches to produce Pickering emulsions. In order to investigate the stability phenomenon SCFA-starch Pickering

emulsions, and how the droplet size and chain length affect resulting emulsion stability over time. Initially, and after 50 days of storage of short chain fatty acid starch Pickering emulsions (SCFA-SPEs) were characterized to identify the particle size distribution of emulsion droplets and starch particles, microstructure, emulsion index (EI), and stability by using Static Multiple Light Scattering. Increased in starch concentrations led to decrease of emulsions droplet size. Apart from that, the emulsifying capacity of SCFA-SPEs were improved by increasing the chain length of SCFA, where pronounced results were observed in SCFA-rice-SPEs as less amount non-adsorbed starch was observed. Quinoa-SPEs were showed to have a good capability in stabilizing the Pickering emulsions in the native or modified state. High stability of emulsions was observed in butyrylated and propionylated quinoa starch at a higher level of modifications which had small droplet size with high EI over the entire 50 days storage. Thus, at optimized formulation, SCFA-SPEs are potential in stabilizing emulsions in functional foods, pharmaceutical, or food industrial application.

Effect of drying conditions on pasting properties of rice

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

Impact of alternative irrigation practices on rice quality

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Current global concerns about water scarcity present a need to investigate more water-efficient rice production methods. Alternate wetting and drying (AWD) is fast emerging as a water-saving irrigation practice, but its effects on rice quality are largely unknown. To ascertain the impact of water-saving irrigation practices on rice quality, three irrigation treatments, namely continuous flooding with cascade delivery (4 fields); continuous flooding with multiple-inlet delivery (4 fields); and AWD with multiple-inlet delivery (4 fields), were established on 12 production-sized (16.2 ha) fields in 2017. Results of rice quality evaluations showed that irrigation treatment had a significant ($P < 0.05$) effect on chalkiness. Samples harvested from the AWD fields had slightly greater mean chalkiness (5.6%) than samples harvested from the two continuously flooded fields (5.1 to 5.2%). Milling yields were not affected ($P > 0.05$) by irrigation treatments. The average milled rice and head rice yields across irrigation treatments were 73% and 59%, respectively. Regarding pasting properties, while peak and breakdown viscosities were not affected ($P > 0.05$) by the irrigation treatments, setback viscosity, which is often linked with cooked rice texture, was impacted. Among the irrigation treatments, mean SB was least for the AWD treatment (146 cP), while the mean SB for the continuously flooded fields were similar at 168 to 169 cP. In summary, the use of AWD with multiple-inlet delivery did not impact milling yields of rice relative to the conventional practices of continuous flooding. However, rice harvested from the AWD treatment fields had slightly greater chalkiness and lesser SB.

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

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Unripe banana shows high starch content in the pulp, and among the banana varieties studied, "purple" banana (*Musa*AAA subgroup *Red dacca*) showed starch granules with filamentous shape. These granules are not a result of two or more starch granules fused together to form elongated starch granules, as observed in high amylose starch. Therefore, the aim of this work was to evaluate the morphological, structural and molecular evolution of main components in the development of this morphology. Starch was isolated from unripe banana fruits harvested at 6, 12, and 16 weeks after inflorescence emergence (6-SD, 12-SD, and 16-SD, respectively).

Morphology of the starch granules changed during development of the fruit, starting with semi-spherical shape (3.6 μm) at 6-SD, progressing to an oval shape (6.1 μm of width and 16.5 μm of length) at 12-SD, and then reaching filamentous shapes (6.9 μm of width and 24.3 μm of length) at 16-SD. Maltase cross in the filamentous starch granules corroborated that these are individual granules where the concentric rings are perpendicular to the direction of granule growing. The results of crystallinity percentage, temperature, and enthalpy of gelatinization indicated that during evolution of the starch granule morphology, the molecular order was higher. The double helical structures, responsible for the internal packing of starch granules appeared when the filamentous starch granules are formed, which can decrease the hydrolysis rate. The amylose/amylopectin ratio did not change during development of the fruit, the length of amylose chains was heterogeneous at 6-SD, changing to homogeneous length at 16-SD. In contrast, the chain-length distribution of amylopectin showed that A, B1, B2, and B3 chains are simultaneously synthetized when the starch granule has filamentous shape and are not the result of the increase in the percentage of long chains (B2 and B3) as it was previously considered. Filamentous starch granules are produced due to evolutionary process originated by a modification in the disposal of the concentric rings from a radial to axial arrangement, leading the starch granule to increase in size just in one direction of the plane and transforming its shape from semi-spherical to filamentous.

Effect of pre-harvest desiccant application on properties of β-glucan from oat groats

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Pre-harvest desiccants are commonly used to control moisture levels in cereal grains before the harvest. It has been claimed that oat composition is affected by pre-harvest desiccant application. The aim of this study was to evaluate differences in β-glucan in the treated versus untreated (with or without pre-harvest desiccants) oat groats. Two cultivars (Rockford and Souris) of oats were grown at Minot and Prosper, North Dakota, in 2015, and the desiccant was sprayed at the soft dough stage, ripe stage, or not applied. β-Glucan viscosity was determined by treating ground groats with digestive enzymes measuring viscosity with a Rapid Visco Analyzer (RVA). β-Glucan solubility was determined according to AACCI Method 32-23.01. Molecular weights were analyzed using high performance size exclusion chromatography with light scattering detection (HPSEC-MALS). β-Glucan viscosity was not significantly ($P > 0.05$) affected by treatment at soft dough (1082 cP) or ripe (1166 cP) stages compared to untreated (1150 cP) controls. Use of the desiccant at the soft dough stage significantly ($P < 0.05$) reduced the percentages of β-glucan content and solubility versus untreated samples. β-Glucan content and solubility ranged from 4.35 to 4.65% and 52.1 to 60.6%, respectively. No significant ($P > 0.05$) differences were observed in β-glucan solubility from the desiccant treated at the ripe stage. Treatment at soft dough (4.4×10^6) and ripe (3.8×10^6) stages significantly ($P < 0.05$) increased β-glucan molecular weights compared to the untreated controls (3.5×10^6). The solubility of β-glucan decreased as the molecular weights of β-glucan in groats increased. Overall, the desiccant application seems to have effects on quality of oat groats and β-glucan characteristics from the groats if applied at too early of grain development.

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

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

starches more than the sugar counterparts, potentially because sugar alcohols form stronger hydrogen bonds with starch due to the open ring structure and extra hydroxyl group. The data generated in this study provide a comparison of the effects of different sweeteners at different concentrations on the gelatinization temperatures of a variety of starches, which should be useful for developing reformulation strategies when replacing the sweetener and/or starch in food products for which starch gelatinization is an important quality parameter.

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

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

Effects of sorghum proanthocyanidin interactions with partially gelatinized wheat starch and potato starch on resistant starch content

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Proanthocyanidins (PA) have been shown to increase resistant (RS) in cooked corn starch by interacting with amylose. Increasing RS in widely consumed starch-based foods, at the expense of quicker digested starches, could increase satiety and decrease total caloric intake. Our work aimed to determine the effect of PA on RS content of partially gelatinized wheat starch (WS) and potato starch (PS). Extracted sorghum tannins were incubated with WS and PS at 70°C, and 90°C in 30% and 50% ethanol solutions (E) for 20 min. The different temperatures were used to examine PA interactions with starch at different gelatinization stages. Ethanol was used to limit starch swelling and increase PA solubility. The RS content was determined by *in vitro* starch digestibility. WS and PS samples incubated with PA in 50% E were significantly ($P < 0.05$) higher in RS % than the control samples at both temperatures. RS increased in WS from 23.1% to 76.1% at 70°C, and from 1.5% to 20.9% at 90°C. On the other hand, PA had a lower impact on RS formation in PS, which increased from 84.7 to 91.3% at 70°C, and from 36.8% to 42.7% at 90°C. PA-PS interactions were limited likely due to a more tightly packed granule without the surface channels found in WS. In the more gelatinized 30% E treatments, however, the opposite effect was observed: WS showed a significant increase in RS only at 70°C; 18.8% RS vs 5.7% RS in the control. By contrast, PA treated samples increased in RS from 40.2% to 63.5% at 70°C and 26.2% to 50.5% at 90°C. Therefore, PA seems to have higher interaction with WS under conditions restricting gelatinization, whereas the interaction is higher with PS under more gelatinized conditions. This suggests PA-starch interactions can be optimized depending on starch source to enhance RS formation.

Effects of environmental temperature during maturation on spring wheat starch characteristics

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

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

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

Production of an enzymatic extract from *Fusarium oxysporum* f. sp. *melonis* using sonicated brewers' spent grain as substrate

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Mexico, the fourth largest producer of beer, generates 1.87 million tons of brewers' spent grain (BSG) per year. This contains high levels of dietary fiber, being 25% hemicellulose, formed by arabinoxylans and ferulic acid. It has been reported that arabinoxylans favor growth in intestinal microbiota populations, whereas ferulic acid is a natural antioxidant. The BSG has been modified by chemical treatments, commercial enzymes, fungus, and/or bacteria, for the production of bioethanol. Therefore, the objective of this work was to obtain an enzymatic

extract from *Fusarium oxysporum* f. sp. *melonis* using BSG as substrate for the production of β-1,4-xylanase and evaluate its potential use in BSG modification, increasing arabinoxylans and ferulic acid availability. Wet BSG provided by a brewing industry was dried at 45°C during 48 hr. Afterwards, chemical composition, including contents of lignin, soluble, insoluble, and total dietary fiber was analyzed. In addition, the contents of total phenolic compounds, free and bound phenols, and phenolic acids were determined. The production of the enzymatic extract was monitored, divided into 2 stages: first an inoculum was obtained and later, the enzymatic extract containing β-1,4-xylanase, using sonicated BSG (600 W, 30 min) or BSG without sonication (control) as substrate was obtained. The moisture content of BSG decreased from 83.0% to 4.4% after drying. The dried BSG had 24.3% protein, 8.7% fat, and 4.1% ash. The total dietary fiber was 60.7%, corresponding 0.9% to soluble fiber and 59.8% to insoluble, which 24.4% was lignin. The content of total phenol compounds was 3.85 mg AGE/g of sample, which 3.73 corresponded to bound phenols and 0.12 to the free ones. The phenolic acids found were: ferulic 1.14 mg/g, p-coumaric 0.18 mg/g, and sinapic 0.01 mg/g. At the first stage of the production of the enzymatic extract, an activity of β-1,4-xylanase of 15.5 U/mL (day 4) was obtained, remaining constant during the following 2 days. At the second stage, a higher activity (26.5 U/mL at day 6) of this enzyme was measured. The sonicated BSG is a good substrate for the production of β-1,4-xylanase. The application of ultrasound to BSG could be an alternative to the use of chemical treatments which can represent a risk to human health and the environment, allowing the use of this residue in human nutrition.

Simple and fast methods for the assessment of wheat grain pre-harvest sprouting

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Pre-harvest sprouting (PHS) of grain is one of the major concerns in wheat production and adversely affects grain quality, marketability, and price. While the falling number (FN) test is accepted and widely used as a standard method for the assessment of wheat grain PHS, it is a low throughput and expensive test, requiring the grinding of grain prior to the test, a FN test instrument, and an experienced technician, making it unsuitable for the evaluation of a large number of breeding lines in the development of PHS-resistant wheat varieties by breeding programs, and for the rapid screening of wheat grain in truck loads at the grain elevator for segregation. We explored simple and fast alternatives to the FN test for the determination of wheat grain PHS damage. Three approaches, including 1) electrical resistance of wheat grain soaking water using a portable electrical multi-meter, 2) absorbance of alpha-amylase dye tablet solution of wheat grain grits using a spectrophotometer, and 3) hot paste flow viscosity of wheat grain meal using a Bostwick Consistometer, were examined for the assessment of wheat grain PHS. The test procedures and conditions were established and evaluated considering their capacity to differentiate the grains of three wheat varieties showing low, medium, and high degrees of PHS as indicated by their FNs. All three approaches clearly differentiated the wheat grains of different FNs, proving their potential for the assessment of wheat grain PHS. The three approaches were further examined for their performance using the grains of fifteen soft winter wheat varieties with a wide range of PHS and FN. The electrical resistance, spectroscopy absorbance, and flow viscosity all showed strong relationships with FN and alpha-amylase activity, and yielded r-squares ranging from 0.93 to 0.97 for the former and 0.82 to 0.87 for the latter, proving that all three approaches could be developed as methods to more simply and quickly assess wheat grain PHS than the FN test. Electrical resistance of wheat grain soaking water was the simplest and fastest test with no need for grinding grain, while hot paste flow viscosity of wheat grain meal yielded the best prediction of FN.

Wheat flour as a model system to study process effects of sonic agglomeration—A new food compression technique

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Sonic agglomeration is a densification process newly applied to food products through the adaption of sonic welding technology. The process, which can yield energy-dense compact bars, is advantageous over standard uniaxial compression because the application of sonic energy serves to momentarily plasticize particle surfaces due to localized vibrational heating during compression, thus yielding permanent interparticle junctions and products of superior quality. Cereal/grain based bars formed through uniaxial compression, relying on static pressure only, require a high proportion of non-nutritive syrups or binders for bar cohesion. By contrast, compression employing sonic energy (in which the compressing crosshead is a sonic horn), can yield firmly compacted products without the incorporation of such less-nutritious ingredients. The military has employed sonic compression to produce a range of calorically dense meal-replacement bars that are of high sensory acceptance (>8 on a 9-point hedonic scale) and is now pursuing fundamental research using model systems concerning the relationships among process parameters, energy developed in the bars, and the resultant bar characteristics. In moistened (10% added water) wheat flour systems, using a modified Branson ultrasonic welder with a 1.5 inch by 1.75 inch rectangular horn and receptacle, it was determined that: developed energy (joules) was a linear function of sonication time and percent maximum vibrational amplitude; that product temperature and moisture loss were linearly related to developed energy; and, that developed energy was an exponential

function of specimen weight. Such findings are the basis of understanding the sonic agglomeration process and for predicting the behavior of formulations during development of compressed products.

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

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

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

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

Financial feasibility of safer maize storage technologies for smallholder farmers in developing nations: A case study in Guatemala

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Several maize pests, including fungi, rodents, and birds, thrive in warm, humid areas, boosted by poor post-harvest practices such as inadequate storage. This in turn causes significant safety, quality, and trade problems between producers and consumers. Increasing agricultural productivity is closely associated with improved storage to ensure food supply in developing countries. However, while improved storage options have become

available in the market, few studies have focused on the financial capability of growers to acquire them. The goal of this study was to investigate the financial feasibility of new technologies compared to traditional storage practices. The ability to safely store grain for longer periods allow farmers to wait and sell when prices are higher. Likewise, farmers who need to buy grain can do so in larger quantities when prices are lower. This research surveyed ($n_1 = 280$, $n_{2,3} = 25$) farmers from two townships in Huehuetenango, Guatemala. Further, local NGOs, banks and governmental entities were contacted for supplementary information to strengthen the financial model. Realistic scenarios faced by producers were simulated with Monte Carlo methods according to farm size (producers and consumers = Chain 1), maize consumption (strictly consumers = Chain 2), storage technologies (metallic silos, plastic silos, and plastic drums), and loan period (1, 2, or 3 years). The model provides a comprehensive cost-benefit analysis of storage technologies, which enables producers to identify the option best suited to their needs and preferences. For example, if farmers (Chain 1) choose storage capacity based on their yield history, plastic silos are not a financially feasible alternative due to their higher cost and fixed capacity. As far as metal silos, they seem to be a more feasible option after a loan period of 2 years for larger-sized farms, and after 3 years for medium- and smaller-sized farms. The opposite pattern was observed with plastic drums, likely due to their small capacity. Further, if Chain 2 farmers choose storage capacity based on historical 4-month consumption, all new storage technologies would be financially more feasible compared to traditional practices. The choice of storage capacity is crucial because, if a farmer selects a storage capacity larger than needed, unused space represents an extra monetary cost. The developed platform can be easily adapted to other storage technologies or commodities, and expanded to include other regions of the country, or other developing nations to obtain safer grain products with extended shelf life.

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

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

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

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The interactions within and between main structural wheat dough elements (gluten and starch) present the fundamental basis of microstructure and determine the characteristic functional properties of dough. However, structure-function relationships are still not understood in detail. Their dependence from processing time, raw material fluctuations, process conditions, and enzyme/yeast activity poses a major challenge in clarifying the

mechanistic relations of structure and function. To overcome these difficulties a standardization and simplification of dough is necessary. A promising approach is the imitation of functional wheat dough properties by artificial systems. To imitate wheat dough on a functional level, natural and synthetic hydrocolloids were used in combination with inert filler particles. These systems were investigated by fundamental rheological tests and analyzed by mechanical models (Power Law/Burger Model) to enable an assessment of network properties. In particular, a mixture of natural hydroxypropylcellulose (HPC) and synthetic polyvinylpyrrolidone (PVP), reinforced with glass particles, showed consistent viscoelastic properties to wheat dough. Within the linear viscoelastic region, the slope of storage ($n' = 0.21 \pm 0.01$) and loss ($n'' = 0.24 \pm 0.01$) module were in agreement with wheat dough analyzed ($n' = 0.20 \pm 0.01$, $n'' = 0.21 \pm 0.02$) and cited in literature. But even exposed to lager deformations (creep test) the stress response (instantaneous compliance and retardation time) was in accordance with wheat dough. Based on this artificial system the effect of polymer (HPC/PVP or gluten) particle interactions on viscoelastic dough properties can be identified in more detail by a targeted manipulation of surface functionality of filler particles. For this, surface functionality of glass particles was specifically altered by coating with silanes, offering different functional groups. Depending on silane type none, weak (hydrophobic, hydrogen) or strong (covalent) interactions between particle and polymer matrix were enabled. The results show that network formation (Farinograph curve) as well as network strength A_f, ranging from 15,250 ± 2,316 to 22,591 ± 3,481 Pa $sec^{1/z}$, and the extent of interactions z, ranging from 4.55 ± 0.07 to 5.36 ± 0. 01, were influenced by the different surface functionalities. In contrast to commonly used methods for altering surface properties (e.g., heat or acid treatment) no further modifications of dough systems take place. Thus, a new approach for clarifying the impact of type and strength of particle-matrix (starch-gluten) interactions on the mechanical behavior is available.

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

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

Modeling the environmental sustainability of naked vs. hulled oats

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There is a need for sustainable agriculture, socioeconomic benefits for growers, and enhanced nutrition for the consumer. With these needs in mind, a unique variety of oat has been commercialized. SowNaked™ oats are a naked (hulless) oat variety grown in Montana, with 40% higher protein than traditional oats and a lower CO_2e (CO_2 equivalents) emissions footprint. The objective of this study was to model the environmental sustainability of SowNaked™ oats versus traditional hulled oats to understand the sustainability impact and quantify CO_2e emissions. The environmental sustainability was modeled through lifecycle analysis from farm to factory and was contextualized through interviews with customers and farmers. The two main contributors of this lower CO_2e impact were 1) more efficient farm to factory transportation with the elimination of the need for hull removal, hull transport, and further processing of hulls; and 2) no steam or kiln processing. CO_2e emissions were reduced by 217,000 lb, which equates to a greenhouse gas emissions reduction equal to 235,000 miles driven by car and a CO_2 emissions reduction equivalency of 11,000 gal of gasoline consumed.

Rheological characterization of nixtamalized corn dough

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Corn can be nixtamalized (soaked and cooked in an alkaline solution) to improve its nutritional value, flavor, and aroma and to reduce mycotoxins. The nixtamalized corn is then ground in order to obtain a dough (masa) that will be used to produce tortilla chips (nacho type). No satisfactory rheological method is known to analyze nixtamalized corn dough. As a result, industrial producers face problems during process due to a lack of prior characterization. The objective is to find a rheological method able to analyze nixtamalized corn dough in a repeatable and discriminative way. Three nixtamalized corn doughs of various quality (good, medium, and bad) were tested with the Mixolab. A specific tool called a "dough kit" was used to directly analyze pre-made dough. A protocol called "Chopin+90g" has been applied. This protocol is similar to the standard protocol (AACC Method 54-60.01) except for the dough weight (90 g). All analyses were made in duplicate to evaluate the repeatability of the method. In order to evaluate the significance of the results, an ANOVA test coupled to an HSD interval of Tukey was used. The results showed this protocol allowed the assessment of nixtamalized corn dough: 1) The repeatability results are very good given the low standard deviations obtained (0.07 on average taking into account all parameters and all samples). 2) The statistical analysis proves that the method is discriminative: C2, C3, and C4 torques are parameters that allow efficient classification of the different qualities of doughs. 3) Finally, the results are consistent with the quality of the flours: when the dough is heated, the lower the torques, the better the sample process performances. For example, the lower the C3 parameter is, the better the behavior of the dough during process is (2.67 Nm for bad quality dough, 2.37 Nm for good quality dough). Rheological properties of nixtamalized corn doughs can be evaluated and the quality of such products can be predicted thanks to the Mixolab.

Selection and evaluation of rice flours for gluten-free cookies

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More and more people are now choosing a gluten-free diet. Over the past decade, various products have been utilized to replace wheat, which is high in gluten. Rice is often chosen for its neutral flavor and its whiteness; it is easy to digest, low in sodium, and has hypoallergenic properties. The rice flours available on the market vary widely in terms of suitability to replace wheat flour. This complicates their use in gluten-free preparations, since it has a direct impact on the quality of the finished products. The Mixolab has the capabilities to measure physical dough properties like dough strength and stability and also to measure the pasting properties of starch on actual dough. It measures in real time the torque (Nm) produced by mixing of the dough between the two kneading arms. It is used to characterize the rheological behavior of dough subjected to a dual mixing and temperature constraint. The goals of this study were to determine the ability of the Mixolab to differentiate between different rice flours, evaluate the impact of the rice origin on cookie quality and draw correlations between Mixolab's parameters and cookie characteristics. As depicted from the Mixolab patterns, significant variations during mixing, pasting, and gelling were noticed among the rice flours depending on their botanical origin. Cmax, Cs, C2, C3, C4, and C5 varied from 0.59 to 3.33 Nm, 0.26 to 1.20 Nm, 0.31 to 1.44 Nm, 0.93 to 2.54 Nm, 0.74 to 1.93 Nm, and 1.42 to 3.29 Nm, respectively. Looking at the results of the cookie tests baking, one can notice that all rice flours were able to produce cookies with correct shape and color. However, significant variations in cookie weight and thickness were noticed, in agreement with the Mixolab findings. Cookie weight and thickness varied, respectively, from 9.5 to 11.60 g and 48 to 64 mm. Our results also revealed high correlations between technological tests results and Mixolab characteristics. Correlation coefficients (R^2) were 0.88 and 0.64 between cookie weight and C5 and cookie thickness and C4, respectively. This study confirmed strong variability in the quality of rice flours depending on their botanical origin. Mixolab was successful in evaluating their rheological performances. Cookie baking tests revealed significant differences between cookies in terms of weight and thickness

Effect of particle size and cooking method on navy bean starch and protein hydrolysis and raffinose family oligosaccharide extractability

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The presence of intact cell walls in pulses is known to increase the resistant starch content of pulse flours. However, little information is available to directly show the effects of cooking on the integrity of the cell walls. Furthermore, the effect of the cell walls on protein digestibility and raffinose family oligosaccharide measurements has not been studied. This work, therefore, studied the effects of pulse flour particle size and cooking method on starch and protein hydrolysis during in vitro digestion and on the level of extractable raffinose family oligosaccharides. Dehulled navy beans were milled and sieved to three different size fractions:

300–500 µm, 75–300 µm, and <75 µm, approximately corresponding to clusters of intact cells, intact cells, and completely disrupted cells, respectively. Each flour fraction was processed under three different moisture conditions: roasting (low moisture), baking (intermediate moisture), and pasting (high moisture). The raffinose family oligosaccharide content of the raw and processed fractions was measured. An in vitro digestion experiment was also conducted with each fraction of the untreated and cooked flours to measure the rates of starch and protein hydrolysis. The results demonstrate the importance of considering the particle size distribution of pulse flours.

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

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As one of the most ancient wine products, Chinese rice wine was a low-alcohol wine fermented by rice. And, the quality of the wine was significantly affected by raw material properties and fermentation process. To study the effect of degree of rice milling on the characteristics of Chinese rice wine, five rice cultivars collected from Hubei province with four different degrees were prepared. The results showed that the moisture content and starch content of five rice cultivars increased, while ash content, total fat, protein content, crude fiber content, and B group vitamins decreased as the degree of milling increasing. Starch content increased from 60% to 80%, total fat decreased from 7% to 2%, and crude fiber content decreased from 1.2% to 0.3%. During the fermentation process, alcohol content increased from 3% to 12%, amino acid-state nitrogen content increased from 0.02 $g \times L^{-1}$ to 0.4 $g \times L^{-1}$ with fermentation time, while the content of total sugar decreased from 25 $g \times L^{-1}$ to 2 $g \times L^{-1}$. The features of Chinese rice wine were enhanced by higher milling degree which improving the content of starch and reducing the content of crude fiber. Compared to high milling degree of rice, the alcohol content of Chinese rice wine using unpolished rice was low while the pH was high, which was not suitable for Chinese rice wine fermentation. In conclusion, the high milling degree of rice was more suited for Chinese rice wine fermentation.

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

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

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

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The use of a baking test is a common method to evaluate suitability of wheat flours for production of high-quality cookies, however, the test is time consuming. The possibility of correlating target quality parameters of cookies with time-saving techniques utilized to evaluate wheat flour, but also suitable with non-wheat flours, is of great interest. The objective of this study was to investigate correlations among rapid test indices (i.e., water and lactic

acid retention capacities, oil binding capacity, and Rapid Visco Analyzer (RVA) indices) of bean powder blends and nutritional, geometrical, and textural properties of bean cookies. Bean powders of 25 edible dry bean (*Phaseolus vulgaris* L.) varieties were investigated in order to understand the effects of bean genotype on cookie quality parameters. As powder particle size implicates a different surface contact area with the solvent, all dry beans were ground in order to be of similar particle size (≤0.5 mm). Baking potential varied greatly among bean genotype: cookie protein and resistant starch contents ranged from 7.7 to 10.2% and from 9.4 to 17.9%, respectively; cookie thickness and fracture strength ranged from 0.93 to 1.17 cm and from 87 to 226 kPa, respectively. Water retention capacity values were significantly ($P < 0.05$) correlated with cookie protein content and hardness ($r = 0.49$ and $r = 0.42$, respectively), while oil binding capacity values were correlated with rapidly digestible starch values ($r = 0.55$, $P < 0.005$). RVA indices were not correlated with bean-cookie properties. Results of this research have demonstrated that some rapid test indices can be used to partially design bean cookie features and that bean genotype has a significant effect on cookie nutritional composition as well as geometrical and textural properties. Outcomes of this research can guide the making of value-added bean cookies.

Suitability of selected Australian varieties for premium yellow alkaline noodles as measured by sensory evaluation and triple cutting ring (TA-XT2iPlus)

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Textural properties of premium yellow alkaline noodles (YAN) (referred to as ramen in Japan) are an important quality attribute influencing consumer acceptance. Ideally, YAN in Japan should be firm, springy, not sticky and smooth. In addition to these quality characteristics, textural stability in a hot soup is a critical quality trait of YAN. Wheat and flour protein have been positively correlated with noodle firmness and elasticity and negatively with smoothness. In 1999 Crosbie et al. reported a requirement of low to moderate starch-swelling properties, flour swelling volume (FSV) ~14–17.5 mL/g for ramen noodles. The objective of this study was to benchmark selected varieties of APH and AH for their suitability for ramen noodles using sensory evaluation by a trained panel. Most common method to evaluate texture of noodles is by sensory evaluation. Preferences for YAN vary due to the many different noodle types. In general YAN texture is a complex relationship of firmness and springiness immediately after boiling and the stability of the noodle texture following a resting period of 7 min in hot soup. YAN stability equates to change in noodle texture from assessment at time zero to assessment at time 7 min. In addition to texture, color, and color stability are very important quality traits for ramen noodles. Australian wheat varieties grown in Queensland (WLD) and New South Wales (NSW) ranged in grain protein content from 11.4 to 15.8 (11% mb), and wheat varieties grown in South Australia (SA) and Western Australia (WA) had a grain protein content in the range of 12.3 to 14.8% (11% mb) have been compared to North American wheats and assessed by sensory and triple cutting ring (TA-XT2iPlus) for their suitability for YAN. Three textural properties (firmness, springiness, and stability) of YAN were evaluated by trained sensory panel first, followed by the triple cutting ring measurements. North American wheat showed stronger mixing properties, while Australian wheat in general showed higher starch gelatinization when analyzed by MixoLab. The objective of this study was to develop a new method using Stable Micro Systems (SMS) new triple cutting ring attachment to address the textural properties of noodles immersed in a hot soup and measure changes that occur between the end of cooking time and noodle consumption.

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

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

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

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

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

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

Antioxidant phytochemicals in peanuts and their sprouts

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

Determination of protein content in soybean meal using hyperspectral imaging

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Soybean meal is the second highly consumed animal feed ingredient next to corn. Protein and amino acid contents are the most important quality factors. Protein correlates well but not perfectly with amino acid composition. Non-uniform distribution and varying amino acid profiles have made protein content, and by inference amino acid contents, hard to measure. In this study, near-infrared (NIR) reflectance hyperspectral imaging (HSI) (SWIR microHSI™ from Corning, Inc.) was used to predict protein content of soybean meal and to show the distribution of protein content in a soybean meal sample. Total of 189 soybean meal samples with 10 regions of interest per sample were analyzed using a reflectance NIR HSI system in the 850 to 1,700 nm wavelength. Mean spectra, which were preprocessed using standard normal variate, and reference % protein content measurements were the input data in the partial least squares (PLS) regression for model calibration. The final model achieved root mean square error (RMSE), R^2 and standard error (SE) of 0.699, 0.835, and 0.699, respectively. The model was then used to predict and visualize protein content distribution in a sample. The performance of the model for soybean meal protein content is relatively low as compared to NIR models for whole grains, but it is comparable with other NIR models for soybean meal. This study serves a precursor to the use of imaging technology to measure amino acid composition (i.e., lysine, methionine, and cysteine) in soybean meal and other animal feed ingredients.

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

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

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

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Recent disease outbreaks from Shiga-toxigenic *Escherichia coli* (STEC) strains (O121, O26) in the US have been associated with contaminated wheat flour. As wheat milling does not involve any lethality steps to control pathogen contamination, antimicrobial intervention steps in wheat tempering could potentially minimize microbial loads. Sodium bisulfate (SBS) is a known antimicrobial agent with strong acidic properties, but there is no available information relating its microbicidal effects and pH. The objective of this study was to investigate the effects of SBS and pH in reducing STEC contamination in wheat during tempering. In a previous study, the minimum inhibitory concentration of SBS required to inhibit the growth of STEC surrogate *E. coli* ATCC 1427 was determined as 0.25%. Hard red winter wheat was inoculated with *E. coli* (~10^6) and tempered to 16%

moisture (wet basis) using the following concentrations of SBS solution in water (w/v): 0.25%, 0.5%, 1%, 5%, 10%, 15%, or 20%, along with a control treatment. The treated wheat was incubated for 1 h at 37°C, and the pH was measured by diluting the samples in deionized water at a ratio of 1:10 by weight. The *E. coli* counts were enumerated by spread-plate method using tryptic soy agar. Logarithmic reductions of the bacterial counts were calculated, and the treatment means were separated using Tukey's studentized range test. Tempering water pH of 2.4, for 20% SBS solution, resulted in the highest reduction ($P < 0.05$) of 2.8 log colony forming units (CFU) per gram in *E. coli* counts when compared with the control pH of 7.0, with a bacterial count of 6.2 log CFU/g. However, lowering the pH below 6.0 did not affect the log reduction of bacterial counts. These results suggest that tempering of wheat using SBS solution at pH levels below 6.0 could potentially control STEC contamination during wheat processing prior to flour production.

Selecting a standard reference material for falling number

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

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

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

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

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

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

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

Rheological properties of starch nanoparticles from pea starch

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Pulse grain value-added processing activities are growing in Canada due to increasing demand for nutritive plant protein. Starch is the major by-product of pulse protein refining, and therefore finding novel applications to pulse starches by nanoparticulation technologies will positively impact the Canadian grain industry. Starch nanoparticles (SNP) were isolated from field pea starches, as well as commercial corn and potato starches. The

rheological properties, of the aqueous SNP suspension was investigated. SNP suspensions of 1-5% (w/v) were prepared and rheological tests at room temperature were performed using a rheometer. Viscosity was measured as a function of shear rate, where shear rates applied ranged from 0.01 to 100 s^{-1} in an upward sweep followed immediately by a downward sweep from 100 to 0.01s^{-1}. Three sweep cycles were conducted consecutively in order to understand the thixotropic behavior of each sample. The frequency sweep test was employed to evaluate the changes in the viscoelastic modulus as a function of angular frequency ranging between 0.1-10 rad/s. The temperature ramp test was carried out to determine the relationship between viscoelastic modulus and temperature. Freshly cooked pea starch paste (3-5%, w/v) exhibited significantly lower viscosity and higher pseudoplasticity and thixotropy when compared to SNP suspensions at the same concentrations. Interestingly, pea SNPs suspension showed an excellent non-thixotropic behavior, demonstrating the aptitude of the suspension to instantaneously recover from the applied stress or strain. This was further confirmed by their highly elastic character (G′>G″). Furthermore, SNPs from native starch showed low thermal stability (i.e., high heat sensitivity), indicated by the change of flow behavior as a function of temperature. This may be due to swelling, partial melting, and solubilization of SNP upon heating. The data suggest that careful selection of processing conditions, such as heating temperature and shearing conditions, is required to achieve the target functionality of SNPs in food industry applications.

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

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

Wheat flour solvent retention capacity: Repeatability and reproducibility performances of a new AACC Standard Method Measurement Method (56-15.01)

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Solvent retention capacity (SRC) is an analytical method used to measure the contribution to water absorption of the main functional flour polymers (gluten protein, starch, and pentosans). Originally established to evaluate soft wheat flour functionality in the United States, the method is gaining acceptance worldwide and is now applied to many wheat types and disciplines in wheat variety development and flour processing across the globe. The first approved standardized method recognized in the industry was AACCI Method 56-11.02. However, this manual method is extremely operator-dependent, due to the need for consistent agitation during the initial hydration phase and intermittent agitation thereafter. Differences in human execution can introduce variation in results, making it difficult for SRC parameters to be effectively integrated into flour specifications. Laboratories have mechanized different parts of the method in attempts to improve accuracy and precision; however, no formal standardized solution has been introduced in the industry. To address this situation, CHOPIN Technologies developed an automated system, based on the concepts of the AACCI standard method, with the aim of eliminating all potential operator impacts on the test and standardizing tubes and centrifugation conditions. This method has been evaluated through a collaborative study involving 12 laboratories that analyzed 12 flour samples in duplicate with 4 solvents (water, sucrose, sodium carbonate, and lactic acid). The automated SRC tests appear

to be highly repeatable and reproducible. Differences in the measured SRC values between laboratories are expected to be lower with the use of the automated CHOPIN-SRC tests because of the much lower relative SDs between laboratories compared with AACCI Method 56-11.02. The study also demonstrated that the tests are applicable to wheat flours with much wider ranges of SRC values than those previously believed to be acceptable, thus they can be used for the evaluation of not only wheat with a soft kernel texture and low protein content, but also for wheat with a hard kernel texture and high protein content. This method has been approved by the AACCI Soft Wheat and Flour Products Committee and also by the AACCI Approved Method Technical Committee as AACCI Method 56-15.01 on the condition of revision.

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

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

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

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

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

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

Structural characterization of starch isolates from the electrolysis treatment of barley flour

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This study was carried out to understand the effects of electrical voltage treatment of barley flour on the structural properties of the final starch isolate. Barley flour (starch 75%, protein 11%, ash 0.9% dry basis, 0% amylose) slurry was prepared in the proportion of flour to water 1:6 w/w and treated by electrolysis utilizing pure platinum electrodes (>99%) of 1.5 mm in diameter each, at voltage (5, 10, 15, 20, and 25 V), electrode length (4, 6, and 8 cm), and constant time of 30 min. Electrolyzed barley flour slurry was centrifuged at 1,593 *g*, and upper protein layer was removed to recover the white portion starch granules. Starch isolates were dried at 40°C and stored at room temperature until characterization. Results showed that electrolyzed starches compared to the alkali-treated starch (conventional isolation method) had lower gelatinization onset, peak, and conclusion temperatures measured by differential scanning colorimeter, as 57.52 ± 0.21°C, 63.56 ± 0.03°C, and 70.43 ± 0.02°C, for 25 V/8 cm, respectively, and 59.92 ± 0.08°C, 66.36 ± 0.01°C, and 73.80 ± 0.78°C for alkali-treated starch, respectively. The lower gelatinization temperatures may be related to loss in crystallinity of the treated starch. Syneresis of starch gels (11% solids, 57°C) was observed for 37 days at room temperature and showed that starches treated at 5 V/8 cm, and 25 V/8 cm had significantly lower water loss as 87.5% and 25.0%, respectively, compared to 100% syneresis of alkali-treated starch. This showed that starches treated with high voltage had superior retrogradation characteristics possibly due to strengthened hydrogen bonds from hydrogen and hydroxyl ions produced during electrolysis. Starch gels (10% solids, 67°C) were left at room temperature (23°C) for 40 days, fast-frozen using liquid nitrogen, and lyophilized; swelling capacity of electrolyzed starch gels ranged from 1,486 ± 10.37% (25 V/8 cm) to 1,631 ± 14.83% (5 V/8 cm). The extremely high swelling/water-retaining capacities show that ionic species during electrolysis produced strong networks for superabsorbent hydrogels valuable for the bio-based polymer industry. Color differences of starch gels showed increased opacity of all electrolyzed starches with whiteness indices of 89.15 ± 1.83 at 5 V/8 cm and 90.82 ± 0.53 at 25 V/8 cm compared to 95.78 ± 0.01 of alkali-treated starch which was distinctly transparent. This may be related to the re-alignment of the starch molecules caused by electric polarization effects. Overall, the electrolysis process showed modification of the structural properties of barley starches.

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

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Isomaltodextrin (IMD) is a highly branched dietary fiber consisting of glucose residues being linked through α-1,6 (~49%), α-1,4 (~19%), α-1,4 (~17%, nonreducing end group), α-1,3 (~3%), α-1,3,6 (~7%), and α-1,4,6 (~5%)

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

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

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

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

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Polyphenols have a significant binding affinity for proteins and are known to form complexes with proteins, which causes changes in the structural, functional, and nutritional properties of both compounds. The objective of this study was to evaluate the effect of polyphenols on functional and rheological properties of black bean protein isolates from the whole bean and cotyledon. The seeds were manually cleaned to remove all foreign matter and dehulled to obtain cotyledons. Both the seeds and cotyledons were milled using a hammer mill. One portion of both seed and cotyledon flour were subjected to phenolic extraction, resulting in whole bean flour with polyphenols (WBWP); whole bean flour free of polyphenols (WBFP); cotyledon flour with polyphenols (CBWP); and cotyledon flour free of polyphenols (CBFP). Four protein isolates were prepared from the four portions of black bean flour described above. Contents of moisture, ash, protein, crude fiber, total fat, total phenol, and available lysine were determined for proximate analysis. Color, wettability, solubility, emulsification properties, foaming properties, water-holding capacity, oil-holding capacity, and gelation dynamics were determined for the physical and rheological properties. The experimental design was a randomized complete block with split-plot arrangement, where whole-plot was flour with or without seed coat and the sub-plot was presence of polyphenols. Protein isolates from CBFP had significantly low ($P < 0.05$) ash and phenolic content and significantly high ($P < 0.05$) protein levels. The color of protein isolates from WBWP and CBWP improved considerably after removal of polyphenols. Protein isolates from CBFP had significantly high ($P < 0.05$) foaming capacity, foaming stability, emulsion capacity, emulsion stability, and oil-holding capacity. Water-binding capacity was significantly higher ($P < 0.05$) for protein isolates with high phenolic content. Polyphenols in protein isolates decreased both the storage modulus and loss modulus of protein dispersions and formed more viscous and less elastic gels. Removal of polyphenols from the black bean protein isolates improved the functional and rheological properties.

The interrelationships of test weight, kernel size distribution, protein content, and yellow pigments and their effects on durum wheat quality

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Durum kernel physical properties has large impact on not only the milling performance, but also semolina appearance and pasta quality. Due to overall dry growing conditions in 2017 and 2018, the majority of durum wheat produced in the Canadian prairies was high in protein content and met the test weight requirements for the top grades of Canada Western Amber Durum (CWAD). However, some durum samples, although graded as No. 1 or 2, had smaller kernel size and were significantly lower in milling yield and semolina quality. This study was conducted to investigate the impact of kernel physical characteristics, with a focus on kernel size and its distribution, on durum milling potential, semolina, and pasta processing quality. Two sets of durum samples were used. The first set was a blend of 14 commercial cargo loading samples. The second set included 21 composites of four CWAD varieties (Transcend, Strongfield, Brigade, and CDC Verona) segregated based on their test weight (75 to 84 kg/hL) and protein content (10.3 to 18.7%). To investigate the kernel size distribution in relation to functionality, kernels were segregated into five fractions based on their sizes with a set of sieve. Semolina yield decreased gradually from fraction > no. 8 (3.18 x 19.05 mm), fraction > no. 7 (2.78 x 19.05), to fraction > no. 6 (2.38 x 19.05). However, there was a large drop in semolina yield for fraction < no. 6, and a drastic decrease for fraction < no. 5 (1.98 x 19.05). Semolina generated from two small kernel fractions had significantly higher ash content. The yellow pigment and protein contents increased by 55% and 32%, respectively, with the decrease of kernel size from > no. 8 to < no. 5. Results showed that the small kernels (< no. 6) had a very detrimental impact on the milling quality and its proportion is a better predictor for milling quality than test weight. Because of the strong negative relationship between kernel size and protein content, spaghetti prepared from samples with a high proportion of small kernels was firmer in texture but less bright in appearance. The much higher yellow pigment content in semolina milled from small kernels did not result in an increase in yellowness in both semolina and pasta.

Effect of condensed tannins on rye and barley flour functionality

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

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

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Pre-harvest sprouting (PHS) is the precocious germination of grain prior to harvest, which negatively impacts seed and end-use quality. PHS is evaluated in two ways: visual inspection or the falling number (FN) test. Low FN values denotes PHS induced starch and protein degradation. This negatively impacts producer prices resulting in global losses of up to $1 billion per year. Thus, identifying PHS resistance mechanisms and the development of wheat varieties that have inherently high FN is important. The first objective of this study is to investigate PHS differences resulting from the allelic variation of *TaPHS1* and *TaMKK3* loci in a winter wheat biparental population. The second objective is to identify differentially expressed genes between PHS-resistant and -susceptible varieties that may be impacting seed dormancy at harvest. The third objective is to identify additional genes associated with FN changes. In a previous study, ~50 Montana-grown spring and winter wheat varieties were assessed for PHS susceptibility and FN, and we determined that *TaPHS1* controls a significant portion of

PHS variability among winter wheat varieties. However, TaPHS1 did not explain PHS variation among the spring wheats we surveyed. In the current study, a winter wheat biparental population was used to test the role of *TaPHS1* and *TaMKK3* alone and in combination upon PHS susceptibility. Seed-specific expression levels of *TaPHS1* and *TaMKK3* and other genes involved in seed maturation and dormancy were assessed via RNAseq analysis of parent lines varying in PHS susceptibility, and the results indicate little change in overall gene expression. To investigate genetic factors that may impact FN variation unrelated to seed dormancy, three sets of spring wheat isolines were studied. These were red and white isolines, and those varying for the presence or absence of *Glupro* or *Gli-B1* genes. Results indicate that *TaPHS1* variation has a greater impact on PHS susceptibility in winter wheat than does *TaMKK3*. RNAseq expression data analysis is in progress. Significant FN variation (in the absence of PHS damage) exists across elite cultivars. The presence of the *Glupro* gene increased FN values by approximately 20 seconds. Presence of favorable *Gli-b1* and red vs white seeds had no observable effect on FN. Future work will include biparental QTL analysis in an effort to detect novel loci affecting falling numbers variation.

Added fiber and dietary fiber: The FDA rulings

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After approximately 25-plus years, the legal deliberations on the definitions of dietary fiber (DF) may have come to conclusion. The Institute of Medicine (IOM) defined DF as the nondigestible carbohydrates (NDC) mainly in plant foods. The IOM also coined the term Added Fiber (AF) for any NDC extracted from a food or synthesized. However, to be included under the umbrella term DF, an AF must have demonstrated a "beneficial physiological effect for human health" (BPEFHH). During the period of 2016-2018, the FDA first approved 6 AF, cellulose, guar gum, pectin, locus bean gum, and hydroxypropyl methylcellulose. beta-Glucan and psyllium husk were reaffirmed as DF having previously been granted health claims to lower cholesterol. The FDA approved, "mixed plant cell wall fibers (intrinsic and intact)" as an encompassing term of great importance in cereal science and the food-baking industries. Also advanced from AF to DF status were arabinoxyln, alginate, inulin, and inulin-type fructans, high-amylose starch (resistant starch 2 – RS2) galactiooligosaccharide, polydextrose, and restraint maltodextrin/dextrin, and most recently, resistant starch 4 (RS4). Among the 15 AF, only one, cellulose, had the ability to improve laxation as determined with stool markers that were used to demonstrate reduced transit times. One primary goal of this paper is to champion the fact increased fecal weight and frequency and not necessarily just decreased transit times should be considered as a BPEFHH for other NDC-AF. Six AF demonstrated the ability to attenuate cholesterol levels, and their levels of efficacy compared to beta-glucan and psyllium husk will be compared. The FDA has indicated a "completion of [their] such a rulemaking, to consider enforcement discretion for declaring their amount" on food labels will be forthcoming; an additional objective of this paper. Three AF were approved that attenuate blood glucose levels, and one was approved to improve insulin sensitivity. Three fermentable AF demonstrated increased calcium (Ca) availability and or retention. While other reports have indicated some of these 3 AF could promote absorption of Fe, Cu, and or M; these elements were not mentioned. The mechanisms to explain the increased absorption/retention of Ca will presented as will the significance of these findings to public health. Polydextrose was approved to both lower energy intake and have and energy value of 1 kcal/g. In summary, review of the BPEFHH effects and the levels to achieve these BPEFHH effect foe the 15 AF will be summarized.

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

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Sorghum is the fifth most important cereal crop grown in the world and the third most important in the United States. It has a great potential for the gluten-free market and as a healthy alternative ingredient. Sorghum can be milled into flour which can be used as a major ingredient for many food applications. Flour quality characterization may aid in understanding the functionalities of the raw material and provide meaningful information to the industry regarding process optimization. Thus, the objective of this study was to evaluate the nutritional, thermal, and pasting profile of red sorghum flour (RSF) and white sorghum flour (WSF). Red and white sorghum were milled at Hal Ross Flour Mill in three days to achieve replication. RSF and WSF samples were collected in each replicate, and were evaluated for proximate analysis, total starch, and damaged starch. Flour pasting and thermal properties were determined using a Rapid Visco Analyser and a differential scanning calorimeter, respectively. Data were analyzed using the GLIMMIX procedure of SAS (SAS 9,4 Inst. Inc., Cary, NC). A greater concentration ($P < 0.05$) of crude protein (9.95 vs. 8.22%) was observed for WSF compared to RSF, respectively. Total potassium and copper concentration were greater for WSF ($P > 0.05$). No differences were observed for the other nutritional parameters. Pasting variables were not significantly different between WSF and RSF ($P > 0.05$). On the other hand, temperatures of gelatinization were different between WSF and RSF. The results revealed a 3.22°C and a 1.47°C increase ($P < 0.05$) in initial and peak temperature of gelatinization, respectively, for RSF, while final temperature of gelatinization and enthalpy of gelatinization were not different

between flours. Our results suggest that RSF and WSF present different thermal profile characteristic which may impact their use as raw material for different processes.

Effect of nitrogen levels on the nutrient quality of corn under organic management

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Approximately 95% of the crop varieties grown under organic management were bred specifically for high input conventional production systems. These varieties, however, lack the resilience and stability in agronomic performances necessary for low input organic production. Moreover, most varieties are mostly screened for starch content and no other nutrients, such as protein and oil for niche markets. This study aimed at selecting corn cultivars adapted for organic production through a participatory breeding approach with Midwest organic farmers. A core set of corn hybrids developed at the University of Illinois and the Mandaamin Institute Wisconsin were selected based on agronomic performance and grain processing characterization in past experiments under conventional and organic management, respectively. During the first year of experiment in 2018, the hybrids were evaluated in a controlled experiment in two locations (Pana and Macomb, IL). The controlled experiment was established in experimental plot size (52 × 177 m) under randomized complete block design with split-split plot arrangement. Three rates of nitrogen (N) application (0, 112, and 224 kg N/ha) delivered as pelletized poultry manure were evaluated based on their influence on the nutrient composition (i.e., protein, oil, and starch) of 10 hybrids (ORG1, ORG2, CONV1, CONV2, CONV3, CONV4, CONV5, CONV6, CONV7, CONV8). An NIR grain analyzer (Inframatic 9500) was used to assess the nutritional composition. A linear regression analysis was conducted to evaluate the effect of increasing N levels on protein, oil, and starch contents. Nutrient content were correlated using Pearson. The protein, oil, and starch contents of hybrids were between 7.5 and 11.0% (db), 3.40 and 5.02% (db), and 68.3 and 72.7% (db), respectively. Regardless of the hybrid, protein ($y_{(\%)} = 0.0037N + 8.4176$; $R^2 = 0.98$) and oil ($y_{(\%)} = 0.0003N + 3.8422$; $R^2 = 0.96$) levels increased, while starch content decreased ($y_{(\%)} = -0.0031N + 71.457$; $R^2 = 0.99$) as a result of increased N levels. Accumulation of protein and oil in whole grain was positively associated ($r = 0.594$, $P < 0.01$), whereas accumulation of starch was negatively associated with protein ($r = -0.892$, $P < 0.01$) and oil ($r = -0.874$, $P < 0.01$). ORG-2, CONV-6, CONV-2, and CONV-8 showed the highest performance in oil and protein accumulation and highest reduction in starch content as the N level was increasing. As part of this project, further characterization of the grain quality characteristics of these hybrids will include evaluations of the amino acid profile and carotenoids, phenolics, minerals, and fatty acids contents. Results will improve our understanding on the response of maize to different management treatments and will add value to germplasm selection for organic grain production systems.

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

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

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

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

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

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

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

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Refined wheat flour made from traditional wheat is a highly functional ingredient that is used in the production of numerous wheat-based foods. Products made from refined wheat flour are devoid in dietary fiber, which has grave public health implications due to the high digestible starch content and low dietary fiber content in refined flour. High-amylose grains have been developed to increase the amylose and resistant starch content within the endosperm of the wheat kernel, which when processed creates a refined wheat flour with both functionality and fiber benefits that can be used to make healthier processed foods. The health benefits of high-amylose grains have

been reported in a number of different clinical studies, with health benefits ranging from blood sugar management to fermentation and subsequent production of short-chain fatty acids. Studies have been conducted to understand the amount of high-amylose wheat flour required in food formulations to deliver measurable levels of dietary fiber in wheat-based products. Typical white bread delivers roughly 1 g of dietary fiber per slice, whereas the inclusion of high amylose wheat flour can yield anywhere from 3 to 5 g of dietary fiber per slice. Furthermore, a traditional flour tortilla delivers roughly 1 g of dietary fiber in a single tortilla, whereas the inclusion of high-amylose wheat flour can yield anywhere from 3 to 5 g of dietary fiber per tortilla. The utilization of high-amylose wheat flour in processed foods allows for consumers to significantly increase their dietary fiber intake while eating common staple foods.

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

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The short shelf life of brown rice as compared to milled white rice results from the formation of unpleasant odors caused by oxidation of free fatty acids in the bran layer. Lipase enzymes, of which there are over 100 in rice, release free fatty acids from lipids. Lipoxygenases act on such fatty acids to produce the compounds associated with the musty smell of brown rice stored for many months. Several lipases and lipoxygenases are expressed primarily in seed tissue and, thus, are ideal targets for gene editing to eliminate their contributions to brown rice quality reductions. These include lipoxygenase-3 (LOX3) and a lipase designated L2 by Tiwari et al. (2016). LOX3 has been mutated with TALEN-based gene editing and silenced by RNA interference (Ma et al. 2015, Xu et al. 2015). Targeting of LOX3 by CRISPR gene editing or of L2 via mutation or silencing has not been reported. LOX3 and L2 were individually targeted for mutation by CRISPR-Cas9 at two locations per gene in the model cultivar Nipponbare. Simultaneous editing of both genes is in progress and T_0 plants have been screened for mutations in the target areas. To date, no seed has been recovered from T_0 lines with mutations in the targeted regions of LOX3. Two fertile lines with homozygous or heterozygous mutations, including both insertions and deletions in the L2 gene, were obtained for further analysis. T_1 plants were screened for mutations and three distinct homozygotic lines were selected for grain production in the T_2 generation. Grain will be harvested at maturity and subjected to accelerated aging in rough rice and brown rice forms, and evaluated for lipoxygenase and lipase activities, free fatty acid content, conjugated diene formation, and seed longevity. Previous research has shown limited effects of LOX3 mutations on brown rice rancidity. With simultaneous knockout of L2, it is hoped that a synergistic effect will result in more drastic reductions in oxidation product formation.

The effects of radio-frequency cold plasma on dough functional properties of hard red wheat, soft wheat, and intermediate wheat grass flours

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Cold plasma has been proposed as a way to affect functional properties as well as safety of food. This technique has the potential to kill surface microorganisms with minimal loss of nutrients or change to sensory properties. Recent studies on cereals have shown that cold plasma may modify secondary structures and solubility of flour proteins. The objective of this study was to compare the effects of cold plasma treatment on hard red wheat (HRW), soft wheat (SW), and intermediate wheat grass (*Thinopyrum intermedium*, IWG), a novel perennial grain. While IWG's cultivation offers environmental benefits attractive to consumers, its protein composition varies from that of wheat, which introduces challenges in its dough functionality. HRW and SW differ in protein content and profile and are therefore suitable for different products. The effects of cold plasma on protein and dough functionality of the three flours were assessed through the following tests: total protein content and solubility, solvent retention capacity, starch damage, Farinograph analysis, dough extensibility and resistance to extension, protein secondary structures, and GlutoPeak analysis. Plasma treatment resulted in moisture loss but did not affect the protein content or solubility. Solvent retention capacity increased for water and sodium carbonate after plasma treatment, indicating that levels of starch damage may have been affected differently across samples. This was supported by starch damage analysis, which indicated that HRW and SW experienced greater starch damage due to plasma treatment (3.34% to 3.53% and 6.03% to 6.62%, respectively), whereas the same was not observed for IWG. Protein secondary structure was also affected differently across samples. SW dough experienced an increase in beta-turns and a decrease in beta-sheets, while HRW and IWG showed no significant changes. Farinograph water absorption increased for all samples (56-61.1% to 71.0-81.6%) because of moisture loss and starch damage. Dough development time increased for SW, decreased for HRW, and did not change for IWG after plasma treatment. The extensibility of SW dough decreased after plasma treatment. GlutoPeak tests after plasma treatment revealed that protein aggregation did not change for HRW, resulted in no aggregation for SW, and aggregation energy significantly increased for IWG (32 to 39.5 GlutoPeak Units). In summary, plasma treatment had different effects depending on the flour type, and functional properties were affected due to starch damage. More work should be done to further explore the molecular mechanisms driving these differences and the effect on product characteristics made of plasma-treated flours.

A multi-linear regression approach for simulation of a traditional (95°C) starch pasting profile using a high altitude (91°C) heating regimen

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The Rapid Visco Analyzer (RVA) is utilized for evaluating the rheological properties of starch-based materials. A traditional RVA test monitors the viscosity of a stirred starch suspension as it is incrementally heated to 95°C, held isothermally for a set time, and gradually cooled to 50°C. At high altitudes, the target temperature of 95°C is unachievable due to boiling point depression; thus, an alternative 91°C profile is recommended for such locations. However, pasting profile outputs obtained via the 91°C profile do not match those of the traditional 95°C test condition, due to differential temperature regimens. The research objective was to utilize a multi-linear regression approach to vary the run parameters of a 91°C heating regimen to match the output of a traditional 95°C pasting profile using native potato starch. Pasting profile targets for the 95°C heating regimen were generated using the RVA standard profile (2.000 g starch; stir rate = 160 rpm; heating, hold, and cooling times = 222, 120, and 228 seconds [s], respectively). Independent variables (3 levels each) investigated for adapting 91°C profile run parameters included: starch weight (1.900, 2.000, or 2.100 g, dry basis), stir rate (120, 160, or 200 rpm), heating time (132, 222, or 312 s), hold time (60, 150, or 240 s), and cooling time (138, 228, 318 s). Measured pasting profile dependent variables/outputs were: peak, trough, breakdown, and final viscosities. A Box-Behnken design was used to fit second-order linear regression models for each individual dependent variable to predict a combination of 91°C run parameters that matched target 95°C pasting viscosity outputs using contour plots. Model predictions were validated by RVA runs and further adjusted to yield a set of 91°C run parameters (1.998 g starch, stir rate = 163 rpm; heating, hold, and cooling times = 222, 152, and 245 s, respectively) that successfully matched 95°C pasting profile target outputs. Regarding main effects, increased amounts of starch increased all pasting viscosity attributes ($P < 0.0001$). Conversely, peak, trough, and final viscosities all decreased as stir rate increased, while an increase in hold time similarly decreased trough and final viscosities, and increased breakdown ($P < 0.0001$). High stir rates or extended stirring at high temperatures likely caused greater destruction of swollen granules, decreasing paste viscosity. Stir rate exhibited significant two-way interactions with starch weight, heating time, and hold time, with the impact of these latter run parameters becoming attenuated as stir rate increased.

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

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Wheat flour tortillas are a popular food in the Mexican population, whose consumption has spread in the American diet. However, they usually have a high caloric content and low nutritional quality. Wheat tortillas are a good candidate for dietary supplementation with different ingredients as a strategy to promote healthy eating. The aim of the study was to evaluate the effect of the addition of two commercial coconut flours on dough rheology and physical properties of tortillas. One of the coconut flours (CF1) was high in fat, and the other (CF2) had a medium fat content. Commercial wheat flour (WF) was used as control. Chemical composition, water retention capacity (WRC), color, and viscosity behavior of flours and their blends were evaluated. Mixograms from WF and its blends with CF1 or CF2 (10%, 20%, 30%, or 40%) were obtained. The total fat content in the tortilla formulations was kept constant (10%). Thickness, diameter, rollability, firmness and water activity of tortillas were evaluated. Fat, ash, and protein content of CF1 and CF2 were significantly higher than WF. Significant differences in fat and protein content of CF1 and CF2 were observed. CF1 and CF2 showed higher WRC than WF, as the substitution level increased, a significant increment in WRC was observed in the blends. The CF2 substitution showed higher L^* values of flour blends than those of CF1, the opposite behavior was observed for the a^* and b^* values. Peak and final viscosity, breakdown, and setback were higher in WF than those of CF1 or CF2. A significant decrease in these parameters was observed as the level of substitution increased, as well as longer optimum mixing time. Tortillas thickness varied between 1.7 and 2.0 mm. The WF-CF1 (60-40) showed tortilla diameters significantly lower than the rest of the tortillas (115.9 vs 124.8-130.5 mm). The tortillas substituted up to 20% of CF2 showed the best rollability scores (1) and were different than the rest of the tortillas, whose rollability ranged from 2.7 to 3.7. The effect of the interaction between type of CF and substitution level on tortilla firmness was significant. The level of substitution, the type of CF or their interaction had an effect on water activity of control and blends tortillas. Substitution levels of 10 or 20% of CF gave bigger and less firm tortillas.

The in vitro digestibility of enzymatic treated starches

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The increase of various related chronic diseases such as cardiovascular disease and type 2 diabetes is high in many societies. Because a low dietary fiber intake is correlated with the incidence of these diseases, there is an urge for novel dietary fibers ingredients. These dietary fibers should positively contribute to the well-being of consumers without causing unwanted sensory effects when applied in food products. Avebe has developed such a novel dietary fiber product (1). This novel type of dietary fiber provides food manufacturers to use other ingredients and to develop food products with a higher dietary fiber content while maintaining excellent texture. Here, an analytical method is reported to quantify the dietary fiber content of this novel dietary fiber product derived from potato starch. The digestibility was determined by incubating the novel fiber and commercial fibers with human salivary α-amylase followed by brush border enzymes and pancreatic α-amylase. The human salivary α-amylase treatment mimics the digestion in the mouth, while the brush border enzymes (rat intestinal acetone powder) and the pancreatic α-amylase mimic carbohydrate digestion in the small intestine. The obtained results have been compared to scientific literature and the AOAC 2009.01 method. The *in vitro* procedures show that the novel dietary fiber derived from potato starch behaves as a dietary fiber under conditions mimicking *in vivo* conditions. The fiber content is directly correlated with the fraction of (α1-6) linkages in the product. Moreover, the *in vitro* digestion reveals that the degree of digestion also depends on the duration of the brush border enzymes treatment. The pretreatment with the human salivary α-amylase, to mimic digestion in the mouth, has no effect on the digestion. This novel dietary fiber product derived from potato starch acts as a dietary fiber, and its digestibility depends on the amount of (α1-6) linkages. 1. Leemhuis H. et al. J. Agric. Food Chem. 62(49):12034, 2014.

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

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

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

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Antioxidants are widely used in food, feed, and pet food industries to delay lipid oxidation and prevent quality deterioration. There has been a rising demand for the gradual replacement of synthetic antioxidants with naturally derived antioxidants. Corn coproducts, such as distiller's dried grains with solubles (DDGS) and corn gluten meal (CGM), are cheap sources of proteins containing abundant antioxidative peptide sequences and structural domains. The objectives of this study were to develop antioxidative peptides from corn DDGS and CGM proteins through enzymatic hydrolysis, to evaluate the antioxidant performances using chemical assays and model systems, to isolate fractions with superior antioxidant properties, and to identify their peptide compositions. Hydrolysates prepared with Neutrase and Alcalase displayed promising yield and antioxidant capacity among the 11 commercial proteases evaluated. The effect of critical variables, including protein substrate content, enzyme-to-substrate ratio, and reaction time, on the production were studied. Selected hydrolysates were further fractionated through ultrafiltration using an Amicon® Stirred Cell device. Medium-sized fraction revealed relatively stronger antioxidative activities with regards to free radical scavenging activity, metal ion chelating activity, reducing power, and oxygen radical absorbance capacity. Selected antioxidants were further formulated into fish oil, poultry fat, pork fat, model emulsion, ground pork, dry dog food, and dry nursery pig feed at different levels, which were incubated under accelerated conditions in an oven, and POVs and TBARS were measured. The inclusion of corn antioxidants significantly improved the oxidation stability of these systems

and effectively inhibited lipid oxidation. Both POV and TBARS decreased with increased amount of the antioxidants. In addition, the corn antioxidants also effectively reduced HepG2 cell growth via non-toxic mechanisms, indicating its anticancer potential. Peptide compositions of the most promising fraction from ultrafiltration and RP-HPLC were identified using MALDI-TOF/TOF MS. Our study demonstrated that corn coproduct proteins are feasible sources for peptide antioxidant production, and these antioxidants could be potentially used as alternatives to synthetic antioxidants in improving the oxidative stability of various lipid-rich products.

Exploring dry grain fractionation as a means to valorize high protein malting barley

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Malting barley varieties are potentially the most profitable commodities for producers; however, barley selected for malting purposes has to meet stringent quality requirements. Excessive grain concentration (>12.5%) is often the reason why barley is rejected for malting grade and sold at a lower price on the feed market. The objectives of this study were to explore dry grain fractionation as a means to valorize high protein malting barley by producing high fiber fractions for human nutrition and starchy fractions for adjunct brewing. Several Canadian malting barley varieties with grain protein concentration above 14% (db) were milled on a Buhler laboratory mill, resulting in six flours streams. Coarse and fine shorts were further processed using a Buhler laboratory shorts duster, resulting in coarse fiber fractions and two additional flour fractions. The total yield of combined flour fractions ranged from 50.2 to 51.6%, whereas the yield of fiber fractions ranged from 41.5 to 43.7%. The fiber fractions were enriched in beta-glucans (9.3-11.2%, db), arabinoxylans (9.9-11.3%, db), and proteins (22-26%, db), with average 2.2-, 1.7-, and 1.5-fold increase of these constituents, respectively, compared to the whole grain. The content of vitamin E in fiber fractions was higher than in the whole grain, ranging from 82 to 109 μg/g. The fiber fractions also exhibited an improved ratio of tocotrienol to tocopherols. The combined flour fractions were depleted of beta-glucans (0.6-0.7%, db) and arabinoxylans (0.5-0.6%, db), contained acceptable levels of proteins (11.5-13.5%, db), and high levels of starch (79-82%, db). Mashing experiments with 20% replacement of malt with flour fractions showed a significant improvement in malt extract without any negative effects on other malting quality parameters, such as wort beta-glucans, wort viscosity, and the average degree of polymerization of starch dextrins. The results of this study clearly showed that high protein barley can be valorized by fractionation into health beneficial fiber fractions and starchy fractions that can used as adjunct in brewing.

Structure, function and evolution of starch binding domains

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

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

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Micronutrient deficiency disorders are widespread in predominantly rice-consuming countries, particularly in South Asia and Africa. Approximately 15-20% of the global milled rice is consumed in parboiled form. Accordingly, parboiled rice is an effective vehicle for micronutrient fortification without changing consumer

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

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

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

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

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Alternative planet-friendly protein sources are increasingly acknowledged as a sustainable solution to feeding the growing population. Fava bean (*Vicia faba* L.) is a protein-rich pulse underutilized for human consumption mainly due to some negative impacts of non-nutritional compounds. An environmentally friendly approach is being developed by employing pearling, supercritical CO_2 extraction, air-current assisted particle separation (ACAPS) followed by wet-fractionation to scale-up the isolation of fava proteins, minimal in these compounds. As a first step, studying the distribution of the macro-nutrients and some of the non-nutritional factors throughout the grain by pearling can lead to efficient fractionation. However, unlike cereals, pulses have the

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

High amylose wheat starch characteristics and the effect on fiber content in food applications

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Resistant starch is a good source of dietary fiber for human health. Resistant starch type 2 can be produced by the increased concentrations of amylose in the starch granule via genetic backcrossing. Resistant starch type 2 is extensively studied in many cereal grains, but the knowledge on high-amylose wheat is limited. High-amylose wheat (HAW) commercial varieties, containing higher than 60% amylose, and more than 35% total dietary fiber (TDF), were examined for starch characteristics and digestion pattern to understand the factors affecting fiber retention in bread and pasta applications. Starch crystallinity, molecular size distribution, chain length distribution, gelatinization profiles, and x-ray diffraction pattern of high-amylose wheat cultivars were investigated and compared to a control hard red spring wheat. To understand the impact of starch morphology on digestion, samples were digested using AOAC 2009.01 TDF method, and the high molecular weight dietary fiber was examined under a microscope. At each step of pasta and bread processing, samples were analyzed for TDF to understand fiber retention. The HAW had B-Type x-ray diffraction pattern and significantly higher amylose and long-chain amylopectin fractions. HAW starch had irregular shape but highly resistant to digestion. Bread and pasta made with HAW had 2-7 times TDF compared to control, and heat treatment step had the largest impact on TDF.

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

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Although flour yield is of great concern to wheat millers, an understanding of the grain traits that influence flour yield is still lacking. Endosperm separation from bran during roller milling, expressed by the proportion of remnant endosperm, was identified as one of the major factors influencing the flour yield potential of wheat grain in our previous study. However, little is known about the endosperm characteristics governing its detachment from bran during roller milling. The objective of this study was to identify the biochemical characteristics of the outer endosperm (OE) associated with endosperm separation from bran during roller milling, and subsequently with flour yield. The biochemical compositions of the OE, flour, and bran of ten SRW wheat varieties exhibiting a large variation in flour yield were determined and their relationships to flour yield were examined. Wheat grain was milled to obtain flour and bran using a modified Quadrumat Senior experimental milling system. The OE was obtained by further passing the bran through the break-roll unit three times. The flour yield of ten soft red winter wheat varieties ranged from 66.7 to 75.9% and 1.7 to 3.7%, respectively. The protein, starch, arabinoxylan (AX), and phytate contents of the OE ranged from 12.6 to 18.4%, 60.2 to 67.3%, 1.7 to 2.1%, and 0.2 to 0.4%, respectively, among the ten varieties. The ash, water-soluble AX, water-insoluble AX, and beta-glucan contents of the OE ranged from 0.6 to 1.1%, 0.3 to 0.6%, 1.2 to 1.7%, and 0.3 to 0.5%, respectively. The ash, water-soluble AX, water-insoluble AX, and beta-glucan contents of the OE exhibited significant relationships with flour yield at $P < 0.01$, $P < 0.05$, $P < 0.01$, and $P < 0.01$, respectively. Wheat varieties showing a flour yield higher than 75% were higher in ash, water-insoluble AX, and beta-glucan contents of the OE than the varieties with a flour yield lower than 68% by averages of 0.3, 0.3, and 0.2%, respectively. The ash and water-soluble AX contents of flour also exhibited significant relationships with flour yield at $P < 0.01$. The water-soluble AX, water-insoluble AX, and

beta-glucan contents of the OE seem to influence endosperm separation from bran during roller milling of wheat grain. Outer endosperm that is low in water-soluble AX and high in water-insoluble AX and beta-glucan may facilitate efficient detachment of endosperm from bran during roller milling, positively contributing to flour yield.

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

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

Milling process and cultivars impact pea flour functionality and flavor profile

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

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

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Intentional sprouting of grain to modify grain products nutritional composition and flavor has been in practice for thousands of years. However, few studies have tested the impact of controlled sprouting on wheat flour functionality and flavor. In this study, grain of nine hard red spring (HRS) wheat (*Triticum aestivum* L.) cultivars

was sprouted with the goal of attaining a falling number (FN) value of 200 from a starting FN of 350 seconds. Paired samples of sprouted and sound HRS grain were then assayed for nutritional composition, functionality in bread baking, and in bread taste tests. Sprouting reduced grain hardness and test weight while increasing grain color brightness, yellowness, and redness. Whole sprouted grain flour had twice the alpha-amylase activity and a large decrease in flour swelling power relative to sound grain flour. Sprouted flour also contained increased free amino acids and monosaccharides while having decreased sugar alcohol content. Total dietary fiber trended down in the sprouted grain flour while starch content remained unchanged. Whole grain flour color parameters were relatively unaltered by sprouting. Sprouting reduced dough mix times while increasing loaf volume. Sensory panel evaluations demonstrated that testers preferred bread prepared from sprouted grain flour to bread prepared from sound grain while also finding that sprouted grain bread tasted less bitter and grainy while also being perceived as sweeter and moister. The results demonstrate that controlled sprouting of wheat grain could be used to increase whole grain flour functionality in bread baking and consumer acceptability of whole grain foods.

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

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

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

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

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

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Soft durum is an emerging new grain ingredient used as a novel product. Unlike traditional durum, soft durum can be milled on any mill that handles soft and hard wheat; no special, dedicated mill is necessary. Because of its ease of milling, soft durum has shown extensive potential to be used in traditionally soft wheat products, bread, and pasta. Several objectives continue to be explored: translocation of Glu-D1 genes for better bread potential, introgression of the *Gpc-B1* gene for added grain protein, and studying the agronomics of soft durum to provide greater value to the growers. Glu-D1 alleles were translocated into two populations of Soft Svevo in place of the Glu-A1 allele. These two Glu-D1 alleles were Dx5+Dy10, typically associated with stronger gluten properties, and Dx2+Dy12, typically associated with weaker gluten. Following a bread bake of 60 lines containing these translocations, the Soft Svevo with Dx2+Dy12 resulted in greater bread loaf volumes and better dough handling properties. The dough from Soft Svevo containing Dx5+Dy10 was overly strong and did not have sufficient oven spring. The Gpc-B1 allele was crossed into Soft Svevo using the variety Desert King High Protein. Following three environments of evaluation, 30 lines with and without Gpc-B1 did not show any bread quality differences, though there was a protein content increase of 0.9% when Gpc-B1 was present. Soft durum was grown in several locations across several crop years to evaluate various agronomic properties. Soft Svevo and several varieties developed from Soft Svevo were evaluated for resistance to aluminum toxicity, Hessian Fly, stripe rust, stem rust, dwarf bunt, and cereal cyst nematode. A seeding rate study was also completed at two locations to evaluate the optimum seeding rate for maximum yield. Soft durum exhibited moderate resistance to strong resistance to stripe rust, stem rust, cereal cyst nematode, and mixed results to Hessian Fly. No aluminum toxicity resistance was observed. The seeding rate found to maximize yield was 161 seeds/m^2 in dry locations (<28 cm precipitation/year), and 237 seeds/m^2 in a higher rainfall area (~48 cm precipitation/year). The more knowledge gained about soft durum, its dough behaviors, and agronomics, the greater potential for its cultivation and utilization.

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

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

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

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The use of Plasma Activated Water (PAW) for the modification of starch and for other food applications have been a subject of research interest in recent times. The production of PAW results in the formation of hydrogen peroxide, nitrates, nitrites, superoxide ion, radicals, singlet oxygen, hydroxyl radicals, and ozone among others.

These reactive species then interact with surfaces or foods they come into contact with. This study investigated the effects of cooking starches from different botanical sources (normal and waxy rice; tapioca; normal, waxy and high amylose; normal and waxy potato) with PAW on their pasting profiles. PAW was prepared by discharging a plasma jet over distilled water under constant stirring for 10 min. The atmospheric plasma jet was produced with the Enercon Dyne-A-Mite IT LM4810-54 Atmospheric Air Plasma Surface Treater. The nozzle of the plasma treater was 25 cm above the surface of the water (2 L). Changes in pH, conductivity, and oxidative-reductive potential (ORP) of the PAW was monitored. The starches were then cooked with the Micro Visco Amylograph to 95°C and the cooled to 30°C. The peak viscosity, pasting temperature, final viscosity, breakdown and setback viscosities were measured. pH of water decreased from 7.29 to 3.10. Conductivity and ORP increased from 7.94 to 292 mS and from 272 to 554 mV respectively. Significant effects on all pasting parameters studied was observed except for pasting temperature. Slight increases in the pasting temperature were observed in tapioca, waxy corn, normal, and waxy potato starches. The final viscosity of normal potato starch significantly decreased from 821 to 394 BU. However, there was no change in the final viscosity of normal corn starch. Except for normal rice starch, deceases were observed in the final viscosity of all the starches. Breakdown of most of all the starches increased except in normal potato starch. Setback, which gives an indication of starch retrogradation reduced in all starches after PAW cooking. The effects observed in potato starch was more significant than that observed in the cereal starches. PAW cooking of starches significantly affected the pasting properties of starches and could be used as a possible starch medication technique.

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

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

Optimization of recovery of anthocyanins from colored wheat

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

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

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

BRICE project: Understanding checking and breakage of biscuits and dry cereal products

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The 4 Years BRICE collaborative project (started 2015) has the following objectives; i) to better understand checking and breakage (C&B) of different products (rusk, crackers and biscuits), ii) to develop tools and analytical means allowing a better on line or at line control of the status of the products, and iii) to develop process-based solutions in order to mitigate C&B in industry. This presentation will focus on the case of biscuits. A round and thick biscuit (ROB) and a rectangular (REB) and thinner biscuit with piercing points have been used. The C&B counting was done over a 15 days storage. A higher C&B occurrence was observed for the ROB opposite to REB. Karl Fischer (water content determination) was combined to an automated near-infrared imaging bench to monitor water distribution at center and at surface of the products as well as the apparition of checking. A non-homogeneity of the distribution of water in ROB was observed along the plan and thickness dimensions, unlike REB, confirming that C&B can be explained by a non-uniform water distribution in the biscuit. A bench marking has been done between surface water content (determined by Karl Fisher) and by using a NIR hyperspectral imaging bench to assess the relevance of surface information on checking apparition. As a result, checking was found to occur within 1 to 2 days after baking. A PCA applied on a large number of ROB and REB biscuits yielded in specific wavelengths along the two main axis. The first axis was linked to the water wavelengths. The second axis was linked to different wavelength in relation with carbohydrates. The apparition of checking on the second axis was effective and visible with false color based on the axis's wavelengths before the apparition of the checking on the biscuits. An in-depth study has been done considering a model recipe made of water, sugar, and flour. Indeed, sugar and water are expected to play a significant role on starch gelatinization and, therefore, on the mechanical stability of the final product. Seven flour/sugar ratio and two dry matter/water ratio were tested in terms of gelatinization temperature and degree of starch gelatinization, showing that the formulation interfere on water penetration in starch granule and with the degree of gelatinization.
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Interest of choline chloride for salt reduction in bread: Structure-properties relations and societal acceptability

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Reducing salt in foods is a public health concern. This project was supported by a PhD which was defended in April 2019; it aimed at reducing salt by 50% in a bread with the adding of 25% of choline-chloride (based on 1.8 g of sodium-chloride as reference). Choline-chloride (CC), which is also vitamin B4. In the food ingredients nomenclature, choline is E1001 and is identified as an emulsifier; choline holds also three European Health-Claims. It is used under different salts, such as choline-chloride (E1001iii), which is temperature resistant (melting temperature 247°C) and is GRAS by the FDA. From a sensorial point of view, CC provides a salty taste

and can be used as an efficient substitute even though it is not as salty as sodium-chloride. Another new and unexplored advantage of CC, as far as we know, lies in its interaction with starch and bread staling. In aqueous solution, CC behaves like an ionic liquid and causes a reorganization of the internal structure of the starch grain. The staling study highlighted the positive effect of CC on bread texture (softening) and on the retrogradation of starch. Indeed, the CC restricts the recrystallization of amylopectin due to less availability of water in the medium and decreases the staling kinetics of the bread. An in-depth investigation has been done using calorimetry and x-rays diffraction over a wide range of CC concentration and playing also with the order of presentation of the ingredients (CC solubilized of as a dry ingredient) using original mixing cells in isothermal calorimetry conditions. A full phase diagram has been established on a model system (water-cc-flour). The consumers acceptance has been investigated in three focus groups targeting different categories; health-oriented young people, young parents, and consumers sensitive to nutritional information. Among consumers who are very sensitive to the traditional values associated with bread, the "functionalization" or "nutritionalization" of this food constitutes a major obstacle to its consumption. Appropriate wording should accompany the marketing of such salt substitute. As a conclusion, CC is a relevant alternative to salt that combines technological and sensory benefits, its success will depend on the consideration of issues related to societal acceptability.

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

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The reference fat for French brioche is butter, which contains a high levels of saturated and trans fatty acids. In this study, five shortening composed of fat from vegetal and/or animal origin including in some of them an emulsifier were developed to replace butter with the objective of improving their nutritional profile. The impact of these shortenings on mixing and fermentation time, brioche properties (specific volume, crumb texture, alveolation, water content, and fatty acid composition), and staling rate were studied. Rapeseed oil gave brioches with the better nutritional profile. Properties the most affected by the shortening substitution were mixing time and firming rate; it was assumed that the observed changes may be attributed to the presence of emulsifiers and/or to the composition (saturated fat) of the shortening. Shortening containing lipids from vegetable sourcing, and emulsifiers gave soft dough with long mixing time and brioches with slow firming rate during storage. The Young modulus was measured during staling on 5 brioches in duplicate; the values after 31 days of storage at 10°C was 4.1 kPa ± 0.5 (butter), 7.0 kPa ± 0.8 (Duck Fat), 9.1 kPa ± 1.3 (milk fat/duck fat), 2.2 kPa ± 0.7 (milk fat/rapeseed/sunflower/texturing agent), 4.9 kPa ± 1.1(rapeseed/texturing agents), and 7.4kPa ± 1.0 (anhydrous milk fat/sunflower/texturing agents). For each brioche, the Avrami model parameters, k (rate constant in d^{-1}) was determined; kinetics was faster for increasing level of fat saturation. Time constant as ranging between 0.07 days for milk fat/rapeseed/sunflower/texturing agent), up to 0.31 days for butter, and 0.28 days for duck fat. Duck fat resulted in dough and brioche with properties close to that of the control (butter brioche), with half less saturated fat and almost no trans fatty acids. Then, duck fat appeared as an interesting alternative to butter, combining a better nutritional profile, without affecting production characteristics and brioche properties.
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Impact of mixer geometry on gluten network structure and dough aeration

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Dough mixing, the first step of bread making, has a strong impact on the final structure of the bread. It aims at (1) distribution and homogenization of dough ingredients, (2) hydration of flour particles, and (3) development of an isotropic gluten network and embedment of gas cells in the dough. The gluten-network plays a major role in the gas-holding capacity and final bread volume. This study aims at exploring the impact of the mixing conditions and mixer geometry on dough aeration and rheology. A 10 liters Spiral-dough-mixer (SPI11-VMI/France) was used with power counter which was used to follow the evolution of the gluten-network during mixing. A maximum of consumed power was observed for a "t_{PEAK}" time, over which overmixing occurs with negative impact. An experimental design was used considering a sandwich-bread dough and three parameters: spiral-tool rpm, bowl-tool nip, and bowl-tool speed (rpm) ratio. Dough aeration was the response. It was found that t_{PEAK} was strongly correlated with the number of tool revolutions, the temperature increase and the specific energy, indicating that these parameters can be used to follow dough development. Tool speed, bowl speed, and the bowl-tool nip control the shear rate of the mixer that have a strong effect on dough aeration, mixing time, structure and rheology, showing the importance of mixer geometry on dough properties. Imaging of the gluten network (CLSM+ rhodamine/B) was done to monitor the gluten-network structure and connectivity of the gluten strips. The time to reach maximum consistency during mixing is matching with the maximum dough

aeration. During overmixing (after time to peak), dough aeration declines. The dough porosity at time to peak declines with decreasing nip and rises back for highest nip levels. The nip was found to be very impacting on the connectivity between the gluten strips and on the size of the gluten strips. This was monitored by CLSM microscopy. The protein strips length, the branching rate and the end point rate increased with increasing nip whereas the protein width was declining with increasing nip. As a conclusion, the control of the structure and geometry of a mixer plays a major role in the formation and quality of the dough obtained during mixing; impact on bread structure will be pointed out. Acknowledgements: This project was funded by VMI, ONIRIS, and ANR-LABCOM "MIXI-LAB" project (contract ANR- 15-LCV3-0006-01).

Processing suitability of sucrose alternatives for potential sugar reduction in muffin

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

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

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

the standard deviation of the reference values) values of the MLR models were 2.13 for chlorpyrifos, and 2.64 for aldicarb. The present study results clearly indicate that SERS spectroscopic method could be more ideal and promising analytical tool for high-throughput analysis of grain-based feeds and foods contaminated with pesticides than most analytical methods commercially available in the market. The proposed method can serve as a powerful and valuable screening tool for risk management of food and feed safety on the market.

Nutritional benefits of germinated wheat

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Wheat whole grains are a good source of dietary fiber and an array of bio-actives including minerals such as iron (Fe) and zinc (Zn). However, only 5 to 10% of Fe and Zn ions are bio-accessible as these minerals are both physically and chemically entrapped. The physical barrier is set by the rigid cell walls which withstand conventional milling and human digestion enzymes. Phytic acid, the main storage form of phosphorus (P), chelates divalent cations like Fe and Zn. During germination hydrolytic enzymes are activated and *de novo* synthesized to fuel seedling growth. Endoxylanases alter the cell wall by hydrolyzing and solubilizing arabinoxylan into water extractable arabinoxylan (WEAX). At the same time, the increase in phytase activity makes minerals available. Both the opening of aleurone cells and breakdown of phytate by germination may result in a greater mineral accessibility in the human gastro-intestinal tract. To explore the potential of steeping and germination of wheat optimal conditions were selected from a multifactor experiment based on phytate and WEAX content. Steeping for 36 hr at 15°C and germinating for 120 hr at 26°C decreased phytate content from 0.96% to 0.64% of initial dry matter and increased WEAX content from 0.48% to 1.34% of initial dry matter. While the Fe and Zn bio-accessibility in the grains was 5% and 3%, respectively, that in the germinated grains was 6% and 8% when the cellular matrix was preserved, and 22% and 21% when it was mechanically disrupted by milling. This revealed that controlled germination of wheat improves mineral bio-accessibility when the cell walls are substantially broken down. Moreover, high-definition μ-X-ray fluorescence microscopy was here for the first time used to map changes in distribution of Fe and Zn between and within wheat tissues during germination. While Zn and Fe are clearly confined to the aleurone cells in regular wheat, co-localizing with P globoids, Zn was translocated to the pericarp, coleoptile, and radicle during germination. This proves that it is more available in the seedling than in the aleurone, where it is used for different biological functions, such as protein synthesis.

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

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

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

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This research aimed to improve the functional properties and increase the resistant starch (RS) contents of pulse starches through enzymatic modification. Lentil (LS), faba bean (FBS), commercial pea (CPS), and normal maize starches (NMS) were incubated with 1% (v/w) maltogenic α-amylase at pH 5.5 and 50°C for 4, 8, and 24 hr. After the 24-hr incubation, the degrees of starch hydrolysis ranged from 34.4% (FBS) to 38.4% (CPS), and the enzyme

treatment reduced the amylose contents of LS, FBS, CPS, and NMS by 6.4%, 4.9%, 2.8%, and 2.0%, respectively. The modification decreased the pasting viscosities of all the used starches drastically, which could be attributed to the enzymatic breakdown of starch molecules. The enzyme treatment effectively elevated the gelatinization temperatures, but lowered the enthalpy changes and retarded the retrogradation of all the starches, resulting from shorter amylopectin branch chains of the modified starches. The 24-hr enzymatic modification increased the RS contents of cooked LS, FBS, CPS from 2.7%, 3.4%, and 4.2% to 8.2%, 9.9%, and 11.4%, respectively, while a considerably smaller extent of increase was observed for NMS (from 1.6% to 3.6%). Modification with maltogenic α-amylase has been demonstrated to be a promising approach to diversifying the functional properties and reducing the *in vitro* digestibility of pulse starches in the current study.

Progressive alterations in swelling and pasting characteristics of tapioca starch by heat-moisture treatment with different holding times and iterations

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Cross-linking modification is a cost-effective approach to restrict the swelling of starch during gelatinization. Due to the health concern over residual chemicals, researchers are actively seeking for physical approaches to alter the gelatinization properties of starch. In this study, tapioca starch was subjected to heat-moisture treatment (HMT) at 95-96°C for 0-60 min with up to 6 iterations, then its swelling power (SP) at 60-90°C and pasting profiles were analyzed to investigate the impact of HMT parameters on its gelatinization properties. Additionally, the correlation between SP of HMT starch and its pasting properties was evaluated. Results showed that HMT led to considerable decreases in SP at 90°C of starch from 42.6 g/g to 15.9-22.4 g/g. Moreover, increasing the holding time of HMT progressively reduced the SP at 90°C. The progressive decrease in SP was also observed with increasing the iteration of HMT. In addition to the lowering of SP, HMT altered the peak viscosity (PV) of starch from 2,194 cP to 1,410-2,211 cP and the percentage ratio of breakdown to PV (%BD) from 57.6% to 3.5-37.5%. Concurrently, the final viscosity was increased from 2,178 cP to 2,839-3,733 cP with the percentage ratio of setback to hot paste viscosity (%SB) ranging between 105.2-147.4%. In addition, increasing the holding time and iteration progressively reduced the PV and %BD, and increased the %SB. In terms of the correlations between pasting parameters of HMT starch, it was observed that the decrease in PV (ΔPV; PV_{Native} - PV_{HMT}) was negatively, linearly correlated with %BD (R^2 = 0.908) and was positively correlated with %SB (R^2 = 0.913). Furthermore, ΔPV was found to positively correlated with the decrease in SP (ΔSP; SP_{Native} - SP_{HMT}) at 90°C (R^2 = 0.833). The findings of this study demonstrate that the adjustment of holding time and iteration of HMT could progressively alter the granular rigidity, SP, and pasting properties of tapioca starch. This approach would also further widen the applicability of tapioca starch to the situation when a chemically modified starch with restricted swelling properties during heating and high viscosity during cooling is needed. Besides, the observed correlations between (a) pasting parameters of HMT tapioca starch and (b) PV of the starch, and its SP may be useful to estimate the HMT-induced change in viscosity of tapioca starch by its SP.

Rapid analysis of sorghum grain composition using ATR-FTIR spectroscopy

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

Storage stability of acetylated tapioca starch: A viscometric study

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Pasting properties of starch can be tailored via chemical modifications to suit the food processing requirements, while the properties may be influenced by the residual chemicals. However, research in this regard is limited. In this study, commercial acetylated tapioca starch (CATS) before (UW) and after fully washed (FW) with deionized water were stored at 25 and 55°C for 84 days, and the pasting properties of both CATSs were analyzed to investigate the changes in pasting characteristics of CATSs during storage in the presence of residual chemicals. Result showed that the degree of substitution (DS) and gelatinization peak viscosity (PV) of FW-CATS were comparable to those of UW-CATS, while FW-CATS was characterized with reduced pH (4.46 vs 5.28) and conductivity (22 μs/cm vs 451 μs/cm). During the subsequent storage, CATSs exhibited marginal changes in DS and pH, plus gradual increases in conductivity with increasing storage time. In contrast, the PV of UW-CATS remained comparable during storage, while that of FW-CATS decreased significantly and the extent depended on the storage condition. After storing at 25°C for more than 30 days, the PV of FW-CATS gradually decreased with increasing storage time. Moreover, when the storage temperature was elevated to 55°C, the decrease in PV was even more drastic with increasing storage time; more than 50% decrement in PV was observed for FW-CATS after storing at 55°C for 50 days. The findings of this study reveal that the residual chemicals from the modification resulted in limited effect on pasting viscosity, especially PV, of CATS. Moreover, eliminating the residual chemicals by repetitive washing significantly reduced the pasting viscosity of the starch, suggesting the trace of chemicals (such as sodium acetate) can play an important role in stabilizing the pasting properties of CATS.

Composition and foam properties of whole wheat dough liquor as affected by pentosanase and glucose oxidase

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Pentosanase (Pn) and glucose oxidase (Gox) are effective in improving the quality of whole wheat buns, forming higher loaf volume and better crumb structure. The discontinuities of liquid lamellae structure formed from the aqueous phase of dough, known as dough liquor (DL), play a critical role in gas cell stabilization and finally influence crumb structure. However, the effects of Pn or Gox on the composition and physicochemical properties of DL (rheological behavior, foam properties, etc.) extracted from whole wheat buns dough are remaining unclear. In the present study, DL was separated from Pn or Gox treated dough of whole wheat buns through ultracentrifugation method. Their composition and physicochemical properties, especially the foam properties were investigated. The results indicated that either Pn or Gox could increase the DL yield and changed its composition. Pn promoted the increase of water extractable arabinoxylan and Gox enhanced protein level in DL. Additionally, Gox catalyzed the formation of large protein aggregates, as well as protein-polysaccharide conjugates linked through disulfide and/or non-disulfide. As a result, the size of foams prepared with DL and their stability were significantly modified by Pn and Gox, especially at 60°C, which can assigned to the enhanced ability to resist thermal stress, probably through retarding their coarsening and/or coalescence. The smaller bubbles size and higher stability were supposed to be good for forming fine crumb structure and higher loaf volume of the products. This study extended knowledge of the relative contribution of Pn and Gox to the texture of whole wheat products by improving the foaming properties of DL during processing.

Composition and interfacial properties of whole wheat dough liquor as affected by pentosanase and glucose oxidase

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Pentosanase (Pn) and glucose oxidase (Gox) are effective in improving the quality of whole wheat buns, forming higher loaf volume and better crumb structure. The discontinuities of liquid lamellae structure formed from the aqueous phase of dough, known as dough liquor (DL), play a critical role in gas cell stabilization and finally influence crumb structure. However, the effects of Pn or Gox on the composition and physicochemical properties of DL (rheological behavior, foam properties, etc.) extracted from whole wheat bun dough are remaining unclear. In the present study, DL was separated from Pn or Gox treated dough of whole wheat buns through ultracentrifugation method. Their composition and physicochemical properties, especially the foam properties were investigated. The results indicated that either Pn or Gox could increase the DL yield and changed its composition. Pn promoted the increase of water-extractable arabinoxylan and Gox enhanced protein level in DL. Additionally, Gox catalyzed the formation of large protein aggregates, as well as protein-polysaccharide conjugates linked through disulfide and/or non-disulfide. As a result, the size of foams prepared with DL and their stability were significantly modified by Pn and Gox, especially at 60°C, which can assigned to the enhanced ability to resist thermal stress, probably through retarding their coarsening and/or coalescence. The smaller

bubbles size and higher stability were supposed to be good for forming fine crumb structure and higher loaf volume of the products. This study extended knowledge of the relative contribution of Pn and Gox to the texture of whole wheat products by improving the foaming properties of DL during processing.

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

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Rapid Visco Analyzer (RVA) is a reliable instrument that is commonly deployed to determine the pasting properties of starch. The conventional model of RVA can only measure starch pasting properties at heating temperatures up to 95°C, which, thus, cannot assess the performance of starch in high-temperature processing, such as retorting, jet-cooking, and extrusion. In this study, RVA 4800—the latest model of the viscometer having high-temperature capability—was utilized to determine the pasting properties of representative waxy, normal, and high-amylose starches containing 1.8-69.7% amylose at heating temperatures of 95-140°C. As the temperatures increased from 95 to 140°C, the pasting temperatures and peak viscosities of most waxy and normal starches were not altered, but their holding strengths and final viscosities decreased, which could be explained by thixotropic thinning and thermal degradation of starch molecules under the high pressure condition. Consequently, the paste adhesiveness or gel hardness of most waxy and normal starches was decreased by high-temperature cooking. By contrast, heating at temperatures above 120°C fully gelatinized wrinkled pea and high-amylose maize starches, allowing the starch granules to swell for viscosity development and subsequent gel formation. Matrix structures of the freeze-dried starch gels/pastes were observed under scanning electron microscope to elucidate how the changes at granular and molecular levels at the tested heating temperatures affected the pasting and gelling properties of various starches. This research provided new insights into the relationships between the thermal properties, pasting properties, and gelling ability of different starches at heating temperatures of 95-140°C.

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

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Pulse starch has a lower rate of starch digestion compared to starch from cereal grains. A further increase in slowly digestible starch (SDS) and resistant starch (RS) in pulse starches could yield a novel ingredient. Pullulanase (P) debranching of amylopectin is an effective strategy for increasing the quantity of linear fragments in starch and, thus, increases levels of RS upon autoclaving and retrogradation. The process is time-consuming (over 24 hr) and the high viscosity of substrate hinders the debranching efficiency. Ultrasonication (U) can quickly decrease substrate viscosity and also shows molecular scission and debranching effects on amylopectin. Therefore, the objectives of this study are to debranch pea starch by simultaneous pullulanase treatment and ultrasonication (PU) and to investigate the accelerated enzymatic reaction and synergistic debranching effect on the production of pea linear glucans and, thus, the enhancement of SDS and RS content in debranched pea starch (DPS). DPS-PU was prepared from pre-cooked starch slurry (5% w/v, 80°C for 10 min) with an ultrasonic processor (20 kHz, 600 W) at varied amplitude (0%, 40%, 70%, or 100%) and pullulanase concentration (40, 200, or 1000 npun/g) for 0, 1, 3, 6, and 24 hr. Total starch and free glucose content were determined. Amylose or linear glucan content was determined by the concanavalin A precipitation method. Thermal properties and molecular weight distribution were also characterized. *In vitro* starch digestibility was analyzed based on the method described by Englyst et al. (1992). The results showed that a synergistic debranching effect was obtained under optimal conditions of pullulanase (40 npun/g) and ultrasonication (100% amplitude in pulse mode, 1 min on followed by 9 min off), which produced 73.5% linear glucans, 18% SDS, and 26% RS in the resulting DPS-PU after 6 hr of treatment. DPS-PU contained no substantial amounts of low molecular weight sugars. Even when autoclaving the DPS-PU at 118°C for 30 min, following cooldown, 11% SDS and 25% RS were retained in the DPS-PU, compared with 0% SDS and 12% RS in autoclaved native pea starch. The SDS fraction in autoclaved DPS-PU further increased to 16% while the RS content remained constant during 14 days of cold storage. In summary, DPS-PU is high in large molecular weight linear glucans, low in starch digestibility, and has a thermally stable RS fraction. These advantages make DPS-PU an ideal material for developing food products and/or food ingredients with slow starch digestion.

Effects of thermal treatment, bran content, and storage on development of flavor in intermediate wheatgrass flour and tortilla

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Intermediate wheatgrass (IWG, *Thinopyrum intermedium*) is a perennial crop that has garnered attention for its environmental and nutritional benefits. Grains, including wheat, are typically processed into flour and stored until use. Grains are stable up to 8-12 years; however, flour has a significantly lower shelf life. Thermal treatment may increase grain shelf life by inactivating enzymes that are involved in rancidity, which is a major pathway for the formation of volatile organic compounds (VOC). Reducing the bran content may also increase shelf life by reducing the amount of fat and enzymes available for rancidity. Our objective was to evaluate the effect of steam treatment and level of refinement on the flavor development of stored IWG flour. IWG groats were subjected to steam treatment, milled into refined, partially refined, and whole flour, and then stored at room temperature at 43% relative humidity along with a hard red wheat (HRW) control. VOC were extracted from flour following a dynamic headspace purge and trap protocol and analyzed by gas chromatography-olfactory-mass spectrometry. A descriptive analysis sensory test was conducted with eight trained panelists to evaluate the extent of difference in on 36 attributes describing aroma, flavor, and aftertaste of tortilla made from the stored flour. Lipid oxidation compounds nonenal, 1-octen-3-ol, octanal, and decanal were detected in IWG with higher intensity in whole-flour sample over storage. Steam-treated samples had lower intensity of off-flavor compounds compared to non-steamed samples, attributed to a reduction in enzyme activity. IWG was described as grassier and earthier compared to HRW, due to the presence of alkyl aldehydes and 1-octen-3-ol. Descriptive analysis showed that IWG had more earthy, grassy, and Play-Doh® aromas than HRW samples. IWG had more peanut butter and beany flavor and was also stronger in the five basic flavors and aftertaste than HRW samples. Samples with lower bran content had lower taste, flavor, and aftertaste intensities. Steam treatment may be a viable option for enhancing the storage stability of IWG flour, specifically the partially refined and whole flour. The interruption of enzymatic activity by steam treatment could help prolong the shelf life of IWG, thus off-setting unfavorable odor development and ultimately protecting its properties and rendering it marketable.

Associations of HMW-GS composition and rye translocations with dough mixing properties and sugar-snap cookie baking quality of soft winter wheat

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The sugar-snap cookie baking test is the most commonly performed baking test in the evaluation of soft wheat end-use quality. Soft wheat varieties with good cookie baking potential are believed to be suitable for many other soft wheat products. The high molecular weight glutenin subunits (HMW-GSs) and rye translocations of hard wheat and their associations with bread-baking quality are well understood, whereas those of soft wheat and their associations with cookie-baking quality are still poorly understood. The influences of HMW-GSs and rye translocations on dough-mixing properties and cookie-baking quality were investigated using 50 selected U.S. eastern soft winter (ESW) wheat varieties carrying fourteen predominant HMW-GS profiles accounting for 80% of the recently developed ESW wheat varieties. The 149 ESW wheat varieties grown in 2016 and 2017 were analyzed for grain characteristics (test weight, grain protein content, and kernel hardness), milling quality (softness equivalence and flour yield), sodium carbonate, and lactic acid solvent retention capacities (SRCs), flour protein content, and cookie-baking quality to identify the grain and flour characteristics that predict cookie diameter. Wheat varieties possessing different HMW-GS profiles exhibited large variations in dough-mixing properties and cookie-baking quality, as indicated by midline peak times (MPTs) ranging from 0.6 to 4.6 min and cookie diameters ranging from 16.3 to 19.5 cm in 50 varieties. HMW-GSs at the *Glu-D1* locus significantly affected both dough-mixing properties and cookie diameter, whereas HMW-GSs at the *Glu-A1* and *Glu-B1* loci exhibited significant associations only with dough-mixing properties. MPTs of ESW wheat were ranked in the order of subunits 1 > 2* at the *Glu-A1* locus, 7* + 8 = 13 + 16 > 7 + 8 = 7 + 9 at the *Glu-B1* locus and 5 + 10 > 2 + 12 > 2 + 12_1 = 2 + 10 at the *Glu-D1* locus. For cookie diameter, individual subunits at the *Glu-D1* locus were ranked 2 + 12_1 > 2 + 10 = 2 + 12 = 5 + 10, indicating that subunits 2 + 12_1 are favorable for cookie baking. The influence of rye translocations on MPT and cookie diameter was dependent on HMW-GS profile. Three HMW-GS profiles containing subunits 2 + 12_1 were identified to be the most desirable for the production of cookies as determined by a cluster analysis based on cookie diameter. Sodium carbonate SRC, softness equivalence, flour protein content, and lactic acid SRC together effectively predicted cookie diameter (R^2 = 0.79, P < 0.0001). These results support that soft wheat breeders and cookie manufacturers could make an initial selection of the soft wheat breeding lines and varieties possessing desirable cookie baking potentials by just determination of the subunits 2 + 12_1 presence.

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

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

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

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Gamma-aminobutyric acid (GABA) has been reported to have many functional activities and the GABA enrichment in cereals is important for people's health. In this article, a novel and safe GABA enrichment approach based on mild heat (°C) and relative humidity (RH) treatment for hours (hr) (Step 1: 70°C, 95% RH, 4 hr; Step 2: 40°C, 70% RH, 4 hr; Step 3: 30°C, 70% RH, 4 hr) was examined. Chinese mung bean varieties (34) were processed by the method. Results showed that the average GABA content increased from 4.90 mg/100 g, dry weight (DW), in native mung bean to 31.54 mg/100 g, DW, after mild heat and relative humidity treatment. The No. 8 mung bean variety exhibited the highest GABA content (82.47 mg/100 g, DW) after processing, which was equivalent to 33 times concentration of original mung bean (2.48 mg/100g, DW). The changes in amino acid, free amino acid, and polyamines of mung bean under treatment were different. GABA, serine (Ser), free alanine (F-Ala), and citrulline (Cit) significantly increased. However, valine (Val), free glutamic (F-Glu), free aspartic (F-Asp), spermine (Spm), and free valine (F-Val) significantly decreased. Correlation analysis showed that the content of F-Glu, free amino iso-butyric (F-b-AiBA), free arginine (F-Arg), b^*, and L^* in the native mung bean had a significantly correlation ($r = 0.483$, $P < 0.01$; $r = 0.412$, $P < 0.05$; $r = 0.381$, $P < 0.05$; $r = -0.514$, $P < 0.01$; $P = -0.347$, $P < 0.05$, respectively) with the GABA content in processed mung bean. Besides, the correlation analysis indicated the enrichment of GABA also caused other amino acids and polyamines (especially free amino acid) increase or decrease to jointly resist heat and humidity stress. These results were anticipated to provide useful information on the development of GABA-rich functional products and heat stress plant metabolism mechanism.

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

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

The effects of extended hydration time on dry expanded pet food

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Preconditioning in dry kibble pet food extrusion has always been a part of the process to produce a nutritional and palatable diet. One rule of thumb has been "The Longer, The better," but with economic and equipment concerns in consideration also. The usual hydration time has been the retention time of the preconditioner; time that material is in a preconditioner ranges from a few seconds to a few minutes, depending on the size of the conditioner. This study used three hydration regimes in the processing of dry expanded pet food using extrusion – I) water and steam addition in the preconditioner with no pre-hydration (control), II) pre-hydration for 30 minutes followed by only steam addition in the preconditioner, and III) pre-hydration for 60 minutes followed by only steam addition in the preconditioner. Hydration regime I corresponded to "normal' processing and the raw material was at the usual moisture level of about 12% (wet basis) before entering the preconditioner. Pre-hydration (regimes II and III) resulted in less steam absorption during preconditioning, possibly due to less condensation and lack of contact of steam with water droplets. The resultant product however was lower in bulk density (401-426 g/L), and piece density (0.484-0.514 g/cm^3) as compared to the control (457 g/L bulk density and 0.553 g/cm^3 piece density). Regime III with greater pre-hydration time led to the highest expansion and lowest bulk and piece densities. The average crushing force (measured using texture analyzer under compression mode) was also slightly lower (24.0-24.4 kg-f) for product processed using the pre-hydration regimes as compared to the control (24.7 kg-f). Results indicated that pre-hydration might be an effective way to create a more extensible melt in the context of high protein pet food formulations, leading to greater expansion. This study has significance for the pet food industry as it provides a potential new tool for altering the physical properties such as expansion and texture of products and in turn impacting their palatability.

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

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

had an increase in number and size of pores. The surface pore width was between 0.5 and5 μm, with the smaller sizes being more frequent. The study showed an increase in aflatoxin binding that could be related to the observed changes in surface properties.

Pre-harvest desiccant timing and effects on the fine chemistry of wheat starch

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Pre-harvest desiccants are occasionally used during wheat cultivation to promote uniform crop maturation and timely harvest. Such pre-harvest aids are recommended to be applied at the ripe stage of physiological maturation. However, due to non-uniform maturation, pre-harvest desiccants can come into contact with crops that have not reached ripe stage. In this context, the aim of this study was to determine if pre-harvest desiccant application at different developmental stages (ripe vs. soft dough) has an effect on the physicochemical properties of wheat starch. For this purpose, a greenhouse study was conducted where pre-harvest desiccant was sprayed at ripe stage and soft dough stage to a commonly grown wheat cultivar in North Dakota. Samples were collected before application and every three days after application until harvest. The controls used in the study were sprayed with water in place of pre-harvest desiccant at the same developmental stages. The obtained samples were milled and analyzed for differences in starch granule distribution, amylose and amylopectin ratio, amylose and amylopectin molecular weight, starch granule morphology, amylopectin chain length, and starch thermal properties. The results of the study indicate that pre-harvest desiccant timing does not impact the spatial distribution and morphology of starch granules. The percentage of amylose and amylopectin, amylose and amylopectin molecular weight did not show significant differences between treatments. However, the results showed that pre-harvest affected the thermal characteristics of wheat starch when applied at soft dough stage and that it decreased the average amylopectin chain length. Differences in the proportion of short, medium, and long chain amylopectin were also observed in both treatments. Overall, this study shows that pre-harvest desiccant has some effects on wheat starch properties, especially when applied at soft dough stage, although it is unclear how these changes affect overall functionality of wheat starch in food systems.

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

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

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

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Poly(lactic acid) (PLA) is the most common bio-based and compostable polymer available commercially that is cost competitive and combines a range of desirable properties like melt processability, high strength, and modulus. The films made from this aliphatic polyester tend to be brittle which can be overcome by blending PLA with another bio-based polymer with high flexibility poly(butylene adipate-co-terephthalate) (PBAT), but the resultant blend is only biodegradable in composting conditions. Thermoplastic starch (TPS) was incorporated in PLA/PBAT blends to increase the rate of biodegradability and decrease the cost. Joncryl (0.5%) was used as a compatibilizer. Mixture response surface methods were used to investigate the effect of PLA, PBAT, TPS, and nanofiller nanocrystalline cellulose (NCC) on the responses water vapor permeability (WVP), tensile strength (TS), elongation at break (EB). All factors including levels of PLA, PBAT, TPS, NCC influenced the mechanical and barrier properties of the films. Quadratic models with good predicted R^2 (between 84.3% and 97.59%) were developed for all the responses. Addition of PBAT improved the EB of the films while NCC and TPS addition

decreased the EB. TPS addition decreased the mechanical properties and increased the WVP, but addition of NCC increased the tensile strength of the PLA/PBAT/TPS blends and decreased the WVP. Optimization study was done that could yield films with optimum properties comparable to commercial plastics and maximizing the level of TPS. Films with optimum properties (TS = 29.5 MPa, EB = 12%, WVP = 1.99 g.mm/kPa.h.m^2) were predicted at levels of 64.3% PLA, 14.5% PBAT, 18% TPS, and 2.6% NCC, along with 0.5% Joncryl. The improved mechanical and barrier performance suggested that PLA/PBAT/TPS/NCC nanocomposites have potential use in food packaging applications.

Development of an enhanced beta (β) glucan beverage – evaluating satiety, nutrition and shelf stability

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Oat and barley are good sources of dietary fiber, especially β-glucans. Currently, dietary fiber intake among adults in the United States average about 15 g a day, which is significantly lower than the recommended 25 to 30 g a day. This makes dietary fiber a shortfall nutrient and as such, a nutrient of public health concern in older adults. A limited variety of non-alcoholic high-moisture products have been made from oats and barley though they are widely grown in the United States. Studies have shown that the addition of β-glucans to beverages or high moisture products impairs their sensory qualities (relatively high viscosity) despite improving other rheological properties. Thus, the development of β-glucan fortified foods remains to be highly challenging. Partial enzyme and acid hydrolyses were employed to reduce the unappealing problem of high viscosity while maintaining its satiety increasing functionality and nutritional content. The effects of partial enzyme hydrolysis and partial acid hydrolysis on the viscosity, β-glucan content and hunger suppressing functionality of the beverage containing a blend of GMI423 oat flour and barley flour were studied. Hydrolyses were performed at 50% moisture content at 50°C. Partial enzyme hydrolysis using beta glucanase in a 1% substrate concentration with constant stirring and a 1min deactivation at 80°C, resulted in reducing the viscosity 153-185 centipoises(Cp) to 45-57 centipoises (Cp). Also the β-glucan content of the beverage decreased from 6.52 to 6.23% and it was shown to increase fullness, reduce hunger, reduce desire to eat and prospective intake. Partial acid hydrolysis was carried out with an addition of ascorbic acid (10 mM) in the presence of iron sulphate, with the viscosity decrease inhibited by introducing a OH^- scavenger (glucose) in the solution. This resulted in a slight viscosity decrease from 153-185 centipoises(Cp) to 127-155 centipoises(Cp). Also there was almost no significant difference observed in the β-glucan content of the beverage. Partial acid hydrolyzed beverage was not preferred in the sensory tests and hence not evaluated on its hunger suppressing functionality. Partial enzyme hydrolysis was therefore shown to be an effective method to reduce beverage viscosity, maintain β-glucan content, improve sensory parameters and increase satiety. Thus helping to add value to oats and barley by developing a variety of products beyond the breakfast cereal aisle.

Pasta from pulses: Conventional extrusion or extrusion-cooking?

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Nowadays, consumer demand for healthy foods with low environmental impact is growing. Pasta from pulses represents a potential solution that the food industry could offer to meet current consumer needs. Indeed, pulses are rich in fiber and proteins and are more sustainable than cereals. Moreover, the absence of gluten makes them suitable for people suffering from celiac disease and/or gluten intolerance. It is known that gluten-free pasta production from rice or corn is produced by conventional extrusion of pregelatinized flour (labeled here as process A) or by extrusion-cooking of native flour (process B). In the case of pulses, limited information is available regarding which technology is better (process A or B) to obtain a product with desirable quality. To answer this question, this work focused on understanding the relationship between raw materials and processing conditions and their effect on pasta quality. Pasta from rice and red lentils was prepared using two technologies. Process A consisted in a conventional extrusion of flour from pregelatinized grains, while process B involved extrusion cooking of native flour. The effect of processing on starch properties was assessed by measuring starch susceptibility to alpha-amylase hydrolysis (AACCI Method 76-31.01) and by evaluating pasting properties (MVAG, Brabender©). The weight-increase of cooked pasta, the loss of solids in cooking water and textural characteristics were evaluated. The pasta-making process significantly affected starch properties, promoting a high degree of gelatinization which was notable by the increase in starch susceptibility to alpha-amylase hydrolysis and by the decreased capacity to form a gel during the MVAG test. However, the extent of starch modifications differed according to the type of raw materials (rice and red lentils) used. This could be due to differences in composition (i.e., amount of fiber, starch, and proteins) and/or starch organization. Finally, both pasta-making processes were found to be effective in obtaining gluten-free pasta from either rice or red lentils. However, samples from process B resulted in pasta with a non-homogeneous structure, showing some non-hydrated points that might affect both water absorption and textural properties. Based on the results process A seems to be the more suitable process for producing pasta from red lentils.

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

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

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

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Chickpeas and other pulses are gaining popularity because of their nutritional quality and sustainability. Chickpea flour is commonly prepared using hammer mills and de-hulling typically involves higher water usage. Roller milling can be more beneficial than hammer milling with greater hull separation and lower water usage. The focus of this research was to optimize the use of roller mills in processing chickpeas into flour and a larger particle meal. Milling characteristics of two varieties were studied, Kabuli and Desi. These varieties are commonly used and differ in size and composition. Kabuli seeds were larger with thinner hulls and Desi seeds were smaller with thicker hulls. Lab-scale roller mills were used for initial process design. Flow sheets were designed for each variety; one for flour (≤150 µm) and one for meal (300-750 microns). Independent variables included the number of rollers, roller gap size, roller characteristics, sieve separation, and tempering methods. Results were analyzed on flour yield, chemical composition, particle size, starch damage, and functionality in baking crackers. Compositional tests included ash, protein, lipid, fiber, and total starch. Extent of damage to starch and water interactions were measured using Rapid Visco Analysis (RVA). Cold tempering to 11% was found to be optimum, with flour yields up to 92%. Proximate analysis of flour showed reduction in crude fiber as compared to the whole chickpea from 3.8% to 0.92%, and an increase in total starch from 39.9% to 46.6%. Flow sheets designed for meal produced an average of 20% flour as by-product. RVA peak viscosity for chickpea meal was very low (191-248 cP). For flour, higher peak viscosities were observed for Desi (1,050-1,100 cP) as compared to Kabuli (850-900 cP) and also lower breakdown for Kabuli (80-105 cP versus 77-123 cP). Pasting temperatures were similar for both flours (70-75°C). These data suggested greater amount of damaged starch in Kabuli flour. Crackers baked from these raw flours were consistent with this inference, as crackers from Kabuli flour had a smoother appearance than the ones from Desi. Both had undesirable flavors compared with crackers baked from commercial chickpea flour that was precooked. The commercial flour had very low peak viscosity (80-90 cP) showing the impact of thermal treatment. Future work will include scaling-up the milling process to a pilot-scale roller mill and thermo-mechanical pretreatment of flours using pilot-scale twin screw extrusion to get rid of off-flavors as opposed to the currently used thermal treatment.

One pot preparation of rice-gels from white rice using rapid visco analyzer

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"Rice-gel" is a novel material which is used as an ingredient to modify the texture of bakery products and noodles. However, its gelling mechanism and the effects of processing conditions and rice characteristics on the gel properties are still not well understood. The processing of rice-gel includes three steps: 1) cooking of rice grain, 2) high-speed shearing, and 3) gelling. The original processing procedure calls for 300 g of rice grain, whereas a recent report from Sasaki (a) used about 20 g of rice for preparation of cooked rice. In this study, we used 4 g of rice on a Rapid Visco Analyzer (Newport Scientific) for each step of the processing procedure and evaluation. 1) 4 g of white rice was cooked in 22 ml of water, using a temperature program that follows the temperature change of a rice cooker. 2) For high-speed shearing, the paddle was rotated at 2,000 rpm for 10 to 20 min after rice was cooked. 3) For the gelling procedure, the temperature was quickly brought down to 7°C while measuring the viscosity of the paste. For comparison, hot rice paste was taken out of the canister just after high-speed shearing and poured into an acrylic mold, pressed between glass plates, kept at 4°C to make a solid gel, and hardness of the gel was determined with a compression test. Effects of variety and shearing conditions on gelling and gel hardness were determined using this small-scale evaluation system. Rice with high apparent amylose content showed higher viscosity compared to those with lower amylose content. Rice paste sheared at 80°C showed higher viscosity than those sheared at 20°C. The hardness of the gel after one hour showed a positive correlation with the viscosity of the paste. These results were compared to the hardness of the gel prepared with larger scale process. Thus, this small-scale method is expected to be a useful tool for small quantity evaluation such as in the breeding program or basic research for studying the effects of conditions and additives on the properties of rice-gel. (a) Sasaki et al. Food Sci. Nutr. 7:721-729, 2018.

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

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

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

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Harmful molds such as *Aspergillus flavus* have the potential to generate mycotoxins on corn thereby jeopardizing consumer health and posing significant economic losses to growers. This study investigated the efficiency of IR

with subsequent tempering step at 50-60°C for 24 h to dry corn to the safe storage moisture content (MC); the study also investigated the resulting microbial decontamination and fungal diversity on treated corn using metagenomics techniques. Infrared treatments were performed with corn samples at bed thicknesses of 1.5, 2.7 and 4.5 cm. A pilot-scale, continuous-flow, radiant heating system equipped with catalytic IR emitters was designed and built to conduct the corn drying and decontamination. Drying was done at 5.55 kW/m^2 for IR heating intensity, fixed product-to-emitter-gap size of 450 mm, belt drive speed of 0.11 m/s, and intermittent heating duration of 30 s. Result showed that duration required to reduce the corn MC from 21 to 13.5 percent depended on the corn bed thickness. The efficiency of IR drying was also improved with addition of tempering step. Results indicated that when corn bed thickness increased from 1.5 to 4.5 cm, the percentage of moisture reduction significantly reduced. This research also revealed that the drying was feasible with simultaneous decontamination of microbes on the corn. *Aspergillus* and *Oidiodendron* were the most susceptible fungal genera affected by the IR drying. There was significant reduction in these fungi. In conclusion, this work showed that IR drying of corn holds promise as a rapid drying method with potential benefits of microbial decontamination of corn; this may help producers combat mold related problems such as mycotoxin contamination.

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

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

"Super Soft" wheat kernel texture

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

meeting. Overall, results have advanced the understanding of the genetic inheritance, endosperm morphology, and functional quality associated with the Super Soft kernel phenotype. Current studies are working towards identifying the genetic basis and physical-chemical mechanism of the Super Soft trait.

Study of the components influence on noodle dough loosening

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The stickiness and looseness of the dough in resting are undesirable for noodle making in the line. The objective of this study was to clarify the mechanism of noodle dough loosening in resting. Japanese domestic wheat "Kitahonami (KH)" and Australian standard white (ASW) were used. Noodle doughs and strands were prepared by AACCI Method 66-60.01 with some modifications. Both ends of noodle strands were set between two boxes and stored for 3 hr in the dough conditioner at 17, 27, 35C at 95% humidity. The distances of hanging down as an index of loosening were 12.3-23.5 cm for KH and 9.3-16.4 cm for ASW at 27C (for 0.5-3.0 hr, respectively). These results showed the dough of KH (DKH) was significantly ($P < 0.05$) looser than the dough of ASW (DASW). Also, the higher the temperature in resting, the easier it was to loosen the dough ($P < 0.05$). Proteins in dough were extracted using 0.5% SDS phosphate buffer with homogenization and analyzed by SE-HPLC. The degrees of extractability of protein (DEP) were 87.2-88.4% (17C), 87.9-89.8% (27C), 87.3-90.0% (35C), for DKH, 83.4-87.4% (27C) for DASW, resting for 0-3.0 hr, respectively. DEP for DKH at 35C reached 90% earlier than that at 27C (resting for 0.5, 1.0 hr, respectively). The proportions of polymeric proteins (PPs) were 36.1-35.8-35.5-35.3% (17C), 36.4-36.4-36.4-35.8% (27C), 36.1-36.4-36.0-35.2% (35C) for DKH, 30.0-30.8-31.0-30.7% (27C), for DASW, resting for 0, 0.5, 1.0, 3.0 hr, respectively. These results indicated that the larger the looseness, the faster the solubilization of PPs. Fluorescence intensities of tryptophan (FIT) on dough surface were measured using spectrofluorometer. Decrease in FIT of DKH for 3hr at 27C was significantly ($P < 0.01$) more than that of DASW (274, 140 fluorescence intensity area, respectively). FIT of DKH at 35C was more rapidly reducing than those at 17 and 27C (27C > 17C). Sugars in dough were extracted using 80% ethanol and measured using HPAE-PAD. The amounts of sugars in DASW were significantly ($P < 0.01$) more than those in DKH (62.3-81.7, 30.3-42.6 mg/dry dough gram, 0-3 hr, for maltose, 14.0-15.0, 7.8-8.4 for sucrose, respectively). In summary, it was suggested that protein composition in dough changed in resting, consequently might change the solubilization properties of protein, followed by loosening dough. Also the changes in hydrophobicity in dough affect to loosen noodle dough. The changes in hydrophobicity and protein composition might be linked each other. It appeared that the amount of sugars wasn't a main factor for loosening noodle dough.

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

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

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

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

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

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

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

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

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

5-5 than in NIL 1-1 bread making, crystallization started later during the cooling process and eventually occurred to a lesser extent in the former case. This resulted in a lower level of rigid protons and a higher mobility of the gel network in fresh NIL 5-5 than in NIL 1-1 bread. The higher mobility of mobile, exchanging protons at the end of baking and during cooling when bread crumb had a lower AM content points to the key structural role of AM in bread crumb. In conclusion, the timing of gelatinization during baking and the timing and extent of AM crystallization during cooling were determined by respectively AP crystal stability and AM concentration. That proton distributions were altered in a way in line with starch AM contents and AP chain length distributions, adds support to the suggested interpretation of NMR profiles during bread baking and cooling.

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

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The crystallinity of rice starch shows generally A type, but B type crystallinity is shown in newly developed rice varieties in Korea. The molecular structure and resistant starch of high amylose rice starches, Goami, Singil, Goami2, and Dodamssal were compared. Goami2, Singil, and Dodamssal are developed by mutation breeding with MNU (N-methyl-N-nitrosourea). Amylose contents of Goami, Singil, Goami2, and Dodamssal starches were 25.56, 30.34, 36.33, and 45.78%, respectively. The crystalline structures of Goami and Singil starches was A type, but those of Goami2 and Dodamssal starches was B type. Dodamssal starch showed the highest in initial pasting temperature, but the lowest in setback viscosity. The peak, trough, final, and breakdown viscosities of Goami2 were the highest among them. The molecular weights of amylose of B type starches (1.64 and 1.88 x 10^5) was lower than those of A type starches (3.88 and 3.00 x 10^5). The branched chain length proportions of amylopectin in DP 25-36, and DP $\geq$37 of B type starches were higher than those of A type starches. Resistant starch and total dietary fiber contents of B type starches were higher than those of A type starches. It is suggested that molecular structure of high amylose rice starches should be different from crystalline types and B type starches should have higher resistant starch and dietary fiber contents than A type starches.

Starch nanoparticle formation from high amylose rice starches using ultrasonic treatment

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Ultrasonic treatment is possible to break into the nanoparticles from starch granules instead of acid hydrolysis. Korean high amylose rice varieties, Goami, Singil Goami, and Dodamssal, were used after purification of starch granules. Starch suspensions (1%) were sonicated at 45% power output for 30 min and stood at 5°C for 18 h to separate into the dispersed and precipitated particles. Morphology, particle size distribution, x-ray diffraction, FT-IR, thermal properties and zeta potential of ultrasonicated rice starches were investigated. The particle size of dispersed nanoparticle was ranged from 69.1 to 251.9 nm, but that of the precipitated particle was ranged 728.4-1224.1 nm. The nanoparticle size of Goami2 was the smallest (69.1 nm) among them. The starch nanoparticles showed amorphous without any peaks, but precipitated particles showed the same crystalline types, A type of Goami and Singil and B type of Goami2 and Dodamssal starches. From FT-IR, nanoparticles were formed a new band at 1559 cm^{-1}, regardless of crystalline type of starch. The gelatinization enthalpy of native and nanoparticle decreased from 6.96-8.58 J/g to 0.17-1.70 J/g, respectively. Zeta potential was not affected particles size and was ranged from -36.98 to 16.16 mV, except Singil nanoparticle. It is confirmed that the ultrasonic treatment should be prepared nanoparticles from high amylose rice starches and all nanoparticles changed into amorphous type polymers.

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

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Consumption of whole grain flour (WGF) is recommended due to health benefit. However, demand of WGF is limited due to low processing and end-product quality. Wheat flour quality is significantly affected by milling variables including wheat tempering condition and mill design, but few reports have been available regarding WGF quality in hard red spring (HRS) wheat. This research was performed to examine the influence of wheat tempering treatment on WGF quality characteristics when different milling procedures were used in HRS wheat. Wheat tempering treatments were combinations of three levels of moisture content (10, 13, and 16%) and three storage days (1, 2, and 3 days after tempering). The WGF samples were obtained by two experimental whole grain milling (EWGM) procedures using the Quadrumat Sr. and Udy mills. Kernel characteristics were examined using the Single-Kernel Characterization System (SKCS). Tempering moisture level (TML) was identified as a

primary factor to influence most quality characteristics of WGF. The SKCS hardness parameters such as hardness index, peak force, and modulus of endosperm elasticity showed lower values as TML increased. However, damaged starch content of WGF increased as TML increased. The EWGM procedures showed a contrasting difference in particle size distribution of WGF samples. As TML increased, coarse particle fraction (>0.25 μm), which was mainly composed of bran particles, increased in WGF samples obtained from the Quadrumat Sr. mill but decreased in WGF samples from the Udy mill. Image analysis showed that mean bran particle size was larger for WGF samples obtained from the Quadrumat Sr. mill than those from the Udy mill. TML also had a significant effect on mixing characteristics analyzed using the mixograph. Specifically, mixograph peak time was significantly longer when TML was higher. WGF samples produced by the Udy mill showed higher starch damage and longer mixograph peak time when compared to those from the Quadrumat Sr. mill. Significant linear correlation coefficients appeared for starch damage ($r = 0.625$, $P < 0.001$) and mixograph peak time ($r = 0.759$, $P < 0.001$) between Quadrumat Sr. and Udy mills. These results indicate consistency between two milling procedures in evaluating wheat samples for starch damage and mixograph peak time. The EWGM procedure using a Udy mill is less laborious and time-consuming than the procedure using a Quadrumat Sr. mill. The results indicate that the EWGM procedure using a Udy mill might be used for the evaluation of WGF quality traits, including starch damage and mixing property for HRS wheat samples.

Influence of carbon dioxide-argon radio frequency plasma on structural and functional properties of cereal and tuber waxy starches

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Modification of native starch is necessary due to its insoluble and unreactive nature. Physical methods of modification such as cold plasma is highly desirable because it is devoid of chemical waste generation. Thus, the effect of radio frequency cold plasma on the crystallinity, changes in short range molecular order (NMR), resistant starch, starch damage, and iodine affinity of waxy rice, maize, and potato was investigated. Starches (15 g) were treated for 60 minutes in a plasma chamber filled with carbon dioxide and argon gas at a flow rate of 25 and10 sccm, respectively, and a plasma power of 0 (gas treatment) and 120 W. X-ray diffraction, NMR, resistant starch, starch damage, and iodine affinity of the samples were studied. A 5.5% and 2.8% decrease in crystallinity was seen in waxy potato after plasma and gas treatment, respectively; however, maize and rice were unaffected after treatment. The presence of V-type single helices could be seen in waxy maize and rice but not in potato after treatment as indicated by peaks around 101.1 and 103 ppm. Peaks at 104.2 to 105.3 ppm, visible in potato only, have been associated with the junction zones of the double helices in amylopectin and increases in their areas were noted after both treatments. Resistant starch contents increased significantly in waxy potato (44.31-66.48%) and maize (0.84-1.21%) after plasma treatment with rice increasing only after gas treatment (0.12-1.33%). Similar increases were observed in damaged starches after plasma treatment in potato (0.74%-1.09%), maize (2.20%-2.33%), and gas treatment in rice (5.33% -5.56%).There were no statistical differences in the λ_{max} values of treated and untreated waxy rice and maize starch; potato however increased significantly after plasma treatment (554.5-557.5). The peak values of waxy maize were unaffected by plasma treatment but increased significantly in potato (0.84-1.00) and rice (0.37-0.48). Gas treatment also caused significant increases in waxy rice (0.37-0.59) while a decrease was observed in potato (0.84-0.62). In conclusion, plasma treatment significantly increased the resistant starch and starch damage content of maize and potato but not rice. The iodine affinity of potato significantly increased after plasma treatment. Plasma or gas treatment resulted in no decreases in crystallinity in maize and rice, but however induced the formation of V-type single helices.

Effect of chemical components on porosity and mechanical properties of rice kernels

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Rice, unlike other cereal grains, is consumed mostly as intact kernels or head rice, which makes its economic value twice that of broken kernels. The percentage of broken kernels is one of the factors determining the grade of milled rice with maximum limit of 4% and 50% for U.S. No. 1 and 6, respectively. Fissures and chalkiness are macro-structural defects which have been recognized to weaken kernel mechanical strength, and thereby increase breakage during milling. However, high percentages of brokens (up to 70%) are sometimes recorded even though these defects are controlled prior to milling. Proteins and lipids are the major chemical components in rice after starch and are present in the spaces outside of amyloplasts which contain compound rice starch granules. It was hypothesized that the structural arrangement and interactions of proteins and lipids affect void space sizes that change porosity, and consequently kernel strength and head rice yield. This study, thus, aimed to investigate ways of improving the interaction of rice components with starch through protein denaturation by heating and lipids removal, so as to reduce porosity and increase mechanical properties. Four long-grain cultivars with kernel thickness of 1.98-2.03 mm were selected. Rice protein was denatured under vacuum at 100°C for 1 hr, and rice lipid was removed with hexane extraction for varying times. The porosity and breaking force of treated samples were determined. Significant negative correlations were found between protein denaturation ($r = -0.86$) and lipid

removal (r = -0.68) with porosity, and significant positive correlations between protein denaturation (r = 0.994) and lipid removal (r = 0.74) with breaking force. Protein solubility, which is a measure of protein denaturation showed a significant negative correlation (r = -0.99) with protein denaturation. This significant decrease in protein solubility evidences an increased protein-protein interaction, which reduced the void spaces, and thus, improved mechanical strength. The presence of lipid weakened brown rice kernel strength because its hydrophobic nature limited its interaction with other components, and thus, lipid removal led to better interaction between the components. In conclusion, the increase in mechanical strength could imply an increase in head rice yield and consequently economic value of the rice.

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

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Background: Spontaneous wheat sourdough has been traditionally used to produce baked- and steamed-goods in the world. Recently, the use of wheat sourdough in Japan has gained popularity due to increased consumer demand. Japanese bakers occasionally select a wheat flour of spontaneous sourdough by a criterion of the wheat-growing country in order to distinguish their sourdough characteristics. However, the effect of the wheat-growing country on wheat sourdough fermentation is still unclear. To this end, the fermentation processes of three spontaneous sourdoughs using wheat flours of different growing countries, France, North America, and Japan, respectively, were tracked by both microbial community analysis and targeted-metabolite determination. Materials and Methods: All wheat flours were obtained from flour milling companies in Japan. The dry matter percentages of flour ash were 0.63, 0.51, and 0.61, those percentages of flour protein were 11.4, 12.2, and 13.7, France, North America, and Japan, respectively. Three hundred grams of spontaneous sourdough in a 1.5-L plastic container was backslopped 32 times over a time of period of two months. The dough yield (weight of the dough/weight of the wheat flour × 100) was set at 200. In each backslopping step, fermentation was carried out at 30°C for 8 h, and then stored at 4°C until the next backslopping step. The microbial communities were analyzed by both culture-dependent and culture-independent methods. The concentrations of both lactic acid and ethanol of sourdoughs were assessed by HPLC and enzyme electrode method, respectively. Results: During two months of sourdough backslopping, the bacterial communities evolved through three phases that were driven by different groups of lactic acid bacteria (LAB) species. The dynamism among the metabolites also differed, depending on the species composition of the LAB and yeast communities. In one sourdough, the growth of *Saccharomyces cerevisiae* was detected along with a concentration of increased ethanol, while in the other two sourdoughs, *Wickerhamomyces anomalus* was detected without ethanol production. Regarding the LAB communities, two sourdoughs were eventually co-dominated by *Lactobacillus plantarum* and *Lactobacillus brevis*, while the other sourdough was eventually dominated solely by the heterolactic fermentative bacterium *Lactobacillus fermentum*, and ethanol was produced at the same level as lactic acid. Further research is needed to understand the effect of the wheat-growing area on spontaneous wheat sourdough fermentation.

Characteristics of Korean rice varieties and their potential end-uses

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As Korean consumers are increasingly attracted by Western foods as substitutes for their conventional diets, the Rural Development Administration (RDA) of the Korean National Institute of Crop Science is involved in enhancing and developing alternative rice-based foods, presently hard to find on the Korean market. Traditionally in Oriental countries, milled rice is consumed after boiling in water and combined with other courses. Therefore, to re-vitalize this sector, the RDA is planning the production of added-value foods, such as dried pasta and "risotto", two well-known Italian-style products. Rice from four Korean *O. sativa* varieties (two subsp. *japonica* – Dodamssad and Mylang 344 – and two subsp. *indica* – Saemimyeon and Shingil) were characterized and compared to four Italian varieties, all from subsp. *japonica* (Carnaroli, Volano, Vialone Nano – indicated for risotto preparation – and one subsp. *tropical japonica* – Gladio – preferred for the parboiling process). In addition to the characteristics of the starch fraction (amylose content, alkali test, pasting properties), the cooking behavior (i.e. rice hardness and stickiness) was considered. The three Italian *cvs* recommended for risotto belong to different commercial classes according to their biometric characteristics and their amylose content (Italian law n. 131/2017). Nevertheless, they are all characterized by long gelatinization times (16-17 min), high alkali index (5-7) and good texture after cooking (i.e. surface stickiness as well as good grain consistency). Among the Korean varieties, Saemimyeon cv makes the best risotto, even if its alkali test value is very low and its grain hardness is quite high, traits indicating low starch swelling during cooking. Concerning rice-pasta production, the literature suggests that high amylose (>25%) varieties are preferable, as they are more

suitable in forming a strong and regular starch network during thermal treatments carried out during the extrusion process. With the exception of Dodamssad cv, whose amylose content (41.7%) is too high to obtain (according to its pasting property indications) sufficient starch swelling, Saemimyeon and Shingil cvs seem to have the right traits for assuring good results in rice-pasta processing. In conclusion, none of the Korean rice varieties tested so far seems to guarantee cooking performances for risotto similar to those observed for Italian varieties. On the contrary, the former exhibit promising characteristics for rice pasta-making. Further investigations will focus on starch digestibility, which might be strongly affected by the amylose content and may lower the glycemic index of the cooked product.

Physicochemical properties of alkaline noodle enriched with clarified beetroot juice

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

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

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The consumption of dietary fiber by the Canadian population, despite its association with a range of health benefits, is well below the recommended intake levels. One of the reasons cited by consumers for the low intake levels of dietary fiber is the perceived lower palatability of fiber-rich products. The aim of this study was to gain insight in the molecular interactions and structures in dough and bread as affected by the substitution of part of the wheat flour with enriched dietary fiber fractions. In this abstract, focus will be laid on the evaluation of the effect of dietary fiber rich in beta-glucan on dough and bread properties. A beta-glucan-rich dietary fiber fraction (BDF) was obtained from barley wholemeal using an aqueous enzyme-assisted extraction procedure. Dough samples were substituted with 4.0, 6.0, and 8.0 w/w% extracted BDF. Water absorption and mixing characteristics were determined using farinograph and mixograph analysis, respectively. Freezable water content (DSC), water mobility using T_2 relaxation times (NMR) and dough rheology were also evaluated. BDF substitution of flour led to a significant increase in water absorption and peak mixing time in farinograph and mixograph analyses, respectively ($P < 0.05$). Increasing BDF substitution levels reduce the freezable water content significantly: the percent reduction in freezable water content was 14.0%, 17.2%, and 22.4% for 4.0%, 6.0%, and 8.0% BDF substitution levels. T_2 relaxation times of dough samples also showed a significant reduction with increasing BDF substitution level. Dietary fiber rich in beta-glucan causes changes in dough viscoelastic properties: increasing BDF substitution levels led to an increase in storage modulus (G') and a reduction of tan d pointing to a more pronounced elastic behavior of dough made with BDF. Bread volumes were also reduced with increasing BDF substitution levels. Addition of water to the dough recipe exceeding the farinograph water absorption level results in a noteworthy reduction of G' and a concomitant increase of the specific loaf volume of the resulting bread products.

Evaluation of glutopeak as a tool for screening North Dakota hard red spring wheat breeding lines

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Evaluation of wheat breeding lines with good quality traits, for the release of new varieties of hard red spring wheat (HRS), is key to meet industry needs. The glutopeak has potential to be a fast, effective way to screen breeding lines with acceptable protein quality, in order to decide which lines to advance to further trials. This research evaluated the ability of data from the glutopeak to select lines with good protein quality from breeding

program trials compared to current methods. Eighteen wheat varieties were grown at NDSU Research Extension Centers located at Dickinson, Langdon, and Minot, ND, in 2017. Protein content, dough rheology and baking were conducted according to AACCI methods. Whole wheat protein ranged from 14.4 to 17.4% and gluten index ranged from 84.5 to 98.5. The glutopeak peak maximum time (PMT) ranged from 121 to 249 seconds. Maximum torque (MT) ranged from 51 to 63 glutopeak units (GPU). Aggregation energy ranged from 1,398 to 1,716 cm^2. MT had very highly significant ($P < 0.001$) correlations with protein content (0.74), lactic acid solvent retention capacity (SRC, 0.50), and wet gluten content (0.76). PMT had very highly significant ($p<0.001$) correlations with gluten index (0.44) and mixograph peak time (0.56). Glutopeak results were also consistent across growing locations. When comparing to other screening tools, the glutopeak values had similar or better relationships with flour quality compared to mixograph parameters, gluten index, and lactic acid SRC. Among mixograph parameters, only peak time had very highly significant ($P < 0.001$) correlation with gluten index (0.53). These results show that the glutopeak can be used to differentiate poor and good quality HRS wheat breeding lines. Therefore, the glutopeak has good potential to aid in the selection of more desirable quality HRS lines.

Designing a vacuum dough expansion system to predict bread loaf volume

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Predicting bread loaf volume is the holy grail of the bread industry. Loaf volume is a significant economic factor in the baking industry. Numerous flour and dough quality tests exist, however, none of these tests accurately predict bread loaf volume. The most reliable method to determine baking potential of wheat flours is a standard baking experiment, which is time consuming. Vacuum Dough Expansion System (VDES) was designed to expand optimally developed dough prepared from flour and water. Dough expansion was carried out in a chamber and maximum height of the expanding dough was recorded. This rheological test was paired with a chemical test, the hybrid SDS-SRC sedimentation test that measures gluten proteins that precipitate on the addition of solvents and detergents. Routine flour tests, dough quality tests and baking experiments were also done in parallel. Dough expansion height was significantly correlated with corresponding baked loaf volume for flour blends (gluten concentration from 7.3-14.7%) prepared by spiking vital wheat gluten of a low protein flour ($R^2 = 0.94$). The dough expansion behavior in a weak flour provided evidence of the applicability of VDES for testing effects of dough enhancers and baking ingredients. In a validation study performed on 24 hard red winter (HRW) varieties, specific loaf volume (SLV, Loaf volume/weight) showed significant correlation with dough expansion height ($r = 0.47$) and weight value (obtained from the hybrid SDS-SRC sedimentation test, $r = 0.54$). The best predictor of SLV in this sample set was the Mixolab stability ($r = 0.61$). In another validation sample set performed using 33 hard red spring (HRS) varieties each grown at three locations, loaf volume was found to be significantly correlated with dough expansion height ($r = 0.42$). However, the best predictor of loaf volume in this sample set was good wet gluten from the Glutomatic test ($r = 0.69$). The research established a proof of concept for dough expansion and its potential applicability in measuring baking quality of wheat. The VDES provided linkage between true baking test and other chemical indicators of wheat and dough quality. Inclusion of the VDES in predictive models involving other conventional tests may prove to be effective in predicting bread quality. The results will serve as stepping stone for the larger goal of improving the wheat quality by providing robust, rapid analytical tools to wheat breeders, flour millers, and bakers.

Understanding possible gluten contamination in lentils

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Though naturally gluten-free, supplying gluten-free pulses (peas, beans, lentils, and chickpeas) and pulse ingredients (flours, grits) can pose a challenge due to the possible risk of contamination with either gluten-containing grains or grain dust. Gluten contamination of pulses is possible at several stages, including harvesting, transportation, and processing. Incoming pulse samples are visually assessed and the requirements for cleaning are determined. Regardless of the level of foreign material, several stages of cleaning are used including the use of mechanical separators and aspirators. More rigorous cleaning will be done to obtain gluten-free pulses. The removal of gluten-containing grains from lentils is especially challenging due to the size and shape of the seed compared to other pulse types. To better understand the possible contamination of lentils with gluten containing grains and grain dust, a series of laboratory-scale experiments was conducted. In the first experiment, the influence of granulation size (flour and grit) on the detection of gluten was examined. Lentils (1 kg) which had been visually inspected for the presence of gluten-containing grains and tested for gluten using ELISA-R5 was spiked with two kernels of wheat and milled into grit and flour and re-tested for the presence of gluten. Flour samples tested positive for gluten, whereas gluten was not detected in the grit samples. A second spiking experiment was carried out to examine the effect of grain dust on gluten contamination. Lentils (1 kg) were spiked with wheat flour at levels of 0.1 and 0.2%. All of the samples were above the allowable EU/Codex

Alimentarius limit of 20 ppm. However, after the lentils underwent bench-scale aspiration and vacuum sifting the level of gluten was reduced to well within the acceptable limit. A third experiment was undertaken to examine if the deliveries made by farmers varied substantially in terms of gluten contamination. Lentil samples collected from different farmers were visually examined for foreign material including gluten containing grains. After removing the visual contaminants, the lentils were tested for gluten. Further cleaning of lentils using bench-scale mechanical and aspiration techniques was then carried out and the samples re-tested for gluten. Differences were found among the various samples. Our findings suggest there are a number of factors which influence gluten contamination in lentils. Understanding these factors is critical in ensuring the supply of safe gluten-free pulses and pulse ingredients.

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

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Pea (*Pisum sativum* L.) is a pulse crop widely grown for human consumption worldwide. Different from the common varieties of round pea cultivated in Canada, wrinkled pea is a *rugosus* (*rr*) mutant, which has an elevated level of amylose in the starch. We hypothesized that the increased amylose content could impart unique functional properties and enhance the nutritional value of wrinkled pea flour (WPF). In this study, wrinkled pea (B99/108 and TMP15159 varieties) and round pea (CDC Meadow and CDC Golden varieties) seeds were provided by the Crop Development Centre at the University of Saskatchewan, both of which were grown in two locations in Saskatchewan, Canada. The harvested whole seeds were milled to pass through a 0.4-mm or 1.0-mm screen to prepare WPF and round pea flour (RPF). Total starch contents of WPF (25.4-29.4%, dry basis, db) were significantly lower than those of RPF (46.0-51.2%, db), while the starches in WPF consisted of more amylose (69.9-73.6%) than those in RPF (34.7-39.0%). The increased amylose contents of starches in WPF elevated their gelatinization temperatures. Under normal pasting conditions (holding temperature = 95°C), WPF exhibited negligible viscosities; however, obvious viscosity development was observed when WPF was pasted under high temperature conditions (holding temperature = 110°C-140°C). WPF showed the highest final viscosity at the heating temperature of 130°C compared with 120°C of RPF, which could be attributed to the differences in gelatinization temperature and starch content between WPF and RPF. Coarse WPF and RPF (particle size ≤ 1.0 mm) displayed lower peak viscosities compared with their fine counterparts (particle size ≤ 0.4 mm), which could be explained by the fact that the larger particle size restricted the swelling of starch granules. In addition, WPF showed significantly lower contents of rapidly digestible starch (17.5-21.9%), larger dietary fiber contents (21.8-28.3%), and greater protein contents (25.4-29.6%) in comparison with RPF (39.0-44.2%, 14.3-18.7%, and 21.3-24.7%, respectively), indicating more desirable nutritional quality of WPF. However, particle size did not show clear trends on the nutritional profiles of WPF and RPF. This research demonstrated that wrinkled pea could be a promising crop to generate new pea flours with distinct functional characteristics and enhanced nutritional value.

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

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Baked cereal items undergo degradation post processing and during storage. The type and extent of degradation is related to the product's water properties, formulation, processing, and storage conditions. Current bakery items have consistently shown signs of physical, chemical, and sensory degradation during storage and fielding which has resulted in decreased acceptability. Water activity measurements are temperature sensitive. Both the AOAC official method 978.18 and ISO 21807 require measurements at 25°C. However, the military requirements mandate 3 years storage at 26.7°C and 6 months storage at 37.8°C; additionally actual storage temperatures could be as high as 48.9°C. This effort showed a_w measured at the required temperature and actual storage temperatures where different. These differences may have adverse effects on safety, eating quality, and overall acceptability of extended shelf life bakery items. In one study shelf-stable brownies, cornbread, and two types of cookies were commercially processed and packaged in poly trays. The cornbread had a target $a_w < 0.86$, while the other bakery items had a target $a_w > 0.89$. Samples were equilibrated and measured at four different temperatures. In another study, isotherms were generated at three different temperatures for in-house/commercially produced shelf-stable items, including cornbread, yellow cake, and chocolate cake. The items were packed in a poly tray (PT) or institutional size pouch (ISP). Samples were stored for 4 weeks at 48.9°C and 6 months at 37.8°C. For both studies, a_w, pH, mechanical texture, color, and sensory analysis were conducted initially and after storage to determine the effects of formulation packaging. Results show a_w shifts were observed for all products. The direction of the shift was due to temperature, product type, and packaging type and indicates changes in moisture binding. The cornbread a_w was 0.818, and 0.856 for 25.0°C and 48.8°C, respectively. This increased shift can adversely affect product safety, since it created an environment that can support microbial growth. The brownie a_w was 0.862, and 0.826 at 25.0°C and 48.8°C, respectively. Though this shift did not affect safety, it did affect eating quality. Generated isotherms verified a_w shift and can be used to predict a_w of items stored at various

temperatures, not the recommended measurement temperature. Isotherms can be a tool during development. It can identify the effects of packaging, formulation, and temperature and determine if a_w shifts take place.

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

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

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

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

Compositional and structural factors of coat and cotyledon tissue of red kidney beans (*Phaseolus vulgaris*) from different varieties and growing locations

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Dried beans (*Phaseolus vulgaris*) have long been a part of human diets; they are a rich source of dietary fiber, protein, antioxidants, minerals, and B-vitamins. They also reduce the risk of diet-related chronic disorders such as obesity, type 2 diabetes, and cardiovascular disease. Therefore, its consumption and importance in the diet is on the rise. In this work, we aim to identify the compositional and structural factors responsible for bean processing and nutritional quality. To do so, 19 samples from different varieties of dark red kidney beans harvested at two different locations were studied in this project. Whole beans were characterized for bean size, seed coat to cotyledon ratio and thickness (SEM), micropyle and hilum size (SEM), water-holding capacity, and ash content. In addition, the seed coat was isolated and analyzed for pectin, protein, and phenolic fractions, namely extractable polyphenols (EPP), non-extractable hydrolysable polyphenols (HPP), and non-extractable proanthocyanidins (NEPA). Meanwhile, cotyledon tissue was analyzed for total starch, pectin, and protein content. The pasting behavior of whole bean flour was analyzed at 130°C under high pressure, to emulate cooking in cans, with the new RVA 4800. RVA and water-holding capacity were performed with and without calcium to evaluate the ability of pectin to form insoluble pectates that affect cooking quality. The growing location had a great influence on the protein content in the cotyledon and, consequently, on the total starch content. Pectin and ash content, pasting properties, and microstructural features were all affected by both location and variety. Mechanistic information about the cooking quality of beans was obtained through soaking and cooking experiments. Coat characteristics such as coat to cotyledon ratio, coat thickness, micropyle, and hilum size were determining factors in the soaking behavior (water absorption capacity) of beans. On the other hand, bean size and the pasting properties at 130°C were the most important factors to consider for effective cooking as they affected swelling ability. Interestingly, bean coats contained high amounts of EPP, HPP, and anthocyanidins. This work provides compositional and structural information for the selection of beans for manufacturing premium bean-based food products.

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

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Amylose (AM) and amylopectin (AP) have been reported to contribute to gel properties through the formation of AM-AM, AP-AP, and AM-AP physical junction zones (PJZ) during retrogradation. However, the influence of each of these interactions on the formation of structurally driven slowly digestible starch (SSDS) has not been studied, since both AM and AP were usually present in the starch samples. This understanding is especially interesting for sago and banana starches, which were previously reported to be highly prone to form SSDS. In this work, for the first time, mechanistic information on the retrogradation and digestion behavior of sago (21.4% AM) and banana (30.4% AM) retrograded starches is provided in the presence and absence of AM. These results were compared to those from commercial maize (33.8% AM) and potato (17.4% AM) starches, and their waxy counterparts. Starch retrogradation behavior was assessed by thermal and rheological methods during 7 days of storage. The molecular fine structure and the hydrodynamic radius (Rh) of AM and AP were also analyzed (HPSEC-RI). In general, the absence of AM led to an increase in the total amount of amylopectin re-associations (DSC) and a decrease in the elastic modulus development (G') of gels during storage, which is logical considering the higher amount of AP and absence of AM, respectively. Interestingly, these events did not occur in potato starch, whose waxy counterpart exhibited a lower enthalpy for retrograded AP and higher G' development. Among AM-containing samples, G' at 85°C of gels after 7 days of storage were significantly lower for potato, confirming the lower propensity of potato AM, with significantly higher degree of polymerization (1,650 DP) than the rest of the AM with DP ranging from 840 to 1,316, to participate in AM-AM interactions and contribute to PJZ that build gel structure. In terms of digestibility, maize and potato starch exhibited a decrease in digestion profile through retrogradation that was relatively similar in presence and absence of AM. Nonetheless, AM-free banana, and especially sago starches, displayed a dramatically higher reduction in digestion profile compared to their AM-containing counterparts. This occurrence could indicate that 1) AM of banana and sago does not intervene in the formation of SSDS and/or; 2) that AP from banana and sago could intrinsically form AP-AP interactions that are highly prone to form SSDS. This work provides unique understanding on the interplay of AM and AP to form SSDS and contribute to gel texture.

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

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

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

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

An advanced kilning system for the processing of oat flakes

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

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

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

New model to predict baking volume

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The quality of baked products is determined by the baking volume, which is influenced by different parameters, such as humidity, protein content, as well as the activity of various enzymes. Baking volume is used as the ultimate qualifier, since there is no sufficiently reliable quantitative qualifying method for predicting the outcome of the baking process at an earlier stage. However, the decision on which flour will be used and which technical additives have to be added and in which amounts needs to be taken at a much earlier point. Therefore, a good model for predicting the quality of the final product is needed to increase quality and decrease costs, as well as means of mediating the baking process in due time as a result of such model. The ultimate purpose served would be achieving better overall control of the baking process – from grain to bread. We looked at endogenous enzyme activity in different flours as well as in various additives, such as malts and bread improvers. With a high-throughput enzymatic screening of more than 100 flours and additives, we could observe an enzyme activity pattern, which was then combined with data from traditional analysis such as the falling number, the farinograph test and protein content analysis to predict the baking volume. Using principal component analysis (PCA), we developed a prediction model, with which we can predict the final baking volume with an error rate smaller than 10%. This new prediction model will pave the way for a very precise analytical tool to improve the quality of baked products by combing traditional methods with the analysis of the endogenous enzymatic activity in raw materials.

Impacts of short-term germination on the chemical compositions, technological characteristics and nutritional quality of yellow pea and faba bean flours

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This research aimed to investigate the changes in the proximate compositions, functional properties and nutrition attributes of yellow pea (CDC Amarillo variety) and faba bean (CDC Snowdrop variety) flours as a

function of germination periods (0, 24, 48, and 72 h). Alpha-amylase activities of the yellow pea and faba bean flours gradually increased during the germination, while negligible changes were found in their chemical compositions. Soaking (0-h germination) and 24-h germination noticeably increased the pasting viscosities of the pulse flours, whereas a further longer germination duration decreased the viscosities due to the increased endogenous alpha-amylase activities. Germination effectively enhanced the emulsifying and foaming properties of both pulse flours. With respect to nutritional value, improvement was observed in the *in vitro* digestibility of starch and protein of flours after germination; the treatment, however, did not enhance the *in vitro* protein digestibility corrected amino acid scores (IV-PDCAAS). The raw and 72-h germinated yellow pea and faba bean flours were also used to replace hard wheat flour at 10% and 20% levels for bread baking. In comparison to the 100% wheat flour control, the incorporation of germinated pulse flours at both levels decreased the falling numbers and pasting viscosities. The composite flours tended to require a shorter mixing time for the optimum dough development, and the generated doughs were stickier than the control dough. In addition to the observed changes in the flour and dough properties, the bread baked from the composite flours displayed a reduced loaf volume and slice area but increased firmness. This study revealed the influence of short-term germination on the functional characteristics and nutritional profiles of pulse flours and showed the potential of using the modified pulse flours in bread baking.

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

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The grain supply chain is a complex network of various supply chain participants: farmer, grain elevator, grain processor, distributor, and end-consumer. Each supply chain participant performs several activities supporting their underlying objectives. There is growing interest in traceability in the grain supply chain, to meet business transparency needs and consumer expectations. This presentation will analyze the approach of identifying critical traceability events (CTE) and corresponding key data elements (KDE). The CTE-KDE approach is evidence-based, it identifies and documents activities performed by each supply chain participant then assigns a set of information items to each critical event as KDE. For example, storage of grain is identified as a CTE performed under grain elevator, the necessary KDE will include location of storage bin and supplier details. Also, the CTE-KDE approach is specific to traceability objectives. Some of the examples of traceability objectives are (i) documenting chain of custody; (ii) protecting brand integrity; (iii) meeting customer demands; (iv) ensuring fair global trade; (v) recording sustainability of processes across the supply chain. The CTE-KDE approach requires verifiable data, and an ability to assess graduated levels of success based on data. Data amount and quality is often the weakness of software-driven traceability systems. This paper proposes the use of vulnerability analysis to predict levels of success in a given CTE-KDE situation. A vulnerability analysis model identifies, quantifies, and prioritizes the various factors responsible for reducing the efficacy of a system. Vulnerability analysis measures system attributes (data) relating to (i) frequency of occurrence; (ii) degree of impact of occurrence; and (iii) likelihood of detection. This paper applies vulnerability analysis as a standard method for identifying when and how a traceability system will fail. Vulnerability analysis of an evidence-based CTE-KDE framework accounts for complex interactions among supply chain participant's critical activities. The need for standard measures of evaluating traceability systems is clear. Such an analysis must restrict critical traceability events to be measurable events and key data elements to measurable system attributes.

Drying methods affect physicochemical and functional properties of quinoa proteins

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Quinoa as an emerging ancient grain is becoming more attractive for various food uses, and this is partially attributed to its high protein content, great amino acid profiles especially rich in lysine and histidine that are deficient in most cereals, wide range of minerals and vitamins, and good proportion of omega-6 fatty acids. Quinoa protein could also be a potential food ingredient with broad applications. The objective of this study was to investigate the effect of different drying methods, namely freeze-drying, spray-drying, and vacuum-drying on physicochemical and functional properties of quinoa protein isolates. Quinoa protein was extracted from flour through alkaline extraction (pH 10) and acid precipitation (pH 4), neutralized, and dried with different methods. Critical protein functional properties including solubility, water/fat binding, gelation, emulsification, and foaming properties were tested. Protein physicochemical characteristics including amino acid composition, surface hydrophobicity, sulfhydryl/disulfide content, SDS-PAGE profile, secondary structure, thermal stability, and AFM morphology were also evaluated. Freeze-dried protein exhibited the highest emulsification capacity and stability and oil-binding capacity due to its higher surface hydrophobicity, while spray-dried sample had the highest solubility and water binding capacity at pH 7. Freeze-dried and spray-dried proteins demonstrated better foaming stability than vacuum-dried sample. The color, protein content, and particle size of freeze- and vacuum-dried proteins were similar, while spray-dried sample had significantly smaller particle size and lower protein content. Freeze-dried protein had the highest denaturation temperature but lowest enthalpy, which may be

caused by its higher percent of random coil and lower percent of alpha-helix and beta-sheet structures. In addition, gels (8%) prepared with freeze-dried proteins had higher elastic and viscous modulus than that from spray- and vacuum-dried samples. Overall, quinoa protein demonstrated good functional properties, which could be further manipulated through drying methods.

Prediction of bioactive composition in soybeans using NIR

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Isoflavones and saponins are major classes of bioactives in soybeans that have been linked to cancer prevention and control. Rapid analytical techniques are needed to estimate their levels in soybeans as they arrive at the grain elevators and processing plants. We are evaluating NIRS as a suitable, rapid, nondestructive method to determine isoflavone composition in ground soybeans. Soybean samples (N > 3,000) were obtained from the Agricultural Research Service soybean germplasm collection, and from several locations in United States over a five year period. The soybean samples were ground and scanned on near infrared spectrometers (NIRS) and analyzed by wet chemical methods for total isoflavone composition (genistein, daidzein, and glycitein), and total saponin composition (A group-, B group-, and DMPP group). A subset selection of these samples was used to prepare NIRS calibrations. Selected preprocessing algorithms were applied to spectral data to minimize/eradicate noise or disturbance in the spectra. Partial Least Squares (PLS) regression analysis of preprocessed spectral data and wet chemistry data were used to develop models to predict individual sugars. The selection of a suitable calibration model was based on a high regression coefficient (R^2) and lower standard error of calibration (SEC) values. Optimized PLS regression models were then used to predict validation sets. Reasonable predictions were obtained for isoflavones; however, less than robust calibrations were obtained for the total saponins.

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

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The objective was to evaluate the impact of a wide variation in amylose content (~2-60%) in the same genetic background on semolina properties, pasta quality and in vitro/in vivo starch digestion. Using a common genetic background, durum wheat Svevo was manipulated using TILLING and crossing with donor lines to produce genotypes with amylose content varying from ~2-60%. Grain was milled into semolina and evaluated using AACC and Megazyme methods for protein, color, resistant and total starch, and amylose, while dough was evaluated with mixograph and glutopeak. Spaghetti was made on 1 kg scale and evaluated using AACC methods. In vitro starch digestion of pasta was measured using pepsin/α-amylase/amyloglucosidase method. Glycemic index was measured on 10 subjects using established method of University of Sydney (SUGiRS). The high-amylose (>40%) lines (HA) had lower grain weight and starch content with higher protein content. The HA types (40 and 60% amylose) tended to have weaker dough based on mixograph and very low (~2% amylose) and high-amylose genotypes had higher dough water absorption. The HA genotypes had lower cooking times and higher cooking loss compared to Svevo control (33%amylose), while the low amylose (~2%) made stickier and softer pasta. All lines had lower pasta firmness corrected for protein content relative to Svevo showing an optimal level of amylose influences pasta. However, resistant starch was increased in HA lines (7.4 vs. 0.7%) with other benefits such as a lower extent and rate of *in vitro* starch digestion. Human glucose tolerance tests indicated that an amylose content above ~45% is needed to lower pasta GI. Details of the relationship between amylose content and these properties will be presented. This is the first report of the impact in a common durum wheat background of a wide range in amylose content on pasta and dough quality together with in vitro and in vivo starch digestion comparisons. This information will be useful to the cereal grain community.

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

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Micronutrient malnutrition, especially vitamin A deficiency, is a major health concern in South Africa (SA). Biofortification of crops could be a more effective and sustainable approach for improving the nutritional status of vulnerable groups. However, due to their undesirable sensory properties, most biofortified foods, especially maize, have been found less acceptable compared to non-PVA-biofortified counterparts. Consumer acceptability and nutritional composition of PVA-biofortified foods could be improved by complementing them with other commonly consumed food items to produce modified traditional dishes. The study objective was to determine the effect of replacing commonly consumed white maize and cream-fleshed sweet potato (CFSP) with PVA-

biofortified maize and orange fleshed sweet potato (OFSP), on the nutritional composition of traditional dishes in KwaZulu-Natal, SA. The dishes studied were *phutu* (crumbly maize porridge) prepared with PVA-biofortified maize meal and served with either curried chicken, cabbage or bambara groundnut, and boiled orange-fleshed sweet potato (OFSP). The nutritional composition of uncooked and cooked foods samples were determined using the Association of Official Agricultural Chemists (AOAC) method, van Soest method and the central analytical facilities (CAF) HCI hydrolysis method. Before nutritional analysis, uncooked and cooked food samples with a high moisture content were freeze-dried. Two replicates of each sample were analyzed. Nutritional analysis results showed significant ($P < 0.05$) differences in mean PVA content across the dishes containing PVA maize and each sample had a higher mean PVA content than its control. Generally, amino acid and mineral content varied significantly across the food samples containing PVA-biofortified maize. The samples containing PVA *phutu* combined with either curried chicken or cabbage had a lower mean content of the essential amino acid lysine when compared with their controls. The mean total mineral (ash) content was higher in samples containing PVA-maize relative to their controls ($P < 0.05$). The OFSP had a low protein content (4.51 g/100 g) compared to the CFSP (6.38 g/100 g) but had higher fat and mineral content. PVA content (55.84 µg/g DW) was higher in OFSP than in the control (CFSP) (0.77 µg/g DW). OFSP and PVA-maize *phutu* when combined with other foods, such as curried cabbage, chicken, or bambara groundnut, have the potential for improving nutrient intake and dietary diversity of rural communities in KwaZulu-Natal.

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

A 100 g lab scale corn dry milling protocol for faster determination of coproduct yield and composition
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A new 100 g lab-scale corn dry-milling protocol has been proposed for quick determination of coproduct yield and their composition analysis. Not only the proposed protocol facilitated reliable estimation of corn dry-milling characteristics using only one tenth of the material used in the existing 1 kg protocol, it also generated commercial-sized flaking grits. Ten corn cultivars including yellow dent, colored, and white varieties were milled, producing six different coproducts. Compositional characteristics of corn kernels and generated coproducts were ascertained and compared with their corresponding commercial samples. The corn kernel moisture content was increased to 23.5% (wb) by tempering in a vessel and the tempered kernels were passed through a custom-made lab-scale degerminator. Six coproducts (large, medium, and small grits, fines, germ, and pericarp) were separated using a series of sieving and aspiration operations. The use of roller mill in the separation process was completely avoided, resulting in the recovery of true commercial-sized flaking grits, which wasn't possible in the existing 1

kg lab-scale dry-milling protocol. The coefficients of variability for coproducts generated from 12 milling runs were determined for large, medium, and small grits (<3.62%), fines (9.64%), germ (3.60%), and pericarp (6.22%). The crude oil content of large and medium grits from hard endosperm varieties of yellow dent corn was <1.1% (db). The crude protein and crude oil content of colored corn varieties were higher compared to the yellow dent varieties. The variations in coproduct composition and yields were mainly due to hybrid effects. Absolute density (r = 0.89) and test weight (r = 0.85) were found to be positively correlated with overall large grits yield, while crude protein and crude oil content were also found to be mutually correlated (r = 0.79). Using proposed protocol, coproduct yield was estimated with low standard deviation with respect to means. This new protocol will be helpful in ascertaining dry-milling characteristics of corn cultivars in a shorter time frame with smaller sample sizes.

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

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

Influence of particle size on the flow properties of bread flour

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Differences in the particle size has been found to influence the physical, chemical, and flow properties of flour. The research is focused to study the effect of particle size on the flow properties of hard wheat flour. Hard red winter (HRW) and hard red spring (HRS) wheat flours were sieved to three different fractions: <45 μm, 45–106 μm, and >106 μm. The samples were evaluated for physical (shape, bulk density, tapped density, true density, and angle of repose), chemical (proximate analysis), and flow (dynamic, bulk, and shear) properties. Bulk density of the fractions increased with increase in particle size; as was the tapped density. Highest value for angle of repose, 45.32° was reported for HRW 1 (i.e, <45 μm) followed by HRS 1 sample (44.42°). Bulk and tapped density of the powder were correlated to Hausner ratio (HR) and compressibility index (CI) to represent the flow parameters. HR of the fractions varied from 1 to 1.22. Samples with particle size <45 μm had relatively higher values of CI. These (HR and CI) flow indices indicate "excellent" flow characteristics to the fractions with larger particle size. The shape characterized by circularity (0.775-0.807) had no significant variation (P > 0.05) among particle sizes. Results indicated that HRS samples were more elongated than HRW samples. The flowability represented in terms of basic flow energy, stability index (SI), flow rate index (FRI), specific energy (SE) and conditioned bulk density varied across the particles. SI, SE, and FRI of HRW 1 samples were 1.14, 11.87, and 1.43, respectively; higher than the counterparts. HRW 1 also reported the maximum wall friction of 24.05° among samples. Flow function (ratio of major principal stress to ultimate yield strength) varied significantly (P < 0.05) among the flour fractions. The HRW(S) 3 were classified as "easily flowing" powder whereas HRW 1 samples were "very cohesive" as per the categorization based on flow function. HRW 1 samples also had higher values for cohesion and angle of internal friction. This indicates the potential for bridging/arch formation during discharge of the HRW 1 powder. In general, cohesion, ultimate yield stress and angle of internal friction of HRW samples were higher than HRS samples.

Development of improved method to measure maltose value of wheat flour

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Maltose value (MV) is reduced sugar content produced by amylase in a wheat flour under conditions of pH 4.6-4.8 and converted to maltose. The value is used as the ability to supply reduced sugars from wheat flour during dough fermentation, especially for sponge-dough method. The conventional method defined by AACC Method 22-15 is complicate procedure and uses several poisonous reagents during quantitation by titration. So we aimed to develop a new quantitative method to improve efficiency and safety. In the improved method, 100 mg of wheat flour was suspended in 1 mL of acetate buffer (pH 4.6-4.8) and stood at 30°C for one hour. After centrifugation (2,000 g, 5 min, 5°C), alpha-glucosidase (from yeast) was added to the supernatant, and reduced sugars were

degraded to glucose. The degraded glucose was quantified by a colorimetric method using glucose oxidase/peroxidase (GOPOD) reagent and converted to maltose. In several wheat flours with a wide range of MV (about 50 to 300 mg/10 g), the relationship between measured values of each method showed a good correlation ($n = 73$, $R^2 = 0.986$), and the improved method gave same values as the AACC method; the average of differences between each method was 1.2 mg/10 g. Moreover, each repeatability precision was equivalent; the AACC method was 1.3% (relative standard deviation, RSD%), while the improved method was 1.4% in the five pair measurements of hard wheat flour (MV about 250 mg/10 g). Since the improved method shows same value and precision as the AACC method, could have the possibility of saving time and labor, and reduce the use of poisonous reagents, this study will contribute to efficient and safe work of analyzing MV for wheat flour quality control.

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

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

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

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

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

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

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

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

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

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

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

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

Effect of chemical oxidizers and enzymatic treatments on dough rheology

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

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

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Dry pea (*Pisum sativum* L.) is a notable pulse crop for fulfilling gluten-free requirements to fortify cereal-based foods. However, pea flavor restricts the utilization of pea flour in the food market. Therefore, a green technology, supercritical fluid extraction (SFE), was employed as a deodorization method to improve sensory attributes of pea flour. Optimum extraction conditions (ethanol at 22%, temperature at 86°C, and pressure at 6,195 psi) were significantly ($P < 0.05$) obtained using response surface methodology. The three-particle sizes (>250, >150, and >106 μm) of pea flour were separated using a sieving system and flavor intensity was differentiated by trained sensory panelists. The effects of particle size along with the extraction system on the flavor of pea flour were

investigated using multiple approaches, which were a gas chromatographic (GC) system, a GC-olfactometry (GC-O) system, and sensory analysis. The total volatile contents of un-extracted and extracted whole, >250, >150, and >106 μm flours were 18.1, 7.7, 7.1, and 10.4 ppm and 0.6, 0.7, 0.9, and 1.0 ppm, respectively by the GC system. 1-Hexanol, 1-heptanol, 1-octen3-ol, 1-octanol, 1-nonanol, nonanal, and an alkyl pyrazine were found as major off-aroma compounds in un-extracted pea flour. The SFE system significantly ($P < 0.05$) extracted those compounds from the pea flour at the optimum conditions and further reduced bitterness compounds. Increasing particle size for unextracted and extracted pea flours resulted in less off-aroma compounds based on the GC analysis, but this result did not follow the same pattern as the sensory analysis. The trained sensory panelists stated that nonextracted and extracted larger particle size flour had significantly ($P < 0.05$) higher pea intensity and bitterness than smaller particle size flour. The trained panelists for the GC-O system mostly identified the off-aroma compounds in un-extracted pea flour compared to the extracted pea flour. This research showed that the SFE could be an acceptable method for removing off-flavor from pulse flour. Additionally, different particle sizes impacted the flavor attributes of pea flour; therefore, considering particle size would be useful for improving the sensory quality of pulse flour.

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

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Dry pea (*Pisum sativum* L.) flour is a high-value ingredient for incorporating into cereal-based foods for nutritional enhancement and for producing gluten-free foods. However, its undesirable flavor limits its usage in food market. To address this flavor issue, a novel and green approach, supercritical carbon dioxide + ethanol ($SC\text{-}CO_2$ + EtOH) extraction was used as a deodorizing method to improve organoleptic property of pea flour. Additionally, pea flour with different particle sizes (approximately 250, 150, and 106 μm) were investigated to illustrate their impacts on physicochemical properties. Physicochemical properties of pea flour samples, including two main effects (extraction and particle size), were investigated using approved official methods, Megazyme kits, rapid visco analyzer, and colorimetry. The flours had moisture, ash, protein, and lipid contents (%, d.b.) between 2.09 and 10.1; 2.60 and 2.81; 20.84 and 26.51; and 0.42 and 1.92, respectively. Furthermore, total starch, resistant starch and damaged starch contents (%, d.b.) were between 34.97 and 55.37; 0.56 and 2.99, and 0.25 and 1.99, respectively. The extraction caused the reduction in moisture, resistant starch, damage starch, and lipids and proportionately increased total protein content. The extraction did not damage starch further. Water soluble index was significantly reduced for flours of different particle sizes, indicating that extraction had an adverse effect on protein solubility. The flour samples became lighter in color after the extraction due to removal of carotenoids present in pea flour. The flour with the largest particle size had significantly lower protein, total starch, and damage starch than flour with smallest particle size. The flour with particle size around 150 μm had the highest protein content while the flour with the finest particle size had the highest total and damage starch. Pasting properties of eight pea flours were also varied. After the extraction, the pasting temperature of flour samples increased slightly and decreased based on particle size. However, pasting time tended to increase after treatment. All viscosity parameters (e.g., breakdown, setback) of the flour with the finest particle size decreased significantly with the extraction but increased for the flour with the largest particle size. The $SC\text{-}CO_2$ + EtOH extraction along with different particle size flours caused differences in physicochemical properties of flour samples. Thus, these results support the use of treated flours in lower viscosity applications compared to non-extracted pea flour.

Analysis of amaranth leaves and seeds grown in Puerto Rico

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Amaranth seed has long been used in food products for human consumption in Central and South America, but information is lacking on the chemical composition of leaf and seed of *Amaranthus cruentus* L. or *Amaranthus viridis* L in Puerto Rico. The objective of this study was to develop an amino acids profile, and determine crude protein, dietary fiber, total fat, starch, and mineral (calcium, magnesium, phosphorous, potassium, iron, and zinc) concentrations on 3-week old leaves and mature seeds of field grown *A. cruentus* (Juana, Aurelia, Elena) and *A viridis* (Callaloo). Compositional analysis was completed using AOAC, AACCI, and AOCS official methods. Harvested leaves were dried in a forced air oven at 65°C for 72 hours, and ground in a Wiley mill. Seeds at physiological maturity (15-weeks) were harvested, dried, and ground for analysis. Data was analyzed using SAS statistical program and when means were significant were separated using Tukey's test. Lysine content of both *Amaranth* species was high. There were significant differences ($P < 0.05$) in crude protein (CP) in leaves with Elena (23%) and Aurelia (21%) having higher percentage CP, but among amaranth seeds (19%) there was no significant differences. Among amaranth leaves, there were significant ($P < 0.05$) differences in IDF and TDF, while amaranth seeds differed significantly ($P < 0.05$) for IDF, SDF, and TDF. While, total fat and starch in the

seeds were not significantly ($P < 0.05$) different. Calcium, Mg, and P concentrations differed significantly ($P < 0.05$) in their leaves, but Fe, K, and Zn, did not. Among amaranth seeds there were significant ($P < 0.05$) difference for Ca, Mg, Fe, and P. This study demonstrates that amaranth leaves and seeds are an excellent source of nutrients, with Elena and Aurelia having higher CP in their leaves.

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

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

Characteristics of air-classified fractions from various pea varieties

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

Bioactive components and antioxidant capacities of Tibetan hulless barley cultivars

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In this study, the bioactive components (phenolics, flavonoids, beta-glucans, and gamma-aminobutyric acid) and antioxidant capacities (DPPH radical scavenging capacity, ABTS radical scavenging capacity, and Ferric ion-reducing antioxidant power) of 25 Tibetan hulless barley cultivars were determined and compared, including 4 two-rowed white hulless barley (TWHB), 9 six-rowed white hulless barley (SWHB), and 12 six-rowed purple hulless barley (SPHB). The content of total phenolics, total flavonoids, beta-glucans and gamma-aminobutyric acid varied between 1.74-3.17 mg of gallic acid equivalents per gram of dry weight (mg, GAE/g, DW), 0.50-1.49

mg of rutin equivalents per gram of dry weight (mg, RE/g, DW), 4.31-8.15% of dry weight and 12.78-43.00 mg per 100 g of dry weight. The highest average contents of total phenolics (2.7 ± 0.52 mg GAE/g DW), total flavonoids (1.12 ± 0.39 mg RE/g DW), beta-glucans (6.54 ± 0.31%) and gamma-aminobutyric acid (29.79 ± 12.81 mg/100 g, DW), as well as the highest average level of antioxidant capacities were measured in two-rowed white hulless barley. The correlation analysis showed that the phenolics and flavonoids were the contributors to the ABTS radical scavenging capacity and FRAP antioxidant capacity; the flavonoids were the main contributors to the DPPH radical scavenging capacity. Results showed that Tibetan hulless barley, especially the two-rowed white hulless barley, was the potential sources of phenolics, flavonoids, beta-glucans, and gamma-aminobutyric acid, which suggested Tibetan hulless barley could be used as food ingredients.

Bioprocessing of wholegrain sorghum for improved sensory perception of bread

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There has been a robust growth of the global sorghum market in the last decades. Sorghum has a positive health image and is commonly consumed as wholegrain (WG). However, the utilization of sorghum in food production is challenged by the sensory characteristics. In bread production, for instance, above 20% of sorghum flour substitution results in undesirable attributes such as darker crumb color, lower volume, harder texture, and intense bitter taste. Bitterness in sorghum is caused by phenolic compounds present in the out layer of the grains. Microbial bioprocessing is a potential 'clean label' strategy to improve the texture, nutrition, and sensory quality of WG sorghum bread. The bioprocessing can be tailored to produce functional metabolites such as enzymes, acids, and dextrans. The enzymes and acids produced may result in modification of nutrients and flavor-active compounds. Dextrans are texture-enhancing polymers, which increase the dough strength and bind water, resulting in increased volume, moist mouthfeel, and crumb softness. Furthermore, the presence of dextran might also affect the magnitude of flavor perception of the bread due to the intensive texture modifications. The aim of this research was to study the impact of bioprocessing with dextran production on flavor and texture perception of sorghum-wheat (ratio 50:50) bread. The flavor and texture profile of the breads were evaluated by a trained sensory panel (n = 17). The dominate taste-active compounds, such as phenolic compounds, free sugars, and organic acids, were identified and quantified of by LC-MS, HPAEC-PAD, and HPLC. The effect of dextran concentrations on the suppressing of specific flavor (bitterness and sourness) sensation of bread was determined using magnitude estimation. The results demonstrated that bioprocessing with dextran production significantly improved the texture and flavor perception of WG sorghum breads. The produced dextran significantly increased softness, cohesive structure, and moist mouthfeel of the bread compared to control. The dextran-enriched sorghum bread also showed markedly reduced intensity of sour and bitter taste. The decrease in perceived sour and bitter taste intensities was observed only when the dextran was added to the bread at a concentration higher than its critical overlap concentration (c*).

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

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

physicochemical properties of BR flour and consequently bread qualities. Furthermore, rice germinated under aerobic condition for 4 days exhibited better properties.

Genome-wide association of lipase activity in wheat for quality improvement of wholegrain products
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Quality of wholegrain wheat flour and wholegrain products is strongly governed by lipase activity (EC-3.1.1.3) found in wheat seeds. Endogenous lipase and other esterases cause lipid rancidity in wholegrain flours, which leads to adverse nutritional, sensory, and technological properties. Traditional processes to deactivate the enzymes often involve thermal treatment, which not only are energy consuming but may also decrease the nutritional value of products. Nevertheless, numerous wheat germplasm with broad genetic diversity are available. This study evaluated over 300 European wheat varieties grown in two years (2015 and 2016), within which 66 varieties were grown in an additional year (2014), at the same site with identical field management. Esterase and lipase activities in the wholegrain flour were measured photometrically with *p*-nitrophenyl butyrate and *p*-nitrophenyl palmitate as substrates, respectively. Within each year, both esterase and lipase activities showed wide ranges among all varieties, with a difference up to 3-fold ($P < 0.005$). The results suggest some varieties, such as 'Julius', 'Lona', and 'Banquet', are better suited for stable wholegrain products, as they had consistently low lipase activities in all years. Genome-wide association study (GWAS) was performed and revealed associations to single nucleotide polymorphism (SNP) located in the high quality wheat genome sequence of IWGSC (International Wheat Genome Sequencing Consortium). Four candidate genes were tentatively proposed to be associated to the lipase activity in wholegrain flour. The results are the first steps for evaluation of wheat varieties for wholegrain end use. This study offers a versatile tool to improve lipid stability of wholegrain wheat by genomics-assisted breeding methods, thereby offering new opportunities to optimize the quality of wholegrain wheat flour and wholegrain products.

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

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

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

Nitrogen and sulfur effects on winter wheat quality

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Grain protein concentration and composition are key factors in winter wheat quality. Elevated asparagine concentration in wheat flour also can lead to acrylamide production in baked food products, which can be a health concern. Asparagine concentration represents the acrylamide-forming potential of flour. And, unlike acrylamide, asparagine can be measured cost-effectively. The objectives of this study were to determine the effect of genotype, nitrogen (N), and sulfur (S) fertility on protein concentration, protein quality, dough rheology, and asparagine concentration in winter wheat. The experiment was set up in a $3 \times 2 \times 4$ factorial in 2017 and $3 \times 2 \times 5$ factorial in 2018. There were 3 levels of N (56, 101, and 146 kg ha^{-1} as urea), 2 levels of S (0 and 22 kg ha^{-1} as ammonium sulfate), and 4 levels of genotype (cvs. Everest, Fuller, Jagger, and 2137) in 2017 with an additional genotype (cv. SY Monument) added in 2018. Treatments were arranged in a split-split plot design with four replications each year. Protein composition was evaluated as the percent polymeric protein using size exclusion high performance liquid chromatography. Solvent retention capacity was evaluated using the whole grain SDS-SRC hybrid method. In both years, the ratio of polymeric to monomeric protein was increased by sulfur fertilization, although in 2017 total protein decreased due to dilution. In 2017 asparagine concentration in grain was affected by N, S, genotype, and an N by genotype interaction. Without S, Fuller and Jagger had asparagine concentrations of 20.7 to 21.0 µmol/g and Everest and 2137 had lower asparagine concentrations of 12.8 to 13.8 µmol/g ($P < 0.05$). When S was applied, asparagine concentrations declined to <3 µmol/g, and genotypes were not different from each other. In 2018 treatment effects were not significant. In 2018, S application increased SDS-SRC from 217% to 308%. Treatment effects on dough rheology were evaluated in the 2018 trial using the farinograph. Sulfur application increased average farinograph stability from 9.2 min to 14.6 min. Farinograph stability was effectively predicted by the whole grain SDS-SRC test ($R^2 = 0.78$). Sulfur deficiency is increasingly common in agricultural soils due to lack of S fertilization, increasing yields removing more S from the soil, and the Clean Air Act improving the removal of S emissions from industrial sites. Therefore, information from this study will help producers manage sulfur-deficient fields to improve grain quality and food safety while maximizing yield potential.

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

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Natural sweeteners are increasing in popularity for replacing sucrose in intermediate-moisture sweet baked goods. Sucrose is known to influence product texture by altering starch thermal properties. To guide more informed choices on which alternative sweeteners have the most similar effects to sucrose on starch thermal properties, the objectives of this study were to determine the effects of natural sweeteners and sucrose, at varying concentrations, on the gelatinization temperature, RVA (Rapid Visco Analyzer) profiles, and granule swelling of

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

Bomb calorimetry for measurement of calories and impact of product dehydration methods on caloric determination in military ration items

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Nutritional analysis for military rations has historically utilized the calculation method to determine calories in foods due to instrumentation limitations that made it technically challenging to capture all heat released in bomb calorie measures. However, new instrumentation and methods now provide consistent and rapid measures of calories in foods. Use of the bomb calorimeter is desirable to objectively assess caloric content in foods. It also allows nutrient analysis to be performed wherein total carbohydrate and ash may be calculated when the fat, protein, and moisture contents are known. Bomb calorimetry thus provides another means of performing nutrient analysis that can help laboratories capture nutrient data with minimal testing and more rapid techniques. However, since bomb calorimetry requires reduced moisture content in order to combust foods, some ration items are too wet and must therefore be dried prior to caloric assessment. In this study, various samples were dehydrated fully or to a standard moisture content using various methods to assess the impact of the drying technique on the caloric results. Dehydration methods using various food types were compared in order to determine the extent to which a dehydration method impacted final caloric results. Freeze-dried, ambient dried, 70°C vacuum-oven dried, 120°C IR-dried products such as protein shakes, puddings, meats, dairy products, pasta-based entrées, and other high water content foods were tested. Some products appear more impacted by drying methods than others. Results reported show the measured impact of drying techniques on actual caloric measures.

In situ fortification of vitamin B_{12} in wheat bran by cofermentation with *Propionibacterium freudenreichii* and *Lactobacillus brevis*

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Vitamin B_{12} is an essential micronutrient naturally existing in animal products. A growing interest and need to replace animal protein with plant protein sources have resulted in increased attention to developing vitamin B_{12}-fortified plant-based food. *In situ* fortification by food-grade microorganisms with the ability to synthesize active vitamin B_{12} is a promising alternative to chemical fortification. The present study investigated the effect of a coculture fermentation with *Propionibacterium freudenreichii* DSM 20271 and *Lactobacillus brevis* ATCC 14869 on vitamin B_{12} fortification in wheat bran. *P. freudenreichii* was used as the producer of vitamin while *L. brevis* was selected to ensure the microbial safety of the bran dough. Fermentation trials were conducted in bioreactors to monitor and adjust the pH of the ferments. Vitamin B_{12} level in the dough reached 357 ± 8 ng/g dry weight (dw) after one day of pH-controlled fermentation with *P. freudenreichii*. In cofermentation with *L. brevis,* slightly less B_{12} (255 ± 31 ng/g dw) was produced in one day and an effective inhibition of the growth of total *Enterobacteriaceae* and *Bacillus cereus* was obtained. Fermentation with *P. freudenreichii* for three days did not further increase vitamin B_{12} yield whereas in three day cofermentation the yield increased up to 332 ± 44 ng/g dw. On the other hand, without a pH control, cofermentation resulted in a stronger inhibition of *Enterobacteriaceae* and *B. cereus* growth but a lower level of vitamin B_{12} was reached (183 ± 5 ng/g dw on day 3). These results demonstrated that wheat bran fermented with *P. freudenreichii* and *L. brevis* can be a promising way to produce

vitamin B_{12} fortified plant-origin food ingredients, which could reduce cereal waste streams and contribute to a more resilient food chain.

Significance of tempering methods on white sorghum flour and baking properties

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Sorghum is a substitute cereal for celiac and gluten sensitive people. The current sorghum milling industry is medium scale and uses hammer mills to produce whole grain flour. This results in milling losses, bran contamination, and inconsistent flour quality. Appropriate tempering methods prior to roller milling could produce white sorghum flour and also improves the milling yields and flour characteristics. In this study, the effect of tempering process on flour quality and dough properties were studied. In this study, three sets of tempering methods were carried out on sorghum kernels: (i) cold (at 24°C for 24 h) at 16 and 18% moisture content (mc) (wet basis wb); (ii) hot (at 60°C for 12, 18, and 24 h) at 16 and 18% mc (wb); and (iii) steam (at 25 psi for 5, 10, and 15 s). Physical, chemical, and quality properties of flour and dough were evaluated as an effect of tempering process. The bulk and tapped density of white sorghum flour decreased significantly with increasing moisture content when treated with cold water. However, the opposite trend was observed when treated with hot water in both 16 and 18% mc (wb). The protein content of white sorghum flour did not have any significant differences when treated with cold or hot water. However, the protein content of flour produced from steam tempered kernels were significantly lower than the other treatments. Flour produced from all treatments had high brightness (L = 81.34) value. This showed that there was less bran contamination or less whole grain flour. No significant differences was observed in brightness values when the kernels were treated with cold or hot water or steam. All the flour values had close to neutral a values (a = 2.14). They did not have dominance of either red or green color. However, flour from all treatments showed high positive values (b = 12.50) demonstrating a greater yellow than blue color. A significant trend was not observed between different treatments and moisture contents in both a and b values. The maximum amount as well as good quality (low damaged starch and good protein quality) flour from the designed flow sheet was produced from white sorghum kernels treated with hot water (16% mc) at 60°C for 18 h than the other treatments. The bread quality parameters will be evaluated in the future research.

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

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

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

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There has been a strong demand for gluten-free bakery products due to increased incidence in celiac disease and gluten-sensitivity, as well as consumer's need of diverse food choices. Egg, sugar, and oil are commonly added into wheat-based bakeries to improve dough/batter rheology and product quality; however, less is known about their effects in gluten-free systems. The objective of this study was to investigate the effect of different levels (low, medium, and high) of egg white (EW, 4, 8, and 12%), sugar (5, 7.5, and 10%), and oil (4, 8, and 12%) on gluten-free batter properties and bread quality. Commercial gluten-free flour comprising of potato starch, tapioca flour, sorghum flour, and bean flours was used as the base flour. Batter properties were characterized using a rapid visco analyzer (RVA) and oscillation rheometer. Bread quality attributes, including baking loss, specific volume, color, moisture content, crumb structure, texture, and staling, were determined. Effects of bread formulation on the formation of melanoidins and bread antioxidant capacity were characterized using a spectrophotometer. Adding EW, sugar, and oil decreased batter RVA viscosities and altered batter viscoelasticity. Increasing the amount of EG and sugar greatly increased bread specific volume. Larger number of cells and much evener crumb cell structures were achieved with EG, sugar, and oils. Although adding sugar, oil, and EG did not affect the amount of starch retrogradation, the retrogradation peak temperature was slightly increased based on DSC results. Bread melanoidin content and antioxidant capacity were also affected by bread formulations. This study will benefit the development of better quality gluten-free bakery products.

Effects of drying temperature and relative humidity on the quality properties of Chinese dried noodles

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Drying process is the last and key step in Chinese dried noodle (CDN) production and has a substantial influence on noodle quality. In order to improve the drying process and product quality, an attempt has been made to investigate the influence of drying temperature and relative humidity on the quality properties of CDN. Wheat variety Yongliang 4 was used to make CDN in laboratory, and relative properties were evaluated. The experiment was designed with two factors at three levels for the drying conditions: 300 minutes for drying with varying temperatures (40°C, 60°C, and 80°C) and relative humidities (65%, 75% and 85%). The results showed that the relative humidity had the greatest impact on the quality characteristics of dried noodle products followed by temperature and factor interaction. Compared with the conventional drying method (40°C, 75%), high temperature and high humidity drying process (85°C, 85%) contributed to a slight decrease in the L^* value of CDNs, a slight increase in the a^* value, and a significant increase in the b^* value, the bending strength, breaking distance, and breaking work of CDNs. Relative humidity was the main factor that affected the density of CDNs. The high temperature and high relative humidity environment increased the density of the products. The drying temperature was the most important factors affecting the quality of cooked CDNs, followed by factor interaction and relative humidity. Compared with the conventional drying process, the optimal cooking time of CDNs dried by high temperature was significantly prolonged, and the cooking loss rate was increased. The cooking absorption rate was the highest when CDNs being dried at high temperature and low humidity (80°C, 65%). Compared with the conventional drying process, the hardness, adhesiveness, gumminess, and chewiness of cooked CDNs dried by high temperature and high relative humidity were increased, while the elasticity, cohesiveness and resilience were significantly reduced. Temperature and relative humidity have significant effects on the qualities of dried noodles and noodles after cooking. In the actual drying process, the influence of temperature and relative humidity on CDNs should be comprehensively considered.

Effect of peeling on milling of hull-less barley and the nutritional quality of barley flour

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In the process of hull-less barley milling, it is desirable to obtain a flour with good sensory quality and low nutrient loss, but they always exist in a contradictory form. In this study, the distribution of dietary fiber and beta-glucan in different layers of hull-less barley and their influence on the yield of barley flour were investigated. The results showed that, with a 20% peeling rate, it can obtain better milling characteristics. Compared with flour prepared without peeling, the flour yield increased by 23%, the content of beta-glucan of barley flour increased by 79%, soluble dietary fiber (SDF) increased by 7%, and insoluble dietary fiber (ISDF) decreased by 15%. The effects of two kinds of highland barley flour, which are obtained from peeled barley with 80% of the yield flour and unpeeled with 65%, on the quality of barley noodles (adding 50% barley flour) also were investigated. There was no significant difference in sensory quality between the two kinds of barley noodles. In the process of barley milling, the treatment

of peeling can improve the nutritional and yield of barley flour without reducing the quality. This study provides a new idea for barley milling and hopes to promote the further development of grain science.

A novel starch crop contains more resistant starch after cooking

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

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

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