2018 Cereals & Grains Meeting Abstracts

Abstracts submitted for presentation at the 2018 Cereals & Grains Meeting in London, U.K., October 21–23. Abstracts are published as submitted for citation purposes. They have not been edited by editorial staff. Please send questions or comments to info@cerealsgrains.org.

The recommended format for citing annual meeting abstracts, using the first abstract below as an example, is as follows: Graf, A. The pathway for novel protein ingredients from cereal side streams. (Abstr.) Cereal Foods World 63:A1, 2018. DOI: https://doi.org/10.1094/CFW-63-6-0281

The pathway for novel protein ingredients from cereal side streams
A. GRAF (1)
(1) Südzucker AG, Obrigheim, Germany

Proteins greatly contribute to textural, sensorial and nutritional properties of food products. The application of protein ingredients in food products therefore requires specific techno-functional properties which determine the behavior in food systems during preparation, processing, storage and consumption. The development of novel proteins from cereal side streams require elaborated processing concepts. The impact of processing technologies and conditions on structural and functional changes of proteins need to be taken into account. Extraction and concentration of plant-based proteins from side streams is often challenging as the proteins are entrapped within complex plant structures. The potentials of enzymatic processing are illustrated with the following two examples: 1) In cereal rice processing, the endosperm protein separated from granular starch and fibers by extracting with harsh alkaline media. Solubilized proteins are afterwards aggregated at slightly acidic pH. Thus, the resulting product possesses poor techno-functional properties limiting the area of food applications as protein ingredient. Enzymatic approaches and process concepts for subsequent modification of aggregated rice endosperm protein are presented with the goal to induce functionality. Parameters like solubility, foaming and emulsification as well as texturizing properties are within the scope. 2) Wheat bran accumulates in huge amounts as a by-product of starch and bioethanol production. The protein amino acid spectrum is more balanced in comparison with gluten protein indicating a high nutritional quality. The digestibility of bran proteins is hindered by aleurone cell walls acting as a barrier to digestive enzymes. It is less suitable as protein source in food application and therefore mainly used as animal feed or burnt for energy production. Mild enzyme-aided extraction concepts offer the opportunity for extraction and concentration of the wheat bran protein. Cell wall degrading enzymes facilitate modification of the complex bran matrix and make proteins better accessible. The use of proteases improves protein solubilization and enhances the protein extraction.

Recycling waste bread into a sugar-rich syrup: Potential value-added ingredient for new bakery products
N. Rosa-Sibakov (1), H. Nihtilä (2), M. Siika-aho (1), E. NORDLUND (1), K. K. Katina (2)
(1) VTT Technical Research Centre of Finland Ltd., Espoo, Finland; (2) University of Helsinki, Helsinki, Finland

The conversion of bakery waste into sugar-rich syrup has a good potential to recycle bread waste into a value-added ingredient. The aim of this work was to develop a syrup rich in glucose/maltose by enzymatic hydrolysis of waste bread and to evaluate the use of this syrup on the properties of new bread. The waste bread used was mainly composed of white wheat flour (70% starch). A set of commercial food-grade enzymes (alpha-amylase, amyloglucosidase, maltogenic amylase and protease) were selected and screening trials were performed to find out potential parameters conditions (i.e., bread particle size, slurry concentration, reaction time and enzyme dosages). The sugar profile of the liquid fraction (syrup) was characterized by HPAEC-PAD. Bread was efficiently hydrolysed into glucose or maltose by using suitable amyloytic enzymes. The best dosage of enzymes, i.e. combination of alpha-amylase (50 mg/kg bread) and amyloglucosidase (2,500 mg/kg bread), efficiently hydrolysed starch from bread up to 88% sugars/starch (mainly glucose was produced). A set of commercial food-grade enzymes (alpha-amylase, amyloglucosidase, maltogenic amylase and protease) were selected and screening trials were performed to find out potential parameters conditions (i.e., bread particle size, slurry concentration, reaction time and enzyme dosages). The sugar profile of the liquid fraction (syrup) was characterized by HPAEC-PAD. Bread was efficiently hydrolysed into glucose or maltose by using suitable amyloytic enzymes. The best dosage of enzymes, i.e. combination of alpha-amylase (50 mg/kg bread) and amyloglucosidase (2,500 mg/kg bread), efficiently hydrolysed starch from bread up to 88% sugars/starch (mainly glucose was produced). Syrups rich in maltose were also produced by combination of alpha-amylase (50 mg/kg bread) and maltogenic amylase (2,500 mg/kg bread) up to 64% sugars/starch (maltose was the main sugar produced). Protease did not improve the hydrolysis of starch, but it reduced the viscosity of the hydrolysed bread. After the hydrolysis processes, the whole hydrolysed bread (i.e., without any solid/liquid separation) as well as its syrup (liquid supernatant separated by
centrifugation) were used as ingredients to replace sugars during bread making. The waste bread hydrolysate and separated syrups contained 18.1% and 20.6% glucose, respectively and were therefore used at an addition level of 11% and 9.7% flour weight (FW), respectively. With these addition levels, the waste bread hydrolysate was successfully utilized in replacement of sucrose in bread making without affecting the quality of the product. The sensory quality of the bread indicated that the flavor and mouthfeel of test breads did not significantly differ from that of the control bread. In addition, the bread crust, appearance, friability and elasticity of the crumb were similar among these breads.

No difference in bread volume was observed among the breads. Based on texture profile analysis, breads did not differ in hardness or staling. Enzymatic hydrolysis of waste bread into sugar-rich syrup had a big potential for sugar replacement. Moreover, the recycling concept would be beneficial for bakery industries to overcome their excess production in a sustainable and feasible way.

Bread baking under partial vacuum: About the relative contribution of gas fraction and starch gelatinization on crumb softness
D. GRENIER (1), C. Rondeau-Mouro (1), M. Cambert (1), J. Rouillac (1), Y. Diascorn (1), T. Lucas (1)
(1) IRSTEA, Rennes, France

During bread baking gas cell inflation is governed by the increase in temperature resulting in gas dilation and gas release from the dough where it was accumulated during fermentation. Lowering in pressure significantly enhances gas release in addition to the contribution of the increase in temperature by modifying gas equilibria [1–3]. When applied during baking, partial vacuum favors the inflation of gas cells before the crust sets. Bread baking using partial vacuum results in greater oven-rise and greater gas fraction in the crumb is obtained resulting in decreased density and increased softness for a more pleasant mouthfeel. Mechanical properties of gas cell walls may be part of the increase in crumb softness as well since the time-temperature curves inside dough during vacuum baking are different from those in a dough baked at the atmospheric pressure. The boiling point of water decreases with the decrease in pressure and starch gelatinization and protein denaturation are possibly modified. The present study aims at comparing the expansion of several products as gluten-free bread, buns, Chinese bread and cakes both baked at atmospheric pressure and using partial vacuum. Water losses were characterized and those obtained when vacuum was applied remained in the same order of magnitude as those measured when bread was baked at atmospheric pressure. The modulus of elasticity of gluten-free bread was monitored during storage over 4 days, using a compression stress relaxation experiment. Concomitantly, the extent of starch gelatinization in crumb using NMR [4] and the distribution in water content in the slice of bread were assessed. The relative contribution of the extent of starch gelatinization and gas cell fraction to crumb elasticity was discussed. It was found that the softness of the crumb was mostly driven by the gas fraction and that starch gelatinization was little modified when dough was baked at ~20 kPa. [1] Bell, B. M., D. G. H. Daniels and N. Fischer (1981). Vacuum expansion of mechanically developed doughs at proof temperature: effect of shortening. Cereal Chemistry 58:182-186. [2] Gandikota, S. and F. MacRitchie (2005). Expansion capacity of doughs: Methodology and applications. Journal of Cereal Science 42(2):157-163. [3] Abdelrahman (1993). Composite dough product and a process for producing same. Patent. US 5,192,564, Continental Baking Company. [4] Rondeau-Mouro C., Cambert M., Kovrijia R., Musse M., Lucas T., Mariette F. (2015). Food and Bioprocess Technology 8:777-790.

Role of compositional variation of ancient grains on their functional and nutritional properties as total and partial wheat flour replacer
C. BAKER (1), G. Delamare (1)
(1) Campden BRI, Chipping Campden, U.K.

An increased focus on nutrition and health, and gluten-free alternatives has stimulated interest in developing new ingredients. Due to their morphological resemblance to true cereals and similar processing requirements, pseudocereals like amaranth, buckwheat, and quinoa have the potential to be utilised in similar applications. However, high variation in the composition of these grains has previously been reported. This study provides further understanding on the impact of composition variation of amaranth, buckwheat and quinoa on their functional and nutritional qualities properties, critical to new product development. It also gives insights into the suitability of these grains in gluten-free applications as direct wheat replacer as well as assessing their ability to boost protein and mineral content in composite wheat blends. The approach consisted in sourcing pseudocereals from multiple geographies and analysing their flour for their nutritional properties (protein, minerals, and starch), and pasting properties with a Rapid-Visco Analyser (RVA). They were compared to soft and hard wheat flour, and durum semolina as controls for their typical applications in biscuits, bread and pasta, respectively. Pseudocereals were also blended in a 20:80 ratio with the controls (pseudocereal:wheat) and analysed with RVA and farinograph to evaluate the potential of composite pseudocereal and wheat flour. Amaranth, buckwheat, and quinoa had RVA profiles different from the wheat controls and amaranth could have potential applications in high shear systems due to its stable starch upon cooling. Flour blends in a 80:20 ratio (wheat/pseudocereal) had essentially the same functionality as the flour controls in regards to their RVA profiles. Specifically, the flour containing quinoa and durum semolina showed almost identical farinograph results to durum semolina.
suggested its use for similar applications like pasta. Composite flour technologies would also help enhance the nutritional profile of wheat flours due to the high protein content (amaranth: 14.5–15.1%; buckwheat: 13.6–14.0%; quinoa: 9.7–14.0%; soft wheat: 10.3%; hard wheat: 13.5%; durum wheat: 12.8% protein (dry mass basis)) and mineral content of pseudocereals compared to wheat.

Health benefits of whole grain and promoting whole grain consumption
C. J. SEAL (1)
(1) Newcastle University, Newcastle upon Tyne, U.K.

Cereals are a key component of the diet, providing the foundation for a sustainable, healthy diet pattern delivering energy, protein and many essential nutrients. The nutrient content of cereal-based foods, however, is highly dependent on the degree of processing, especially the degree of extraction during milling. Post-milling processing also has the potential to impact nutritional quality of foods, an area which is largely unexplored. The refining/milling process removes nutrients such as dietary fiber, minerals and phytochemicals which are found in higher concentrations in the bran. This potentially reduces the healthfulness of refined flours and foods made from them. The health benefits of consuming different types of whole grain and whole-grain foods are well documented in both observational and intervention studies, and these will be discussed during the presentation. In particular we have been exploring ways to combine data for multiple outcomes from these studies to provide robust data describing the health benefits. Our aim is to use these data to underpin the call to increase whole grain consumption in all populations and to make whole grains central to dietary recommendations.

Cricket proteins: Functionality and effects on dough rheology
M. A. PEREZ-FAJARDO (1), H. Dogan (1), S. Bean (2)
(1) Kansas State University, Manhattan, KS, U.S.A.; (2) USDA ARS, Manhattan, KS, U.S.A.

The continuous rise in population, environmental concerns, and an increasing shift of consumers’ belief towards eating sustainable foods has led researchers to look for alternate sources of protein. Insect proteins are novel protein sources that are environmentally friendly due to their lower green house gas emissions when compared to beef, poultry, and pork. Farming insects also requires less resources compared to raising livestock. Insects are high in protein, contain chitin which is a source of fiber, and are a good source of B vitamins. There is a wide variation in nutritional and functional quality of protein depending on the type of insect. The objective of this study was to understand how cricket protein powder affects the mixing, pasting and dough development characteristics of bread dough. Two different cricket protein powders, GrioPro (GP) and Entomo Farms (EF), were tested at replacement levels of 10 and 20% (of total flour weight). Each protein source was characterized for their functional properties. The MixoLab constant water absorption protocol was used to study their effect on dough development. In general, incorporation of GP and EF proteins led to two opposite effects. GP caused up to 16% increase in peak torque values (at 20% replacement level), while addition of EF resulted in 10% less peak torque. Both protein powders resulted in increase in dough stability (from 8 min in control samples to up to 11 min in cricket protein included sample). Dough development took longer for the EF samples (around 8 min) while GP was not significantly different than that of control dough. Dough samples collected at peak torque development at 10 and 20% replacement levels were subjected to size exclusion-HPLC analysis to quantify the change in soluble polymeric proteins (SPP) and insoluble polymeric proteins (IPP), as well as gliadins (Gli), and albumins and globulins (AG). Dough samples with EF showed lower peak areas (9,432 and 17,346 mAu) than IPP compared to the control (23,360 mAu) while the SPP dough samples showed higher peak areas (41,414 and 44,133 mAu) to the control (41,212 mAu). The GP samples showed an increase in the peak areas (29,518 and 65,820 mAu) of the IPP compared to the control while the SPP peak areas were lower (39,157 and 39,548 mAu) compared to the control.

Analysis of Ferulic Acid Oligomers
M. BUNZEL (1)
(1) Karlsruhe Institute of Technology, Karlsruhe, Germany

The vast majority of ferulic acid, a physiologically active and functional grain constituent, is ester-linked to arabinoxylans. Ferulates oligomerize via two mechanisms: photochemical coupling, resulting in ferulate photodimers; and enzymatically induced radical coupling, resulting in ferulate dehydrodimers, dehydrotrimers, and dehydrotetramers. Although the concentration of ferulate oligomers (sum of photodimers, dehydrodimers, -trimers, and -tetramers) is much lower compared to monomeric ferulate, oligomers have a major impact on the physicochemical properties of grains, flours, and dietary fiber (e.g. viscosity, gel forming, fermentability) due to their ability to cross-link cell wall polymers. Routine analytical procedures to measure monomeric ferulic acid (after saponification) are available, whereas the analysis of ferulic acid oligomers is hampered by the large number of analytes (including regioisomers and stereoisomers), their low concentrations, and, most severely, the fact that standard compounds are not commercially available. In this presentation we present an overview about different strategies to generate the essential standard compounds and their usage in chromatography-based methods to
analyze ferulic acid oligomers developed by our group over the last decade are presented with a focus on our most recently developed LC-MS/MS based stable isotope dilution assay. Generally, three different approaches to obtain ferulic acid oligomers in quantities and purities that allow for their usage as analytical standards are available: 1) isolation from plant materials; 2) targeted organic synthesis of individual oligomers; 3) enzymatically or chemically induced radical coupling of ferulates resulting in mixtures of ferulate oligomers followed by (multi-)chromatographic procedures to isolate individual oligomers. Whereas isolation procedures from natural sources are generally suitable to obtain non-labelled standard compounds, $^{13}$C-labeled compounds need to be synthesized. Due to its superior chromatographic resolution, gas chromatography after derivatization is ideal to separate ferulic acid dimers. However, the low volatility of derivatized ferulic acid trimers and tetramers does not allow for gas chromatographic separation of these compounds, even by using high-temperature stationary phases. Liquid chromatography can be applied to analyze ferulic acid dimers, trimers, and tetramers using either C18- or phenyl-hexyl stationary phases. Due to its comparatively low selectivity, UV-detection is often problematic, especially to analyze partially co-eluting ferulic acid trimers and tetramers. LC-MS and especially LC-MS/MS approaches are superior in terms of selectivity and (often) sensitivity, but suffer from matrix-induced limitations in accuracy and precision due to ion suppression during electrospray ionization. These limitations can be overcome by using a stable isotope dilution assay.

Analysis of hydrophobic interaction of proteins in dough formation
S. IWAKI (1), S. Aono (1), K. Nakamura (1), K. Hayakawa (1)
(1) Nisshin Flour Milling Inc., Tsukuba-city, Ibaraki, Japan

The objective of this study was to analyze changes in molecular weight distribution and hydrophobic interaction of proteins in dough formation. Two kinds of wheat flour showing different level of mixing strength (strong flour (SF), weak flour (WF)) were used. Dough samples were prepared by mixing flour with salty water using the Swanson mixer. The samples were taken from the mixed dough at the time of mixing start, build up, mixing peak, break down and overmixing. Proteins were extracted from dough by homogenization and sonication using phosphate buffer containing 0.5% SDS (extracted proteins are abbreviated as 0.5(h+s)). On the other hand, proteins were extracted from dough by homogenization using phosphate buffer containing 0.3% and 0.1% SDS (0.3(h) and 0.1(h)). Extracted proteins were separated using SE-HPLC and analyzed for molecular weight distribution. SDS solution was used as a solvent to weaken the hydrophobic interaction of proteins in this study. 0.5(h+s)–0.3(h), 0.3(h)–0.1(h) and 0.1(h) were evaluated as proteins aggregated by strong, moderate and weak hydrophobic interaction. In SF and WF, monomeric proteins (MP : Mw<100kDa) decreased (mixing start → overmixing : SF 79.8→74.4, WF 71.8→64.4 mg/g) and polymeric proteins (PP : Mw>1000kDa) increased (SF 48.9→51.8, WF 34.0→40.1 mg/g). It suggested that MP were polymerized with the other MP or with PP to higher molecular weight PP (result1). On the other hand, high molecular weight PP (MW>10000kDa) decreased after mixing peak (mixing peak→overmixing, SF 11.2→10.1, WF 8.4→7.7 mg/g) and low molecular weight PP (MW<10000kDa) increased during mixing (mixing start → overmixing : SF 38.0→41.8, WF 27.6→32.4 mg/g). It suggested that original high molecular polymeric proteins in flour became lower molecule (result2). Focusing on changes in hydrophobic interaction, in SF and WF, high molecular weight PP aggregated by strong hydrophobic interaction decreased (SF 3.2→0.3, WF 3.1→1.0 mg/g) and high molecular weight PP aggregated by weak hydrophobic interaction increased (SF 0.9→1.9, WF 0.4→1.2 mg/g). It suggested that hydrophobic interaction of PP loosens (result3). From result 1, 2 and 3, it was suggested that polymerization of monomeric proteins and molecular weight reduction due to weak hydrophobic interaction of polymeric proteins occur simultaneously in dough formation.

Tips to communicate about bakery products in a wiser way, by combining consumer and expert concepts
C. DUPUY (1)
(1) Lasaffre, Lez Lille, France

Nowadays, communication about bread is mostly basic, rarely objective. In other domains, like wine field for instance, terms used are more objective and precise. The talk will present the results of an original study, based on the “Bread in words” booklet, about the importance of the level of lexicon in bread field. How do bread consumer speak about bread ? What is the best way to communicate about bakery products : a use of a basic vocabulary, or a more expert vocabulary ? A good opportunity to learn more about the “bread eater experience.”

Growth of eye-shaped bubbles in Danish pastry in relation to optimal lift and crumb regularity
T. LUCAS (1), C. Collewet (1), J. Bousquières (1), C. Deligny (1)
(1) IRSTEA, Rennes, France

The mechanisms of lift in puff pastry, also relevant to Danish pastry and croissant, were established from studies dating from the 70–90’s, dealing with the number of sheets. At that time, the distribution in bubble size in these products was disregarded, preferring some macroscopic criteria like total height or volume of the finish products. In the present study, the distribution in size of bubbles in Danish pastry was characterized as a function of the
number of sheets, allowing the classification of optimal, under- and over- lamination with respect to lift. Imaging techniques were also used at different stages of the pastry preparation in order to better understand the growth of eye-shaped bubbles typical of these products. Proving of the whole pastry was monitored by magnetic resonance imaging. Large eye-shaped bubbles were clearly seen in the fat layers while bubbles growing in the dough layers were round and remained to be small in diameter. In fact, CO₂ produced by yeast during fermentation, responsible for bubble inflation, can migrate towards all nuclei even those present in the fat layers. Eventually, confocal laser scanning microscopy was used at the end of lamination and image analysis permitted to characterize the number, thickness and width of fat fragments in 3 x 4mm² sized samples. Interestingly, the number of fat fragments was well correlated to that of eye-shaped bubbles. The largest and smallest fat fragments yielded to low number of bubbles (between 12 to 44 fat fragments for one eye-shaped bubble), because of gas escape or low occurrence of gas nucleus respectively. The fat fragment most likely to inhabit an eye-shaped bubble was 1–2mm large (1 fat fragment out of 6); this number also correlated the best to the total height of the finish product and the regularity of the crumb texture. Provided confirmation for other preparation conditions, this size could be used as a target for process optimization. This study also modulated the relationship of fat fragmentation and lift currently accepted in the literature; indeed, both high and low levels of fat fragmentation should be avoided. This knowledge could be useful for studies dealing with the replacement of fat layering (Ooms et al., 2015). Ooms, N., Pareyt, B., Brijs, K., Delcour, J.A., 2015. Ingredient functionality in multilayered dough margarine systems and the resultant pastry products: A review. Critical Reviews in Food Science and Nutrition 56(13):2101-2114.

**Novel analysis of growing season weather data – Towards an improved understanding of the effects of weather on wheat protein content and gluten strength**

J. COURCELLES (1), H. Sapirstein (1), P. Bullock (1)
(1) University of Manitoba, Winnipeg, MB, Canada

Wheat protein content and gluten strength are strongly affected by environmental conditions during the crop growing season. There is little understanding of the nature of growing location effects, particularly when appropriate fertility management is implemented by farmers and weather variation is in the normal range. This information is important to farmers and especially to grain buyers when sourcing wheat of a particular market class from different regions. Unfortunately, the analysis of the effects of key weather parameters such as temperature and precipitation is hampered by variable days to maturity (DM) across growing sites. Weather data can be compiled into time periods based on detailed phenology, but this must either be observed, which is challenging, or modeled, which is less accurate. The objective of this study was to develop an improved understanding of weather effects on wheat protein content and quality by implementing a novel weather data analysis protocol that begins with normalization of DM into a fixed number of calendar day intervals, e.g. 2 to 12. Replicated field trials were carried out in 2015 and 2016 involving nine Canadian HRS wheat varieties grown in nine sites distributed across a western Canadian Prairie region spanning > 400,000 km². Measured weather parameters included daily maximum, minimum and mean temperature, solar radiation, average and total precipitation, evapotranspiration and other derived or modeled variables. Gluten strength (work input to peak development or WIP) was determined using a 10 g torque recording strain gauge mixograph. DM and flour protein (FP) content across site years ranged considerably from 76 to 124 days and 10 to 16%, respectively. Gluten strength was similarly variable. As the number of calendar day intervals increased, a pattern of variation emerged for selected weather parameters and critical time intervals that maximized correlations to protein content and gluten strength. Although simple correlation coefficients were moderate in value (r = 0.50–0.60), relationships improved considerably by applying stepwise regression analysis, with R² > 0.70–0.80 for the best 3 or 4 weather variable models. FP and WIP at specific growing locations were most strongly correlated to weather at time intervals near anthesis and the tillering phase of crop development. The novel analysis of crop season weather data employed in this study showed promise as an efficient alternative to phenology based methodology to help explain differences in protein content and quality of wheat that are typically encountered in the Prairies.

**Advances in present-day frozen dough and fermentation technology and its improver and novel bio-tech ingredients development trends**

W. HUANG (1), J. O. Omedì (1)
(1) Jiangnan University, Wuxi Jiangsu, China

This presentation intends to provide an overview of scientific aspects and current understanding of frozen dough (FD) and fermentation technology. Innovation and development trends in new improver and novel bio-tech ingredients are presented with examples. In response to consumer trends, product flexibility and fast response, interest in FD technology continues to increase since its inception in 1970s, especially with improver technology development. With a steady market growth, common FD products are categorized as pre-fermented, unfermented and par-baked, mainly sold “as if freshly baked.” Despite increased popularity of FD products, freezing and frozen storage treatment (F-FST) decreases yeast activity and viability, damages gluten-starch
network and alters individual dough components. In hydrated FD systems, three water sources i.e. rigid, confined and bulk water are redistributed differently through ice crystallization and recrystallization, thus affecting gluten protein, starch and yeast structure, component and functionality. Differences in crystal size, location further exacerbate the effects. Gluten protein, indicated by GMP depolymerization, show increase in S-H groups, indicating S-S bond disruption in FD systems, thus invariably changing molecular weight distribution of glutenin subunits. In starch, granule structure re-organization; decline in amorphous state coupled with increase in crystallinity as granule materials leach out is observed. Yeast activity and viability decrease in FD systems; degree of damage related to freezing conditions used and ability to metabolize different molecules. Additives like hydrocolloids, ice-structuring proteins, ice nucleating agents and novel biotech ingredients like microbial exopolysaccharides and enzyme use of transglutaminase, lipase have enabled: i) increased yeast freeze-tolerance, ii) enhanced gluten and starch functional properties during F-FST. Subsequently, yeast in FD have better fermentative capacity, resulting in improved end-product quality in terms of higher specific volume, lower hardness and increased shelf life. The additives alter ice crystallization and recrystallization characteristics in FD. Contribution to science and industry impact: This overview adds new knowledge and useful insights on: i) use of bio-tech ingredients for clean label technology in frozen dough and food industry, a consumer demand trend for clean label products, ii) optimization of frozen dough processing and equipment technology for modern baking and food industry.

Impact of legume flours on quality of gluten-free rice cookies and muffins
D. Y. JEONG (1), S. J. Lee (2), H. J. Chung (1)
(1) Chonnam National University, Gwangju, South Korea; (2) Suseong College, Daegu, South Korea

Legumes are an excellent source of protein, carbohydrate, dietary fiber, and phytochemicals and might be an alternative for improving the nutritional value of gluten-free products. This study was carried out to investigate the effect of legume flours (cowpeas and mungbeans) on quality of gluten-free rice muffins and cookies. The different processing methods including steeping (1 kg in 1.5 L water at room temperature for 4 hr), boiling (500 g in 1.5 L water at 100°C for 5 min), roasting (200 g, 200°C for 10 min), and high-pressure roasting (200°C in 70 hPa) used to prepare legume flours. The treatment at a high temperature for a short time was effectively removed the off-flavor of the legume flour by validating sensory analysis and minimized the color change during heating. The muffins made with legume-waxy rice flour blends showed irregular pore shape and less pore formation than control muffin made with wheat flour. The height (4.0~4.5 cm) and volume (108~120 mL) of gluten-free rice muffins containing legume were lower than that of the control (4.8 cm and 125 mL, respectively). The hardness (440.5~663.7 g) and adhesiveness (-7.9~ -5.2 g·s) of gluten-free rice muffins increased by adding legume flour. However, no statistically significant difference between control and gluten-free rice muffins containing legume for sensory color preference and overall acceptance by using a seven point hedonic scale with 24 trained panelists. Among the employed processing, roasting method had the best textural and sensory parameters than the other treatments. The overall acceptability of mungbean containing cookies was higher than that of cowpea containing cookies. The muffins containing legume-waxy rice flour resulted in a sensory quality that was close to the control muffin. Overall, considering the physical, nutritional, textural and sensory qualities, the legume-waxy rice flour blends exhibits a great potential for application in gluten-free bakery products.

Advances of using pulse flours in cereal-based products
A. MARTI (1), A. Bresciani (1), M. A. Pagani (1)
(1) DeFENS, University of Milan, Milan, Italy

In recent years, consumer awareness about the environmental and nutritional benefits of pulses has made them a popular choice for satisfying the needs of emerging trends such as vegetarian, vegan, gluten-free, or allergen-free diets. Indeed, pulses have been long known for their nutritional and health-promoting properties, being a good source of fibre, proteins, antioxidant compounds and having a low-glycaemic index. Despite that, the nutritional value of pulses is limited by the presence of antinutrients that decrease digestibility and micronutrient bioavailability. In addition to nutritional issues, consumers often identify off-flavors in products containing high levels (>10%) of pulse flours. Thus, despite Western consumers are increasingly interested in natural and healthy food products—without turning down the hedonistic aspect of food—the use of pulses is underexploited at an industrial scale, and they are seldom used as ingredients in processed foods such as bakery products, bread, pasta and snacks. The present study aims at presenting the lights and shadows of the technological processes currently used to improve the technological and/or the nutritional and sensorial properties of pulses used in foods as grain or flour. The effects of pre-gelatinization and germination on molecular, physical and technological properties of pulses (including chickpeas, cowpeas and lentils) were considered. Moreover, the use of the treated grains/flours was assessed in three types of cereal-based products (i.e. pasta, snacks and bread). Pre-gelatinization was more effective in modifying proteins rather than starch granules, whose gelatinization and retrogradation properties remain the same after treatment. On the other hand, dough consistency improved after pre-gelatinization, accounting for the good quality of the related pasta. As regard germination, flour from sprouted cowpea may represent a better ingredient than the flour obtained from non-sprouted legumes in terms
of sensory properties and overall macroscopic organization. Industrial-scale germinated chickpea flour shows increased bioavailability of relevant micronutrients and of a sensible decrease in anti-nutritional factors. Flatulence-related oligosaccharides almost disappeared in germinated chickpeas, with a concomitant increase in sucrose that positively affected the dough development during leavening. Thus, the availability of pre-treated pulses at an industrial scale expands the potential for the integration of these novel ingredients into the food market and helps to meet increasing consumer demands for natural healthy food products.

**Potential application of enzymes to improve noodle making performance of Korean domestic wheat flour**

Y. MOON (1), Y. E. Hong (1), S. Jeon (1), Y. Zhao (1), M. Kweon (1)

(1) Pusan National University, Busan, South Korea

Almost 99% of the total usage of wheat in Korea is imported from US, Australia and Canada due to very limited production of domestic wheat. The largest consumption of flour in Korea is for making noodle, specially, for dry noodle. *Baegjoong* is one of the most prevalent domestic wheat cultivars, but its quality variation and inferior quality such as weaker gluten strength and higher damaged starch are a major challenge for expanding further end-use applications. In order to improve noodle making performance of Korean domestic flour, application of enzymes was investigated. For the study, water absorption capacity by solvent retention capacity (SRC) test, dough rheological property by Mixograph, and noodle making performance of the flour added with various enzymes were analyzed. Three endo-xylanases from different sources (xylanase A, B, C) and one fungal α-amylase were used. SRC values of the flour used for the study were 62.6% in water, 86.5% in lactic acid, 81.0% in sodium carbonate and 95.9% in sucrose, which indicated relatively low quality flour with high water absorption, low gluten strength, high damaged starch and arabinoxylans. With enzyme treatment (0.025, 0.050, 0.100%/flour basis), water SRC of the flour was decreased significantly by 9–15% of the water SRC of the flour without enzyme. Water SRC of the flour was dropped sharply up to 0.025% and no further significant decrease was observed with increased enzyme concentration. Among the enzymes, xylanase A and amylase were much more effective to decrease water SRC. Mixograph result showed a noticeable change in the rheological property of the flour by adding enzymes. In particular, the flour with xylanase A showed much narrower band width, but adding 10% less water to the flour with the enzyme resulted in a similar Mixograph pattern to the flour without enzymes. In noodle making, a significant or negligible modifications in weight gain of cooked noodle, turbidity of cooking water, and texture of cooked noodle were observed depend on enzymes. Noodle made with 0.025% amylase and 10% water reduction improved quality that resulted in less weight gain, increased firmness, springiness, chewiness of cooked noodle. The water SRC, Mixograph and noodle making results suggested application of enzymes would require less amount of water for mixing noodle dough without deteriorating noodle quality and save a drying time for making dry noodle successfully.

**3D Printing of cereal-based materials: On the relation between rheology and printability**

A. FAHMY (1), M. Jekle (1), T. Becker (1)

(1) Technical University of Munich, Freising, Germany

Due to the precision and accuracy of the 3D printing technology, local and defined tailoring of texture and incorporation of flavors and odorants for specific sensory perceptions of cereal-based materials is achievable. However, to attain precision prints, an appropriate range of material properties needs to be determined. The objective of this study was to develop a method for accessing the print-ability through a model utilizing the rheological properties concerning cereal-based materials and the 3D printing quality and structural stability aspects explicitly: artifacts, dimensional stability and layer forming ability by using shear rheometry and image analysis techniques. For the mentioned purpose, cereal-based inks were formulated employing wheat flour doughs with different water concentrations, wheat starch-egg protein blends and corn starch-protein-hydrocolloids mixtures using soy and egg protein as well as methyl cellulose and hydroxypropyl methyl cellulose. A simplified model of a single screw extruder was adapted to obtain the exerted strain rate during the deposition process, which is then applied, as an imitation technique, on the rotational Rheometer to obtain the rheological properties after structural destruction caused by the extrusion process. For geometrical evaluation, the printed areas and lengths of simple printed lines and superposed lines were obtained using MATLAB object segmentation and analysis techniques, then compared to the reference models. Imaging results showed that, the print lengths of the soy protein enriched starch-methyl cellulose blends increased depending on the hydration level by 20 to 50% compared to the model. Also, increasing egg protein concentration in starch-methyl cellulose blends led to a decrease in length from approximately 140% to 60% of its theoretical length. Finally, replacing traditional texturing methods with 3D printing technologies and establishing a print-ability guideline for cereal-based materials, the design of highly defined food textures and reproducible foam like multi-component matrices is becoming more attainable.
Young bamboo culm fibre and bamboo shoot fibre as an alternative to make grain-based products healthier  
(1) UNICAMP/FEA, Campinas, Brazil; (2) UNICAMP/FEAGRI, Campinas, Brazil  
Pasta is widely consumed as main meal. Fibre incorporation in food can decrease the glycemic index of products, what is linked with health benefits. Aligned with the increase of consumer health concern, industry uses innovation strategies to produce healthier products based on the application of new ingredients and from alternative sources. Bamboo shoots are already consumed as food and present nutraceuticals properties, and the bamboo shoot fibre (BSF) is commercially available. In addition, the production of young bamboo culm flour (YBCF), an alternative to sustainable obtaining of bamboo fibre, is in agreement with United Nations global issues, converted in 2015 in the 17 Global Goals. Therefore, the aim of our study was to evaluate the effect of partial replacement (0%–5.98%) of Triticum durum wheat semolina (WS) by BSF and YBCF (two independent variables) in pasta formulations using a central composite rotational design (13 trials). All formulations went through the same steps (weighing, mixing, cold extrusion and drying), and were evaluated for optimal cooking time (OCT), volume increase (VI), mass gain (MG), loss of soluble solids (LSS), force to cut, and colour parameters (L*, a* and b*). Consumer acceptance (1-“really disliked” up to 9-“really liked” scale) and intention of consumption (1-“certainly not consumed” up to 5-“certainly consumed” scale) tests were carried out with selected pastas. Statistical analysis was performed using Statistica 8.0 software. Independent variables had no significant influence in OCT and MG of pasta. Notwithstanding, a trend (R² <0.80) was observed for lighter pasta and a* values for dried pastas with BSF, while in the cooked ones, the presence of YBCF was responsible for this increase. VI was higher with lower contents of YBCF, whereas LSS and force to cut presented better values for pastas at the central point. Pastas E7 (1.75% BSF and 0% YBCF); E8 (1.75% BSF and 3.5% YBCF) and E10 (1.75% BSF and 1.75% YBCF) had presented the best technological characteristics. Selected samples (E7, E8 and E10 submitted to sensory analysis) and presented no statistical difference in colour and flavour perceptions, important parameters for consumer choices in market, and presented average above 6 in the acceptance test and 3 in the intention of consumption. We conclude that BSF and YBCF are a promising food ingredient, since the obtained pasta had no change in colour neither in technological properties, besides having a healthy claim and lower glycemic index as a function of its fibre content.

Flour enzyme mapping: From raw material to the finished baked product  
T. HEDIN (1)  
(1) Lantmännen Cerealia AB, Malmö, Sweden  
Endogenous enzymes in flour play an important role in the cereals industry and have an impact on process performance and product quality. We conducted a large-scale analysis of different endogenous enzyme activities, such as amylases, pectinase, hemicellulases in more than 100 different flour samples. The data about the levels as well as the presence of different enzyme activities found in the different flours were compared to other analytical methods, such as diastatic power, polysaccharide and protein content, gelatinisation temperature as well as baking trial outcomes in order to establish a reliable correlation between raw material enzyme profiles and bread quality. The goal is to develop a prediction model for the final baked product thereby providing a more informed approach to the entire baking process including but not limited to prediction of required amounts of additives, reduction of waste due to batch variation as well as reducing the need for baking trials as ultimate measures of raw material quality.

Development of dough stickiness method using sensory and objective measurements  
L. CATO (1), S. P. Cauvain (2)  
(1) Perth, Australia; (2) BakeTran, Freeland, Witney, U.K.  
Bread dough development is a poorly defined concept but commonly relates to changes in the rheological properties of the dough under defined test conditions. A key factor in the processability of dough is the property that we refer to as stickiness; poorly defined and difficult to measure, it remains of practical concern in all bakeries but of concern in industrial bakeries where the opportunities for human intervention remain limited. The objective of this study has been to develop a test method based on the Warburton’s stickiness rig test (WST) (TA-XT2iPlus) for dough consistency and dough stickiness and to understand the effects of higher shear rates on dough to give insights relevant for commercial dough processing arrangements. The scoping study was based on full bread dough recipe and the following parameters: water levels: standard water absorption; ±2.5% and ±5%; dough temperature: 24; 30 and 36°C; delays in processing 5, 10 and 15 min; and salt levels: standard, ±25% and ±50%. Preliminary mixing trials (carried out using doughLab) showed that as dough recipe water level increased total and peak energies decreased and development time increased. As the recipe water level increased, the WST compression peak values fell. This is the expected result as the dough is getting softer and therefore has less resistance to the compressive force of the knife blade. The effect of test speed was very similar for each of the tested water levels with a suggestion that a testing speed of 2mm/min (the standard) was a little more sensitive to the effects of recipe water level. Our results also showed a strong link between dough softness and stickiness when
assessed by hand, though the trials have highlighted a significant degree of personal ability to assess dough stickiness. This strong correlation and degree of individual variability in stickiness assessment is not unexpected, since it has been observed on numerous occasions in test-baking and commercial environments. The strength of the link explains the most common commercial reaction to dough stickiness; namely to reduce recipe water level. Such practices are expedient in the context of achieving the uninterrupted commercial processing of dough but are not necessarily in the best interests of bread quality, and commercial profitability. Practical observations of dough stickiness show that stickiness is transitory and will dissipate in a short time—even in circumstances where moisture losses are prevented.

The impact of Rht-1 semi-dwarfing alleles on end use quality in wheat
E. JOBSON (1)
(1) Montana State University, Bozeman, MT, U.S.A.

Mutant forms of the Reduced Height (Rht) genes were largely responsible for the dramatic yield increases during the “Green Revolution” in the 1960s. The mutant forms of the gene, Rht-B1b and Rht-D1b, have since been incorporated into the majority of modern wheat cultivars worldwide; their popularity due to their decreased stem length, and increased yield compared to tall varieties. However, despite extensive research regarding the agronomic impact of the genes, much less is known regarding their impact on the end use quality of the grain. For this study, we used near isogenic lines developed in a tall spring wheat variety (Fortuna). Lines either carried the semi-dwarfing alleles, Rht-B1b or Rht-D1b, or a differentially acting dwarfing mutation Rht-8. The trial was grown under dryland and irrigated field conditions. Our results agreed with previous findings regarding agronomic traits. We observed a 25% height reduction in Rht-B1b/Rht-D1b lines as well as a 13% yield increase, and a 2% grain protein content decrease in the semi-dwarf lines compared to the tall variety. However, we also observed an increase in flour yield (2%), mixing tolerance (56%), bake mix time (33%), and gluten index (8%) in the Rht-B1b/Rht-D1b lines compared to the tall variety. Despite the increase in mixing tolerance, time, and gluten index, we saw a decrease in loaf volume. We also analyzed the micronutrient content of whole wheat and white flour and found a decrease in micronutrient content (Iron, Manganese, Zinc) in the semi-dwarfing lines. For almost all parameters, Rht-8 lines were intermediate between semi-dwarfing lines and tall isolines. Our findings suggest that Rht-B1b/Rht-D1b decrease seed size, protein, and micronutrient content, but they do not negatively impact dough strength.

Determination of glucose generation rate from various types of glycemic carbohydrates by optimizing the mammalian glycosidases anchored in the small intestinal tissue
J. M. Seo (1), L. M. Lamothe (2), S. Austin (2), B. H. LEE (1)
(1) Gachon University, Seongnam, South Korea; (2) Nestlé Research Center, Lausanne, Switzerland

Rat intestinal acetone powder extract has recently been used as a source of the four mammalian mucosal α-glucosidases to mimic the digestion of glycemic carbohydrates by the enzymes anchored in the brush-border of the human small intestine. Here, it was hypothesized that the composition of the extracted enzyme is mostly sucrose and that the remaining enzymes (maltase, glucoamylase and isomaltase) are still anchored to the intestinal tissues. In this study, a glucose generation rate (GGR) assay was developed to optimize carbohydrate hydrolysis with complexed mammalian α-glycosidic enzymes (α-amylase and α-glucosidases) using various types of glycemic carbohydrates. The amount of released glucose by the optimized GGR assay was determined by the glucose oxidase/peroxidase method. Results clearly showed that the carbohydrate-based substrates were hydrolyzed to glucose differently compared to the α-glucosidase extract and the GGR value was increased. Notably, lactose was hydrolyzed to monosaccharides at a similar GGR compared to isomaltulose, while the previous approach using α-glucosidase extract did not hydrolyze it well. Current experimental methods use all types of anchored enzymes, while the α-glucosidase extract mainly contains sucrase released by protease in the small intestinal brush-border. Thus, glycemic carbohydrate (e.g., cereal/starchy-based breads, biscuits and noodles) digestion using the small intestinal tissue has higher correlation to glucose generation than the α-glucosidase extract, and this approach can be used to analyze carbohydrate quality or in vitro digestibility.

A gluten protein allergenicity study in Australian wheat varieties from historic times to present
C. G. FLORIDES (1), Chris Florides (2,3), Angela Juhasz (2), Wujun Ma (2), Thiru Vanniasinkam (3), Russel Eastwood (4), Frank Bekes (3), Chris Blanchard (3)
(1) Western Australian State Agricultural Biotechnology Centre, Perth, WA, Australia; (2) Murdoch University, Perth, WA, Australia; (3) ARC Industrial Transformation Centre for Functional Grains, Charles Sturt University, Wagga Wagga, NSW, Australia; (4) Australian Grain Technologies, Wagga Wagga, NSW, Australia

A considerable number of people, primarily in western populations, chose to follow gluten-free diets these days and wheat flour products have gained the reputation of being controversial food. Prevalence of gluten related food disorders, e.g. coeliac disease, wheat allergy, gluten intolerance, etc., have increased in the last 20 years and modern wheat varieties are often blamed. It is claimed that intensive wheat breeding during and since the green
revolution has changed wheat from a safe nutritious food to one that has become allergenic. Gliadins are the principal immunoreactive fraction of gluten, due to the high content of specific immune reactive peptide sequences (epitopes) in their primary structures. 172 Australian wheat cultivars released over the last 150 years (1860 to 2015), grown in the same environment, were assessed to determine their immunoreactivity. We used three replicates and analysed the results obtained with matrix assisted laser desorption ionisation time of flight mass spectrometry (MALDI-TOF), liquid chromatography MS MS (qTOF), and reverse and size exclusion high performance liquid chromatography, using Data Explorer, Genomic WorkBench, Excel, UniProt and ProPepper software. We quantified the gliadin content and composition of these cultivars and determined their immunoreactive epitope content. We have also discovered a small, highly toxic α-gliadin group, and mapped the immunoreactive epitopes of its members. The allergenicity of each of these Australian wheat cultivars was estimated, based on their gliadin abundance and immunoreactive epitope content. We identified considerable variation in the gliadin content, composition and immunoreactive epitope content, between all varieties tested, regardless of their release date. We have clearly proved that historic wheat varieties are potentially as immunoreactive as the more recently released cultivars. Australian wheat breeding companies will be able to select varieties with low immunoreactivity to use in their breeding programmes, in their endeavour to breed cultivars whose flour products will be aimed for people at the lower end of gluten intolerance.

Bile acid binding by native and modified oat and barley β-glucan

E. MARASCA (1)

(1) ETH Zürich, Oberrieden, Switzerland

It is well known that a diet rich in soluble dietary fibers (SDF) such as β-glucan can help reducing serum cholesterol levels, leading to a decreased risk of cardiovascular disease. However, β-glucan undergoes different modifications during food processing, which alter its viscous properties and its interactions in the gastrointestinal tract. SDF can interact with bile acids (BA) micelles in the small intestine, preventing their re-absorption with a subsequent excretion in the feces and serum cholesterol reduction. Some studies suggest that oxidized β-glucan has a higher binding activity than native β-glucan, while others state that this property is solely linked to the capability of β-glucan to form highly viscous solutions. In this study, a model was set up to investigate the BA binding capability of native and modified oat (OBG) and barley (BBG) β-glucan and to understand the relationship between viscosity, molecular structure and BA binding. A centrifuge tube equipped with a dialysis unit was used to mimic the unstirred water layer (UWL) of the small intestine. The kinetics of passage of a bile salt mix across the dialysis membrane, in the presence and absence of native and modified OBG and BBG extracts, were studied as a model for passage across the UWL. As modifications, TEMPO and NaIO4 were used to oxidize β-glucan in a controlled way, in order to understand how structural changes affect BA binding. Acid hydrolysis was used to reduce the molecular weight (hence the viscosity) of the fiber without any changes to its structure. The data were fitted using first order kinetics to derive rate coefficients (K) that quantify the effectiveness of the native and differently modified β-glucan in binding the BA. The K of native OBG (0.061) and BBG (0.06) were both significantly different from the blank (0.162). TEMPO OBG and TEMPO BBG also resulted to be effective in slowing down the BA passage, since their K (0.089 and 0.079, respectively) were significantly different from the blank (p<0.05). In general, rate coefficients decreased with molecular weight (measured by HPSEC) and viscosity (shear rate 20–2,000 s⁻¹). However, TEMPO oxidized samples still had a strong BA binding power despite their significantly lower viscosity (over 90% reduction). This suggests that a combination of viscosity and molecular interactions control the BA binding. However, opposite of what suggested in literature, oxidation does not seem to improve the BA binding capability of the fibers.

Deterioration mechanisms and preservation technologies for high-moisture fresh noodles

M. LI (1), Q. Sun (1), L. Xiong (1), M. Niu (2), B. Zhang (2), K. Zhu (3,4)

(1) School of Food Science and Engineering, Qingdao Agricultural University, Qingdao, China; (2) Huazhong Agricultural University, Wuhan, China; (3) KU Leuven, Heverlee, Belgium; (4) Jiangnan University, Wuxi, China

Noodle, as a traditional staple food in many Asian countries, have been consumed for thousands of years. Fresh noodle, as the traditional form of Asian noodles, is becoming increasingly popular worldwide with modern consumers for its superior flavor and taste. However, the traditional fresh noodles are high in water content and water activity (aw), which accelerate the physiological and biochemical reactions as well as the growth of microorganisms, thus leading to a very short shelf-life for them. Therefore, extending the shelf-life of fresh noodles is a priority for manufacturers in order to ensure their production, distribution, and marketing. In this work, we provide a comprehensive study and basic overview of the deterioration mechanisms and preservation technologies for this high-moisture traditional Asian food. Firstly, changes of the quality parameters of fresh noodles were summarized at macroscopic, structural, and molecular levels to understand the inherent laws and mechanisms underlying their deterioration. Secondly, critical conditions inducing the acceleration of the deterioration of fresh noodle products were evaluated. Then, various quality retention technologies were proposed based on these internal mechanisms and the whole production process, including preservatives (both chemical and natural), physical treatment, ozone treatment, precooling, reduced water activity (or promote the
interaction between water and non-water components), active/modified atmosphere packaging technologies and their combination on the preservation of fresh noodles. This work provides a theoretical and practical significance for the regulation of the storage stability of fresh noodles.

**Physical, cooking characteristics, pasting profiles and starch hydrolysis kinetics of Indonesian rice (O. sativa) varieties**

J. MOGOGINTA (1), G. A. Annor (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Rice is divided into two species *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice) and classified according to its length; short grain, medium grain, and long grain. Indonesian rice varieties are part of the *O. sativa* species and are important staples. On average, Indonesians consumed about 114 kg of rice per year.

Limited data however, exists in literature on the starch hydrolysis kinetics of Indonesian rice varieties. This study aimed at investigating the physical and cooking characteristics, pasting profiles and starch hydrolysis kinetics of five Indonesian rice varieties. This is important to assess their potential uses in various food applications and also for type II diabetes management. This study worked on five Indonesian rice varieties; white rice long grain (IR-64) and short grain (IR-42), brown rice, red rice, and black rice cultivated on Java Island, Indonesia and harvested at the same time. The rice samples were tested for their proximate composition, 1.000 kernel weight, cooking characteristics and *in vitro* digestibility of the cooked rice. White rice (IR-64) was the longest (7.02 mm) while the IR-42 was the shortest (5.67 mm). The protein content of the samples ranged from 8.21% for black rice to 9.21% for red rice. The 1,000-kernel weight and bulk density of the samples were 20.35 g to 15.67 g and 0.79 to 0.88 (g/mL) respectively. The optimum cooking time for the two white rice and black rice varieties were similar (about 15-16 min), while red rice (about 26 min) and brown rice (about 22 min) took longer to cook. This observation may be due to the bran on the red rice and brown rice. Both the white rice varieties retained more water after cooking compared to the brown, red and black rice and had a bigger kernel size after they were cooked. The two-white rice varieties were also softer than the brown, red, black rice when they were cooked. The final viscosity of IR-42 was the highest (1894 BU), while the black rice had the lowest (1137.5 BU). The highest expected GI was observed for IR-62 (68.03) while IR-42 had the lowest (55.71). The rice samples were different in their cooking and pasting characteristics. Their significantly different pasting profiles means they can be used for food applications requiring different viscosities. All the rice samples had medium expected glycemic.

**Challenges in creating suitable testing regimes for oats from field to cereal bar**

J. TRATT (1), D. Sparkes (1), P. Penberthy (2), R. Johnson (3), S. E. Hill (3)
(1) University of Nottingham, Loughborough, U.K.; (2) Jordans Dorset Ryvita, Poole, U.K.; (3) Biopolymer Solutions, Loughborough, U.K.

For the minor cereals, where key quality characteristics are poorly defined and methodology poorly standardised, it can be a challenge to define suitable intake tests that will help in the production of a standard product. The need for assured raw material quality may become even greater when there is adaptation of recipes for products that are salt or sugar reduced. Oats are grown in the East of England and these niche crops have been vigorously studied for several years throughout their growth, primary processing and when used as bulk ingredients in baked products. A challenge when using these oat crops has been the creation of flaked materials that would consistently give good adhesive properties, thus allowing lower sugar levels to be used as the binding agent. To benchmark the oats over 100 batches of commercial flaked oats were assessed using 47 different measures that have included chemical, physical chemical and physical analyses. Data from the 2017 harvest showed some marked differences compared to oats grown in 2016; for example, the protein levels were on average 1% higher in 2017 (as measured by NIR). However, despite the measured oats showing different adhesion properties in commercial and laboratory testing, it was not possible to define what rapid intake assessments could reflect this feature. As oat flake size was considered one of the important factors in the adhesion of the oats, this was investigated throughout the growth and processing of the flakes. Oats grown at different seedling rates, dates of drilling and nitrogen levels and on controlled sites have been evaluated for agronomic performance, grain size and their flaking behaviour. Varieties Mascany and Elyan, grown under matched conditions, and a bulk commercial sample have been dehulled, kilned and flaked using laboratory scale equipment. The changes to the groats during processing to form flakes have been followed, with hardness (using single kernel hardness measures) and surface areas being compared. It was found that the size of the original groat does not necessarily dictate the final flake size. The big challenges now are to utilise the growing body of data accumulated so that: a) rapid intake testing can occur, currently NIR calibrations are being developed and b) the links between crop on the field and final product quality are well enough understood so agronomic interventions are targeted to produce optimum raw materials.
Stability of whole wheat flour, rolled oats, and brown rice during long-term storage and consumer preparation

V. E. Scott (1), O. A. Pike (1), L. K. Jefferies (1), M. L. Dunn (1)
(1) Brigham Young University, Provo, UT, U.S.A.

Demand for whole grains is increasing among health-conscious consumers. However, extended shelf life of whole grains is compromised by polyunsaturated lipids from the germ, which generate oxidative by-products. These byproducts reduce sensory quality and may have a degradative effect on vitamins in whole grain products. The purpose of this study was to determine the degree of lipid and vitamin degradation during long-term storage of three whole grain products: whole wheat flour, brown rice, and rolled oats. We also examined vitamin loss after cooking to determine if oxidative byproducts generated during storage had an effect on vitamin stability during typical household cooking. Whole wheat flour, brown rice, and rolled oats were stored for 12 months and periodically analyzed spectrophotometrically for conjugated dienes (A233) and free fatty acids (A715); and by HPLC for tocopherols, thiamin, and riboflavin. Whole wheat bread, steamed brown rice, and oat porridge were made from samples stored for 0 months and 12 months and were analyzed for vitamin content. Conjugated dienes increased significantly (p<0.05) only in rolled oats, while tocopherols decreased significantly in whole wheat flour and rolled oats and insignificantly in brown rice. Free fatty acids increased significantly in whole wheat flour and brown rice. Thiamin and riboflavin were stable in raw stored grains and cooked products made from stored grains except for brown rice, in which we observed a significant decrease (>10%) in thiamin after 12-month storage. These results suggest whole wheat flour, brown rice, and rolled oats may experience significant lipid and tocopherol degradation, but storage does not appear to affect thiamin and riboflavin in raw stored products. Cooking caused additional degradation of thiamin after 12-month storage of brown rice, but vitamin content was stable in the other stored whole grains during cooking, indicating that accumulated oxidative by-products may not appreciably affect vitamin stability during cooking.

Gluten’s for stretch, bubbles for elasticity: Implications for flour quality for dough performance

S. Bell (1)
(1) Ardent Mills, Denver, CO, U.S.A.

The search for predictability in dough testing for flour quality and dough performance dates back to the 1700’s and continues to date, with efforts focusing on gluten. This paper reviews the recent progress in dough rheology and presents on the importance of the rheology of the continuous, aqueous phase in doughs in governing dough’s bulk rheological characteristics. While it is well-known that non-starch polysaccharides affect the quality of the continuous, aqueous phase in doughs, it would be shown here that dough’s bulk characteristics of extension and elasticity are also affected by rheology of the continuous phase, commonly known as the dough liquor. To better understand how the aqueous phase in doughs affects bulk rheology of doughs, a study was carried out by testing doughs made with a range of refined flours varying in protein content and growing locations of wheat. Doughs were tested for strain-hardening and elasticity by rolling a pad of dough using a single roll dough sheeter, instrumented with sensors that measured roll closing forces and dough thicknesses as dough was passed back and forth through gradually reducing roller gaps. In addition, a portion of sheeted doughs were ultra-centrifuged to obtain the dough liquor, the viscosities of which were measured using a Brookfield viscometer. These rheological measurements of doughs and dough liquors led to identifying scaling laws for dough’s extensibility and elasticity in terms of rheology of the continuous phase. Straight dough bake tests showed that the viscosity of dough liquors affected crumb quality of breads with pores in crumbs becoming smaller and dough becoming more elastic when liquor viscosity is reduced. It is known that bubbles grow via Ostwald ripening phenomena when dough rises. These results indicate that the deformability of gas bubbles affects dough’s elastic responses. Characterization of dough liquor has showed the presence of both arabinoxylans and beta-glucans. Thus, non-starch polysaccharides in flour could affect dough’s elasticity and baking qualities. The practice of characterizing doughs using the sheeter and analyzing dough liquors for composition and properties could potentially be transformational for the cereal industry.

Effect of dough conditioners on the stickiness and bread quality of intermediate wheatgrass (Thinopyrum intermedium) at three bran levels

J. Dhungana (1), C. Tyl (1), T. C. Schoenfuss (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Intermediate wheatgrass (Thinopyrum intermedium, IWG) is a perennial crop with environmental and nutritional benefits. However, its deficiency in high-molecular weight glutenins and high fiber content impair protein network formation, posing challenges for products requiring dough rising properties like bread. The objective was to evaluate the effect of five dough conditioners and bran refinement on stickiness and bread quality of IWG. IWG grown in 2015 in Rosemount (RMIWG) and Roseau (RSIWG), Minnesota, was fractionated into bran and endosperm. Bran was added to endosperm at 0% (0B), 50% (50B) and 100% (100B) of its original content. Dough conditioners were: wheat protein isolate, Arise 8000 (WPI) (MGP Ingredients,
Physical modification of cereal biopolymers during grinding – Suitable method for decoding structure–function relationships of wheat based matrices
S. JAKOBI (1)

Changes in dough and bread characteristic caused by the usage of physically evoked flour modification (PM) are extensively investigated. However, mechanistic relations to structural alterations of starch are still not understood in detail. Therefore, the aim of this study was to identify starch structures altering the hydration behavior of wheat flour (SRC, AACC 76-11) and thus matrix functionality, which was enabled by considering the entirety of evoked structural alterations caused by an impact (IG) and a cryogenic grinder (CG). Despite many non-causal relations of WRC and starch structures, only starch accessibility (determined by the accessibility of starch for enzymatic degradation) correlated directly with the hydration (R^2 = 0.771). This approach eliminates incoherent interpretations, as an observed linear correlation of gelatinization enthalpy and WRC of CG flours (R^2 = 0.841), since for IG flours no correlation was observed. Unexpectedly, flour particle size (laser diffraction, Malvern) was no adequate key figure for starch accessibility, whereby changes in starch-protein interactions attracted more attention. The application of specific PM stresses (mechanical, thermal, mechanical-thermal) on pure wheat starch and wheat flour, disclosed high starch–protein interactions causing changes in the gelatinization onset of the flour by thermal stress, which were not apparent for pure starch. For PM of flours, common methods for the approximation of particle functionality, as laser diffraction, were not suitable to predict the hydration behavior of flour in isothermal and heating processes. Ultimately, this is traced back to interactions of starch and surface proteins. Thus, physical modification of flour is a straightforward process to acquire fundamental knowledge in structural based functionality of cereal matrices.

Modification of bran properties by hydro, thermal and pressure treatments, and steamed bread dough preparation methods for improved quality
Y. Lee (1,2), F. Ma (2,3), J. A. Byars (4), F. C. Felker (4), J. A. Kenar (4), S. X. Liu (4), N. S. Mosier (5), J. Lee (1), B. K. Baik (6)

The outer layers of wheat grain, which are mostly separated out as bran during roller milling, deliver many nutritional benefits to whole wheat foods, but negatively affect product quality and sensory acceptance. The physicochemical properties of wheat bran, which are quite different from those of refined flour, are largely responsible for the undesirable characteristics of whole wheat foods; thus, the modification of bran is needed to improve its functional properties and whole wheat product quality. We pretreated wheat bran using various hydrothermal and pressure methods and determined the changes in hydration properties and composition, and identified the optimal water absorption and dough preparation methods for making whole wheat steamed bread (SB) from wheat flour and bran blends. Wheat bran obtained from a commercial flour mill was: hydrated to 70% moisture and autoclaved at 135°C for 5 min; roasted at 200°C for 15 min; jet-cooked at 140°C using a flow rate of 1 mL/min, and inlet and back pressures of 0.48 and 0.28 MPa, respectively; hydrated to 26% moisture and extruded through the barrel with the compartments heated to 60 to 120°C using a screw speed of 250 rpm; puffed
Enzymatic modification of cereal and legume materials for improved functionality in food applications

E. NORDLUND (1)
(1) VTT Technical Research Centre of Finland Ltd., Espoo, Finland

Due to the climate change, and partly also to public health concerns, there is an increasing need to move from animal-based diets towards diets rich in plant-based foods. However, plant-based materials do the function like animal-based counterparts, and there are technological, sensorial as well as nutritional challenges in development of plant-based raw materials in foods, and thus, the objective of the presentation is to show recent development in enzyme-based technologies in the different phases of plant-based ingredient and food processes. First, enzymes have potential in ingredient production. They can facilitate separation of food components. The presentation shows that hydrolytic enzyme treatments assist the liberation and separation of protein components from the cereal side streams. In addition, enzymes can enable removal of unwanted components (e.g. anti-nutrients) during ingredient production, and we have demonstrated, for example, that digestibility of protein in vitro was clearly improved by the degradation of bran cell walls by hydrolytic enzymes. Secondly, enzymes can be used in ingredient modification for improvement of the techno-functionality, sensory quality, and thus, applicability of the ingredient in the end product. The presentation indicates that crosslinking of oat proteins by enzymes can improve colloidal stability of the protein suspension. Then again, our data shows that phytase enzyme is efficient in degrading phytic acid and increased solubility of faba bean protein when studied.

Monitoring in vitro digestion of rice starch using capillary electrophoresis online

J. J. LEE (1,2,3), J. D. Oliver (2,3), R. Ward (4), V. Butardo (5), C. L. Blanchard (1,6), D. Waters (1), M. Gaborieau (2,3), P. Castignolles (2,3)
(1) ARC ITTC for Functional Grains, Wagga Wagga, Australia; (2) Australian Centre for Research on Separation Science, Western Sydney University, Sydney, Australia; (3) Western Sydney University, Medical Sciences Research Group, Sydney, Australia; (4) Yanco Agricultural Institute, Yanco, Australia; (5) Department of Chemistry and Biotechnology, Swinburne University of Technology, VIC, Australia; (6) School of Biomedical Sciences, Wagga Wagga, Australia

Starch digestion is integral to human nutrition where the digestibility of starches can have a profound impact on the individuals’ health. For example, resistant starches are promoted as dietary fibre to combat obesity due to its resistance to digestion. Human in vivo starch digestibility assays such as the widely used glycaemic index (GI) are expensive and prone to generation of variable data. The blood glucose response to any food indeed varies widely in large part because of the wide metabolism variability between individuals. For these reasons, more reproducible in vitro digestibility assays with relatively few tightly controlled components have been developed and are able to generate comparable results to in vivo GI. However, these methods are typically end-point assays which only monitor for glucose. Capillary electrophoresis (CE) with direct UV detection was demonstrated to be highly robust: it can quantify sugars released from in vitro digestion of heterogeneous breakfast cereals offline and monitor fermentation. In this study, CE with direct UV detection was applied to determine glucose as a digestibility marker for GI, and glucose precursor sugars, maltotriose and maltose as alternative digestibility.
markers that may further our understanding on carbohydrate digestibility such as predicting the fractions of
resistant starches. The release of these sugars was monitored with CE from in vitro digested rice starch online
with little to no sample preparation. The protocol was found to be robust and precise using various hydrolytic
enzymes. It can identify sugars with ≤1% relative standard deviation (RSD) and quantify sugars with ~10% RSD.
We envision this method will have an application in the determination of in vitro glycaemic response and in vitro
glycaemic potential between different rice varieties and other starchy foods and provide new insights into the
kinetics of in vitro starch digestion which can complement in vivo starch digestibility assays.

Technofunctional properties of bioprocessed wheat bran protein isolates
E. ARTE (1), X. Huang (1), K. K. Katina (1)
(1) University of Helsinki, Helsinki, Finland

Wheat bran contains up to 20% of proteins that unfortunately, have restricted solubility due to location inside
aleurone cells. By bioprocessing with starters and enzymes, the liberation and solubilisation of bran proteins can
be increased and exploited for a novel protein ingredient in the food industry. The aim of this work was to
evaluate the technofunctional properties of three bioprocessed protein isolates. Milled wheat bran was bioprocessed
for 8h, 35°C either with only starters (Str), or starters and cell wall-degrading enzymes Bel’ase B210 and
Viscoferm (Str+E), or starters, cell wall degrading enzymes and phytase (Str+E+P). After bioprocessing the
proteins were extracted by NaOH, precipitated (HCl, pH 5.5), dialysed and lyophilized. For comparison, a
control isolate was made without bioprocessing. The protein content, peptide content and amino acid profile of
the protein isolates were characterised. The technofunctional properties of the protein isolates were evaluated by
analysing foaming height and stability, and bubble stability (Krüss GmbH). Emulsion stability and particle size
of oil droplets (Mastersizer 3000, Malvern) were analysed from oil-in-water emulsions made with the isolates.
Finally, the bran protein isolates were added to wheat bread at substitution level of 12.2% (control) and 9.9% f.w.
(Str and Str+E) in order to provide 20% of the total energy from protein ("high protein"-claim). Bioprocessing
increased the protein content of isolates from 67.0% (ctrl) up to 81.7% (Str+E). The peptide content in control
isolate was 62mg/g and increased only in the Str-isolate to 75.8 mg/g. Bioprocessing increased the contents of
some essential amino acids, such as threonine and valine. Also, the foams made from bioprocessed isolates were
more stable when compared to the control isolate. The breads containing bioprocessed protein isolate had
slightly higher volume (ctrl: 2.4 ± 0.0 ml/g, Str: 2.7 ± 0.2 ml/g, Str+E: 2.6 ± 0.0 ml/g), however all the isolate
containing breads had lower volume compared to wheat bread (4.2 ± 0.0 ml/g). Adding protein isolate increased
the bread hardness but the softest bread texture of all high protein breads was obtained with Str and Str+E. The
results indicate that bioprocessing changed the protein conformation forming more stabilised foam structure by
increasing the rigidity as well as flexibility of the protein unfolding, subsequently stabilizing the gas-liquid
interface. Bioprocessing is a promising method to modify the physicochemical properties of wheat bran protein
isolates for increased functionality and use in food applications, such as high protein breads.

Effect on bakery products of changing chemical leavening ingredients for healthier nutrition statements
S. BOOK (1), W. Hidalgo (1)
(1) ICL Food Specialties, Webster Groves, MO, U.S.A.

Ingredients that contribute sodium in bakery products are scrutinized by formulators as they attempt to reduce
the levels on the nutrition labels in efforts to meet consumers requests for healthier products. An increase in
potassium is also considered by some to be better for you. The ingredients for chemical leavening (gas
production) typically contain sodium, but have non-sodium replacements that are not as common. The common
ingredient of sodium bicarbonate (SBC) can be replaced by potassium bicarbonate (KBC) and sodium acid
pyrophosphate (SAPP) by calcium acid pyrophosphate (CAPP). This study wanted to understand the effect of
changing ingredients on the rate of carbon dioxide production. Since this measurement is done using model
systems, it was also an objective to evaluate how this theoretical information is manifested in baked products. Gas
production was measured using specialized equipment that is a closed system with the ability to record the
change in pressure during mixing of wet and dry ingredients followed by holding at constant temperature. Two
different model systems were used to represent typical bakery products. One type of model system is a low
moisture low sugar dough-like mixture, which is similar to an American biscuit. Another very different type of
system is high moisture high sugar batter-like mixture, which is more like a high ratio cake. In the low sugar
system, CAPP produces a little less gas than SAPP. When KBC is used in place of SBC, the rate of CO₂ is slowed
compared to SBC. In the high sugar system, there are greater differences between CAPP and SAPP. The presence
of KBC instead of SBC slowed the rate of CO₂ release. This difference in rate of gas production was evident when
biscuits and cakes were prepared. Measurement of pH, size, and texture profile analysis quantified the complex
influence of leavening on final product characteristics. It is possible to create a formula that gives a 50% reduction
in sodium on a nutrition panel. The impact of these ingredient changes are not straight forward due to the
numerous ingredients and interactions in bakery products. Trials are required to understand how batters,
doughs, and final product characteristics will be effected when sodium containing leavening ingredients are
replaced with ones without sodium.
Cereals, gut microbiota and metabolomics in personalized nutrition
R. LANDBERG (1,2)
(1) Department of Biology & Biological Engineering, Food & Nutrition Science, Chalmers University of Technology, Gothenburg, Sweden; (2) Department of Public Health and Clinical Medicine, Umeå University, Umeå, Sweden

A poor diet and lack of physical activity are major risk factors for non-communicable diseases (NCD). Most population strategies to reduce NCD burden have used public health recommendations which are based on “one size fits all”, including recommendations on whole grains. The raise in NCDs worldwide, calls for more efficient prevention strategies. Whole grain foods represent a food group that has consistently been associated with lower risk of several NCDs in observational studies but results on intermediate endpoints in feeding trials have been more inconsistent, possibly due to the presence of responders and non-responders and that study designs have not taken this into account. Personalized nutrition, or precision nutrition, aims to provide customized dietary advice tailored to the individual for optimal health. Gut microbiota and its activity reflected in metabolome has recently gained attention as a target for personalized nutrition strategies. Several studies, but not all, have shown that gut microbiota composition at base-line affect the variation in postprandial glucose responses and long-term weight-loss in humans consuming high-fibre cereal diets. In a recent 8-wk cross-over intervention with lignan-rich whole grain rye vs whole grain wheat, among men with metabolic syndrome, we found significantly lower plasma LDL-cholesterol concentrations after whole grain rye intake compared with whole grain wheat intake (P<0.05). For the first time, we showed that this effect was dependent on the pre-treatment Prevotella-to-Bacteroides ratio in fecal samples. This provides support to emerging evidence that gut microbiota affects blood lipids in humans, and some suggested mechanisms will be discussed. Moreover, the potential of applying fecal and/or plasma metabolomics profiling to reflect gut microbiota composition and activity, as suggested in a recent Nature-publication, will be discussed and exemplified with novel data from our lab. This opens up the possibility of using metabolomics as a rapid tool to screen for gut microbiota composition and activities needed for development of optimal dietary strategies in personalized nutrition.

A high throughput small-scale milling protocol for evaluating durum wheat milling performance and semolina quality
K. Wang (1), D. Taylo (1)r, B. X. FU (1)
(1) Canadian Grain Commission, Winnipeg, MB, Canada

Milling properties are an important component of the commercial value of durum wheat and are thus important considerations in breeding programs. The key indicators of milling quality are semolina yield and ash content. Selection for milling performance is difficult because of the high labor and large sample requirement. Milling 2–3 kg of wheat on an Allis-Chalmers laboratory mill in conjunction with a laboratory purifier is a standard procedure for assessing milling quality in Canadian variety registration trials. This study proposes a rapid micro-milling protocol using a Quadrumat Junior (QJ) mill without purification to predict semolina yield based on 200 g of wheat. After grinding with a QJ semolina mill (Breaks 1–3) with the reel sifter removed, the resulting wholemeal was sifted through a universal laboratory sifter equipped with a bottom screen of 180 μm to remove flour and a top screen of 630 μm to retain the bran-rich fraction. Semolina materials between the two screens were collected. The bran-rich fraction was subject to further grinding with a QJ flour mill (Breaks 4–6) to release granulars (150 to 315 μm) which added 10–13% in semolina yield. By adding the recovered semolina from the bran-rich fraction to the granular products (180 to 630 μm) collected from the QJ semolina mill, the overall correlations (R²) for semolina yields improved from 0.56 to 0.78 between the proposed rapid protocol and the standard milling procedure. To further simplify the small-scale milling procedure, the amount of semolina in the bran-rich fraction was estimated since the proportion of semolina in that fraction was relatively constant for all genotypes examined, thus eliminating the need for additional milling of the bran-rich fraction. A model for predicting semolina yield was established using 29 durum lines and verified with varieties grown in two consecutive years. Multivariate regression analysis of the milling fractions revealed that the ease of separation of endosperm from bran layers, the endosperm-to-bran ratio and the friability of endosperm contributed positively to semolina yield. In addition, there were highly significant correlations (R² > 0.74) for semolina ash, yellowness, yellow pigment content and gluten index between semolina samples generated with this proposed rapid protocol and those generated with the standard laboratory procedure. This micro-milling protocol using a single QJ semolina mill without purification is rapid and reliable for selecting durum breeding lines with improved milling performance and for preparing semolina granulars for quality characterization.
Refining the solubility properties of wheat’s high molecular weight glutenin subunits

R. CAZALIS (1)
(1) University of Namur, Namur, Belgium

Numerous studies on HMW-GSs of wheat have been conducted in an effort to characterize their physicochemical properties. Nevertheless, they are far from being fully characterized because of the particularities of these storage proteins. To improve our knowledge of these proteins, we used two chitosan-based buffer systems to investigate their aptitude to resolubilize HMW-GS from a freeze-dried glutenin matrix. In the first place, acetate-chitosan buffer systems increase the protein content that is released from the matrix, compared to dilute acetic acid solution alone. This is a well-used medium applied in extraction methods. In the second place, NaPi-chitosan buffer systems that have neutral pH, and from 1 mM to 10 mM, release specific electrophoretic patterns, while the protein matrix is hardly soluble in the NaPi buffer alone under the same conditions. These last results highlight with additional clarity the differentiated interaction between the chitosan and the different protein subunits. Chitosan-based buffer systems then appear as new tools to differentiate HMW-GSs from a protein matrix, as far as they are more informative than the SDS buffer systems. By coupling them with an analytical technique that combines both a higher sensitivity and resolution, these new tools have the potential to better decipher the individual physicochemical features of the glutenic subunits distributed among the different wheat cultivars.

Dough rheology and bread-baking properties of processed pulse flours

E. GALLAGHER (1), K. A. Millar (1,2), R. Burke (2), S. McCarthy (1), C. Barry-Ryan (2)
(1) Teagasc Food Research Centre, Dublin, Ireland; (2) Dublin Institute of Technology, Dublin, Ireland

Pulse flours offer a protein-rich source of carbohydrates, dietary fibres and minerals, and can be used to develop protein-enhanced cereal based foods. The effects of processing (germination and toasting) of yellow peas (Pisum sativum) on flour characteristics and bread-making properties were investigated. Wheat flour was substituted with pea flour (30%) for the reformulation of white bread. Flour and dough properties were measured using a rapid visco-analyser, controlled stress rheometer and Mixolab®. Scanning electron microscopy images of the grains and flours were captured. Baking properties, including loaf dimensions, crumb structure, texture, staling and protein content were assessed. Confocal laser scanning microscopy (CLSM) images were obtained from the bread crust. Pasting profiles of the flours were significantly affected by the type of processing. Toasting increased peak viscosity (p<0.01), however final viscosity was reduced by both toasting and germination (p<0.01), indicating a reduction in starch swelling. This was confirmed by CLSM images of the bread crust. Toasting and germination increased the elasticity of the dough compared with untreated pea flour (p<0.001) and resulted in a stiffer or firmer dough (p<0.001). Toasted pea flour had higher water absorption (62.9%) compared with germinated and raw pea flour (p<0.05). Water absorption was significantly correlated to loaf specific volume (r² = 0.74) and density (r² = -0.86), as well as crumb hardness (r² = -0.86) and springiness (r² = 0.90). The germination process reduced water absorption and dough stability (p<0.05) compared to raw pea flour. Toasting improved dough stability (p<0.05) which positively correlated to crumb springiness (r² = 0.93) and cohesiveness (r² = 0.90). All loaves were stable for 3 days before bread staling occurred; the rate of which was not affected by processing. Using the colour difference equation, germination resulted in a noticeable difference in crust colour (>3), while not in crumb colour (<3); toasting resulted in a noticeable difference in crumb colour only. This was caused by significant changes to a* and b* values only (p<0.05). Partial replacement of wheat flour with pea flour resulted in a 22.1–30.0% increase in protein content of the bread, compared with a control white bread (p<0.001). Overall, toasting demonstrated the most potential in improving dough mixing properties and loaf quality of breads reformulated with pea flour. Results highlight the potential of protein-rich pea flour in bread making.

Point/counterpoint debate on glycemic index/glycemic load

I. MACDONALD (1)
(1) England

Although the term “Carbohydrate Quality” is a rather abstract concept that has little nutritional relevance, it can be valuable when trying to identify food sources of carbohydrate that are likely to make a positive contribution to health. One of the characteristics of carbohydrate containing foods which can contribute to this assessment of “Quality” is the Glycaemic Index (GI). Classifying foods on the basis of the GI is a strategy endorsed by many health organisations and public health bodies making recommendations for a healthy diet both for the management of diseases such as diabetes and cardiovascular disease, and for the wider healthy population. Despite this, the concept of GI attracts some controversy and there have been many attempts to discredit it. This controversy is at least partly the result of a failure to understand what the GI actually is, and that the glycaemic response to a food in an individual is not the same thing as the GI of that food. GI is clearly defined and its measurement should also follow clearly determined international guidelines. The variation in the glycaemic response to a carbohydrate containing food both within and between people and as a result of other foods consumed at the same time are important but do not negate the concept of GI. There is clear evidence in the
literature from both prospective cohort studies and randomised controlled trials that reducing the GI of the diet is associated with positive health benefits in clinical settings and for the general population. This presentation will consider the evidence underlying the value of using GI as an index of the “quality” of the carbohydrate foods being consumed.

**FODMAP levels of cereal-product ingredients and the impact of malting on the FODMAP profile**

L. ISPIRYAN (1), C. Axel (1), M. Heitmann (1), E. Zannini (1), E. K. Arendt (1,2)
(1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland; (2) APC Microbiome Institute, Cork, Ireland

Fermentable oligo-, di-, monosaccharides and polyols (FODMAPs) are poorly absorbed carbohydrates and have been shown to trigger symptoms of irritable bowel syndrome (IBS). The low FODMAP diet is an efficacious therapeutic approach to reduce symptoms of IBS. As cereal-based products are often very high in FODMAPs, research is needed to develop functional products suitable for the low FODMAP diet. Especially fructans and galacto-oligosaccharides (GOS) are known to occur in higher levels in cereals. However further investigations are required to classify ingredients for cereal products and identify technological approaches to reduce FODMAP levels. A selection of 35 different cereal flours, grains, malts and sprouts, pulse flours, gluten-free flours, protein isolates and other cereal product ingredients such as vital gluten, bran from oat and wheat as well as wheat starch, was screened for fructans, GOS and sugar alcohols, such as sorbitol, mannitol and xylitol and mono- and disaccharides glucose and fructose, and lactose. Furthermore the impact of malting on the FODMAP-profile was investigated by a comparison of the lab-scale malted wheat, barley and lentils with their corresponding raw material. All carbohydrates were analysed by HPAEC-PAD (high pressure anion exchange chromatography with pulsed amperometric detection) performed on a Dionex ICS5000+ chromatographic system using a CarboPac PA1 column and a CarboPac PA200 column. The amount of total fructans was additionally determined with an enzymatic assay. The FODMAP profiles of the ingredients, show, in accordance to other studies, huge differences for the different raw material analysed. Wheat-based flours contain higher amounts of fructans. Pulses, such as lentils, peas and fababean contains high amounts of GOS. Whereas gluten-free flours, for instance quinoa or rice flour, have very low FODMAP levels. Particularly fructans and GOS are the most relevant FODMAPs in cereals, while polyols, for example xylitol or sorbitol, have a low natural occurrence in cereals. The malting trials showed no difference in the fructan content of wheat and barley, but a significantly reduced GOS content in lentils. The conducted study provides, in addition to existing literature, further information about the FODMAP composition of cereals and other ingredients of cereal-based products. Furthermore, malting has been identified to be potentially a useful tool to reduce GOS in lentils. However further research is required to identify other (bio-)technological tools to lower the total FODMAP content in high FODMAP raw material, such as wheat and to enable the development of functional food products.

**Changes in dough macro-structure can influence celiac peptide release in breads**

O. J. OGILVIE (1)
(1) The University of Auckland, School of Biological Sciences, Auckland, New Zealand

It is generally accepted that food processing can alter the allergenicity of food proteins. This is because processing alters the structure of both food proteins and the food matrix through processes such as protein aggregation, protein unfolding and chemical modifications. These structural changes will alter the physicochemical state of protein allergen, which in turn may affect its digestibility and form on absorption/presentation to the immune system. Celiac disease is initiated by peptides released during the proteolytic digestion of gluten proteins (gliadin and glutenin) within the gastrointestinal tract. These gluten proteins play a central role in the structure of wheat based foods due to their ability to self-assemble into a higher order structure, called the gluten macropolymer; this polymer undergoes dynamic structural changes during the processing (mixing) of bread dough. The present study aimed to characterise and the release profile of peptides that are allergenic to celiac patients throughout digestion using both quantitative and untargeted LC-MS/MS; importantly, production of the immunogenic 33mer peptide was monitored. Model celiac peptides were not detected in the gastric phase of digestion. During the intestinal phase, under-mixed breads released celiac peptides, including the 33mer peptide, >20% slower than optimally and over-mixed breads. This trend was seen in all peptides quantitated. Confocal laser scanning microscopy (CLSM) was used to probe the effects of processing differences on gluten macropolymer structure in breads. The protein polymer in under-mixed doughs was distributed non-homogenously in relation to the starch granules. Conversely, in optimally- and over-mixed breads, polymer distribution was homogenous in relation to starch granules with finer polymer strands visible as mixing increased. These novel results suggest that changes to the macrostructure of gluten within bread may influence the speed of gluten digestion and in turn the release of peptides allergenic to celiac patients. This may alter the
The impact of delayed permanent water on grain quality parameters of rice grown in south-eastern Australia

R. M. WOOD (1), C. L. Blanchard (2), J. Mawson (2), D. Waters (1), B. W. Dunn (3), P. Oli (3)
(1) ARC ITTC for Functional Grains, Wagga Wagga, Australia; (2) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (3) NSW Department of Primary Industries, Yanco, Australia

Drought and competition from the environment, cotton and nut crops have seen a reduction in the availability of irrigated water for rice production in south-eastern Australia. The need to maintain yields with less water has led to the development of a water saving technique referred to as delayed permanent water (DPW). Conventional practices have rice permanently flooded throughout most of its life cycle whereas in DPW, the crop is intermittently irrigated during the vegetative stage and permanent water applied until just before the crop reaches the reproductive stage. This water saving practice improves nitrogen and water use efficiency of rice without a substantial reduction in grain yield. Although yield is important in rice production, Australia competes in the global rice market by producing high-quality grain for premium markets with financial penalties applied to growers who do not meet these high-quality standards. Consequently, even with high yields, grower’s returns can be negatively impacted by poor grain quality. Currently, the impact of DPW on grain quality of rice grown in south-eastern Australia is unknown. We compared the effect of DPW with conventional irrigation on grain quality parameters of four commercial Australian rice varieties (Medium grain varieties Sherpa and Reiziq and long grain Topaz and Langi). These data revealed DPW reduced rice grain breakage during milling for grain varieties Sherpa ($p < 0.05$) and Topaz ($p < 0.01$). Protein content was significantly positively correlated with the head rice yield (HRY; the proportion of unbroken grain expressed as a percentage of harvested grain) for all varieties in both irrigation treatments; however, protein content did not differ between the irrigation treatments. When analysing cooking parameters, RVA peak viscosity was lower in the DPW treatment compared to permanent flood which increased RVA setback for all varieties despite no differences in amylose and total protein content. These data indicate that water stress during the vegetative stage influences the partitioning of carbon and nitrogen to the rice grain which alters grain quality.

Phenolic compositions and antioxidant activities of Kansas hard red winter wheat varieties

W. Tian (1), Y. LI (1)
(1) Kansas State University, Manhattan, KS, U.S.A.

Whole wheat consumption has been associated with reduced risk of chronic diseases. Hard red winter wheat is the major crop in the state of Kansas, with little information available about its phytochemical profile and antioxidant activity. The aim of this study was to determine phenolic content, flavonoid content, free radical scavenging activity, metal chelating activity as well as phenolic acid composition of 12 top hard red winter wheat varieties grown in Kansas (accounting for more than 50% seeded coverage in 2017). Free phenolic content ranged from 87.66 (LCS Wizard) to 155.9 (Byrd) mmol gallic acid equivalence/100g grain. The bound phenolic content ranged from 547.1 (Jagger) to 768.1 (WB Grainfield) mmol gallic acid equivalence/100g grain. The free flavonoid content ranged from 9.8 (WB Grainfield) to 22.1 (Jagger) mmol catechin equivalence/100g grain. The bound flavonoid content ranged from 112.4 (Jagger) to 249.9 (SY Monument) mmol catechin equivalence/100g grain. The radical scavenging activity was evaluated using 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay and 2,2′-Azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) assay. The metal chelating activity was assessed using a 2,2-bipyridal competition assay with ethylenediaminetetraacetic acid (EDTA) as a standard. The DPPH value of the free fraction ranged from 280.7 (T158) to 399.7 (2137) mmol vitamin C equivalence/100g grain. The DPPH value of the bound fraction ranged from 2,361.7 (LCS Mint) to 3,326.6 (T158) mmol vitamin C equivalence/100g grain. The ABTS value of the free fraction ranged from 641.8 (LCS Wizard) to 1,181.8 mmol (Byrd) mmol Trolox equivalence/100g grain. The ABTS value of the bound fraction ranged from 4,207.4 (LCS Mint) to 7,750.8 (SY Monument) mmol Trolox equivalence/100g grain. The metal chelating activity of tested samples ranged from 103.2 (Tam204) to 315.3 (Byrd) mmol EDTA equivalence/100g grain. Trans-ferulic acid, vanillic acid, $p$-coumaric acid and syringic acid were detected. Trans-ferulic acid was the predominant phenolic acid in whole wheat. The total $trans$-ferulic acid ranged from 138.07 (SY Monument) to 204.9 (Fuller) mmol/100g grain. In summary, the results of this study suggested that photochemical profiles and antioxidant activity of whole wheat are highly dependent on their genotypes. Breeders and food industry may be benefited from a comprehensive understanding of phytochemical content and antioxidant activity of different wheat varieties in order to develop better health-beneficial verities and food products.
Holistic formulation approaches in using starch-rich pulse flours in various food application linking structure and function
J. MALISKA (1)
(1) Ingredion Germany GmbH, Hamburg, Germany

The increased utilization of pulse proteins by the food industry over the last years has renewed the interest in the application of starch-rich pulse flours and pulses starches, by-products of pulse protein dry or wet fractionation processes. In this study, functional properties of starch-rich pulse flours from pea, lentil and faba bean have been evaluated, including gelling properties as well as water and oil holding capacities. Additional processing has been applied to remove the beany and earthy notes typically associated with pulses, which used to limit the use of pulse flours in specific food formulations. The performance of starch-rich pulse flours has been studied in several applications. In gluten-free baked goods including bread, tortilla and cracker, they have been used as base flour providing structure, color and texture benefits. In bread and cracker, they have been used to partially replace wheat flour to enhance the nutritional profile without significantly affecting overall aspect, texture and sensory attributes. In batters and breadcrings, it was demonstrated that pulse flours can be used to reduce fat uptake in the finished product, while providing an even coating, a desirable texture and surface color development. It was also shown that starch-rich pulse flours can be successfully used in sauce applications along with native functional starches to replace wheat flour while providing acceptable color, texture and freeze-thaw stability. Studies concluded that starch-rich pulse flours can be successfully used in low and high moisture food applications without major modifications to the formula or process, while maintaining or improving texture, appearance and organoleptic properties.

Effects of ingredients and processing conditions on the expansion capacity of bread doughs
M. Aigbe (1), M. Albasir (1), G. M. CAMPBELL (1)
(1) School of Applied Sciences, University of Huddersfield, Huddersfield, U.K.

The appeal of raised bread derives from the ability of the dough matrix to expand and retain fermentation gases produced by yeast during proving. This viscoelastic character of the dough arises from the wheat gluten proteins, modified by processing and by interactions with other ingredients. Dough rheology, its measurement and its relations to gluten structure and to bread quality have formed one of the central themes of cereal science over the last century and more. However, measurement of rheology of yeasted doughs is problematic due to the presence of a significant and changing void fraction of gas in the dough, while the metabolic products of yeast also influence the dough rheology. The Dynamic Dough Density (DDD) is a sensitive system that measures the ability of doughs to expand under conditions mimicking proving, by monitoring the changing density of carefully prepared samples of yeasted doughs. As well as indicating the maximum ability of doughs to expand, which is a directly relevant measure of the dough’s quality in relation to breadmaking, the DDD system also gives insights into the partitioning of carbon dioxide between the gas phase and the liquid phase of the dough over the course of fermentation. The DDD system has been applied to understand the effects of fibre addition on dough expansion; in general, fibres damage the ability of doughs to expand, with the effects dependent on the particle size and origin of the fibre. The system has also been applied to investigate the effects of retarding of doughs on their subsequent expansion, and the development of dough rheology via sheeting. Increasing retardation time resulted in an increase in dough expansion capacity, with retarded doughs also taking longer to reach maximum expansion. Passing doughs repeatedly through sheeting rolls enhanced the ability of doughs to expand, up to a point and depending on the roll gap and number of sheeting passes, and offers a low energy alternative to dough development via extended mixing.

Hardness development of cooked noodles during storage: Starch retrogradation and the disturbance from gluten network formation
M. LI (1), A. Tang (2), D. Lu (2), Y. Wei (1)
(1) Institute of Food Science and Technology, Chinese Academy of Agri Sciences, Beijing, China; (2) Food Science and Engineering College, Beijing University of Agriculture, Beijing, China

Hardness development is important for monitoring the shelf-life of ready-to-eat cooked noodles. Starch retrogradation, water absorption, and gluten network formation are the three factors that may influence the hardness development for cooked noodles during storage. This study aims to investigate the role of crystalline structure on the noodle hardness development during storage (0–21 days, 4°C). Pregelatinized wheat starch (PGWS) (0, 10, 20, and 40%) was used to produce reconstituted noodles with varied crystalline ratios (17.25, 14.76, 12.94, and 11.88%). Texture properties, morphology, starch/protein distribution, short range ordered structure (SROS) and crystalline structure changes of cooked noodles were analyzed systematically using a texture analyzer, SEM, FTIR microscope, and DSC, respectively. The addition of the PGWS led to a significant decrease in hardness (599–500g) for noodles with a decreased crystalline ratio. With the prolongation of storage time, the hardness of cooked noodles with different ratios of PGWS increased differently, that the hardness of noodle with 0% PGWS increased fast in 0–14 days (599–1,847g) and remained unchanged afterwards, noodles
with 10–20% PGWS increased fast in the first 4 days, and noodles with 40% PGWS increased significantly during 0–2 days. The SROS of noodles showed similar trends with the noodle hardness development; in addition, the enthalpy for retrograded starch were correlated well with noodles with 0, 10, and 20% PGWS, but not for noodles with 40% PGWS. On the other hand, the gluten network was formed differently when the PGWS was added in different ratios, that noodles with 40% PGWS showed a denser inner structure (SEM) with some clustered structures, and the distribution of protein/starch (FTIR microscope) was less even than noodles with 0 and 10% PGWS. This may disturb the starch retrogradation and slow down the hardness increase. This study confirms the recrystalization of gelatinized starch leads an increase in the hardness during noodle storage; however, pregelatinized starch affects the inner structure of noodles and slows down the hardness development. More direct evidence on the correlation between the crystallinity and noodle hardness will be further explored.

Optimization of formula and processing condition for making gluten-free rice bread with tamarind gum
Y. E. HONG (1), Y. Zhao (1), Y. Moon (1), S. Jeon (1), S. Angalet (2), K. A. Lee (3), M. Kweon (1)
(1) Pusan National University, Busan, South Korea; (2) Angalet Group International, Elmhurst, IL, U.S.A.; (3) Soonchunhyang University, Asan-si, South Korea

The demand for gluten-free foods is increasing continuously not only by people with a gluten allergy, but also due to the influence of the media on health improvement by reducing gluten consumption. Rice is a staple crop in many Asian countries and popularly used for gluten-free bakery products. For making bread using rice flour, gums such as carrageenan, xanthan gum, guar gum, pectin, hydroxypropyl methylcellulose (HPMC), and methyl cellulose (MC) have been used extensively as gluten substitutes to provide the viscoelastic properties. Tamarind gum, which was recently approved as generally recognized as safe (GRAS), has shown the potential applicability for gluten-free bread with wheat starch, but not with rice flour yet. In order to apply tamarind gum successfully for making gluten-free rice bread, an experimental design by a factorial design including a center point was used for optimization of formula and processing conditions. Gum concentration (GC), water amount (WA), mixing time (MT) and fermentation time (FT) were selected as factors and two levels were used for each factor: 1, 2% for GC; 80, 100g for WA, 5, 10 min for MT; and 30, 60 min for FT. For quality evaluation, pH of batter of rice bread after fermentation, bread moisture, bread volume and firmness were measured. Based on statistical analysis of the data, significant factors were identified for each quality parameter. Fermentation time influenced significantly pH of batter after fermentation that pH of batter decreased as increased fermentation time. Water amount was the most significant factor contributed to bread moisture that showed higher bread moisture by formulating with high water amount. Specific gravity of batter was not affected by any factors tested. Bread volume was influenced significantly by fermentation time and water amount. With increasing fermentation time and water amount, bread volume become bigger. Bread firmness was affected significantly by water amount and fermentation time. As increasing water amount and fermentation time, bread become softer. Gum concentration and mixing time did not show any significant effect on rice bread quality. Specially, the tested gum concentration in this study is relatively low due to FDA allowed usage level, which might not exhibit a significant effect of gum concentration. Overall, 1% gum, 100g water, 7.5 min mixing time and 60 min fermentation time were the optimized formula and processing conditions for maximizing bread volume and minimizing bread firmness.

Molecular structures of starch in wild rice and its potential health benefits
R. J. Henry (1), T. Tikapunya (1), H. Smyth (1), A. Furtado (1), A. I. M. Moner (1), R. G. Gilbert (1,2), L. Huang (2), Q. Liu (1,2)
(1) Queensland Alliance for Agriculture and Food innovation, University of Queensland, Brisbane, QLD, Australia; (2) Crop Genetics and Breeding, College of Agriculture, Yangzhou University, Yangzhou, Jiangsu Province, China

The structure of starch influences the quality of the grain and may also contribute to the rate of digestion of the starch. Starch properties in rice and other cereals have been explored by inducing mutations or loss of function in genes in the starch biosynthesis pathway. These experiments result in altered starch structures and properties. However, these disruptions of starch biosynthesis also often cause a reduction in starch production and lead to loss of grain yield. Much has been learned about the role of specific enzymes in starch synthesis from these studies but the products are not often useful in cereal production. Wild rices represent a source of novel variation in starch structure that has evolved under natural selection and as a result is not necessarily associated with any loss of yield. We have explored variation in novel wild rice populations by sequencing their genomes and relating genetic variation in gene sequences to starch structures. Novel sources of diversity resulting in very high amylase have been identified.
Gluten-free wonton dough wrapper with red kidney bean flour: Shear and axial compression strain analyses

P. CHOMPOORAT (1,2), Z. J. Hernandez-Estrada (2), P. Rayas-Duarte (2)
(1) Maejo University, Chiang Mai, Thailand; (2) Oklahoma State University, Stillwater, OK, U.S.A.

Red kidney bean, a good source of protein and fiber, could be utilized as an alternative ingredient for gluten-free wonton wrapper. Combination of red kidney bean and rice flours will form different wonton dough structures due to their differences in protein and amyllose and amylopectin. Comparison of deformation forces could reveal insights to the viscoelastic behavior of gluten-free wonton dough wrapper. The objective of this study was to investigate viscoelastic properties of gluten-free wonton dough wrapper containing red kidney bean flour using small and large deformation tests. Gluten-free wonton dough was prepared with five levels of red kidney bean substitution (0, 10, 30, 50, 70 and 90%, based on rice flour). Experimental compliance and strain responses were tested with a Burgers model consisting in a Kelvin and Maxwell model in series with one Kelvin element ($r^2>0.99$, P<0.0001) to obtain coefficients of pure elastic deformation (spring), viscoelastic deformation (spring-dashpots elements) and pure viscous flow (dashpot). The regressed parameters of gluten-free wonton dough wrapper from large deformation (compression-recovery test; 3 N for 5 s compression and 55 s for recovery) and small deformation (creep-recovery test, 20 Pa shear stress for 100 s and recovery at 0 Pa for 100 s) were evaluated. Furthermore, firmness and stretchability of gluten-free wonton dough wrapper were analyzed by breaking point in a compression test (TA-XT2 Texture Analyzer). The results indicated that the coefficients of all elements changed with substitution level of red kidney bean flour in gluten-free wonton dough. With 30% red kidney bean flour substitution, gluten-free-wonton dough decreased stiffness by 57.8% compared to control; while, 90% substitution produced the strongest dough structure indicated by low pure elastic deformation and high pure viscous flow parameters from both large and small deformation tests. However, there was no significant difference with other substitution levels of red kidney bean. There was a linear softening effect with the addition of red kidney bean flour in wonton dough measured by the breaking point of the dough. Stretchability of wonton dough was reduced with the addition of RKB flour (up to 45.8%). Overall, the shear and axial compression strain tests (compression-recovery test) revealed similar information about 30% red kidney bean flour being the limit for changes in the structure of gluten-free wonton dough before it turns too stiff. Reduction of stretchability with 30% red kidney bean flour confirmed the limit for substitution for the expected attributes of wonton dough.

Value-adding strategies for deoxynivalenol contaminated grain: Characterization of wet milling fractions

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

Fusarium head blight can cause deoxynivalenol (DON) accumulation in grains. Contamination with DON causes great economical loss to producers since it is a toxin. Our objective was to use wet milling process to add value to DON contaminated grain by obtaining DON-free and functional starch and gluten. Hard red spring and durum wheat samples, naturally contaminated with DON, were dry milled into farina and semolina, respectively. The fate of DON during fractionation by wet milling was investigated. The farina/semolina fractions underwent three bench-scale wet milling processes: Martin, medium shear, and high shear. DON levels were assessed on wet milled fractions by gas chromatography with electron capture detection. Determination of starch damage, pasting properties, gelatinization, $^{1}H$ nuclear magnetic resonance and scanning electron microscopy analysis were performed on starch. The gluten fraction was analyzed using size exclusion HPLC and rheometer. For both fractions, protein content was determined. DON concentration in farina (2.45–3.43 mg kg$^{-1}$) and semolina (8.38–9.18 mg kg$^{-1}$) exceeded the security threshold for human consumption. After wet milling, DON was not detectable in starch and protein fractions. Starch produced from the medium shear process, had significantly (P≤0.05) lower protein contamination and higher pasting temperatures, while transition temperatures significantly (P≤0.05) decreased compared to the starch from other two wet milling procedures. Regarding gluten, protein extraction was lower when medium and high shear processes were applied. Higher polymeric proteins percent was obtained when medium shear process was applied. Overall, in fractions for human consumption, DON was not detectable in the starch or protein fractions after wet milling. Demonstrating, wet milling is a novel technique for giving some added value to contaminated grain.

Physicochemical properties of granular cold water-soluble starches prepared by alcoholic-alkali treatment

J. H. LIN (1), Y. H. Chang (2), C. L. Lin (2), X. W. Xue (2)
(1) MingDao University, Changhua, Taiwan; (2) Providence University, Taichung, Taiwan

Alcoholic-alkali treatment (AAT) is a means of preparing granular cold water-soluble starch (GCWS), and the obtained is of a smooth mouthfeel and has a viscosity similar to that of cooked native starch. In this study, potato, tapioca and mung bean starches were treated in 50% alcohol solution containing different concentrations (1, 3 and 5%) of NaOH at 30°C for 1 h. Gelatinization thermal properties, cold water solubility and paste light transmittance of starches before and after AAT were compared. The gelatinization temperatures and enthalpy change ($\Delta H$) of potato starch showed slight decreases after AAT with 1% NaOH. However, gelatinization temperatures of tapioca and mung bean starches increased after AAT with 1% NaOH. The $\Delta H$ of tapioca and
mung bean starches after AAT with 1% NaOH were similar to those of the native counterparts. No obvious endothermic peak was found for all starches after AAT with more than 1% NaOH. The cold water solubility of all native starches and the starches after AAT with 1% NaOH were below 5%, while more than 60% solubility was observed for the starches after AAT with 3% or 5% NaOH. Light transmittance of GCWS pastes was found to decrease when AAT with 1% NaOH was employed, but was identical to or higher than the native counterparts when 3% NaOH or more was employed. Moreover, the extent of increase in light transmittance of GCWS paste was found to be most dramatic for mung bean starch, followed by tapioca starch and then potato starch. The findings of this study suggest the addition of 3–5% NaOH during AAT is advantageous to the preparation of GCWS and the clarity of the resulting paste. Furthermore, the effect is particularly evident in starch, such as mung bean starch, with a rigid crystalline structure and consequently a restricted swelling characteristic.

**Microstructure, rheology and baking performance of wheat doughs enriched with soluble dietary fibres and bio-processed wheat bran**

S. RENZETTI (1)

(1) Wageningen Food and Biobased Research, Wageningen, Netherlands

This study provides an overview of the influence of isolated soluble fibres and arabinoxylans (AX) from bio-processed wheat bran on dough properties. For isolated fibres, different FOS’s and inulin’s were used achieving variation in molecular weight (Mw) from 700 up to 4,000 g/mol. Isolated fibres were added at 9% enrichment level (baker’s percentage). For wheat bran, enzymatic treatments with xylanases, lactic acid bacteria (LAB) pre-fermentation of bran and combination of enzymatic and LAB fermentation were studied as means to vary soluble extract of bran and bran properties. Wheat bran was added at 18% enrichment level. For isolated soluble fibres, bread specific volume (SV) showed a maximum for Mw around 1000 g/mol, with substantial decrease at higher Mw. Variations in crumb hardness were not related to changes in density. On the contrary, hardness was increased with increasing Mw, suggesting a mechanical reinforcement of the crumb cell walls. Elongational properties of dough showed a maximum in extensibility in the Mw ranges corresponding to the observed maximum in bread SV. For wheat bran, a reduction of 43% in SV was observed with the enrichment of untreated bran. On the contrary, bran fermentation showed a substantial improvement in bran functionality, with only 16% reduction in SV with LAB pre-fermented bran. Variations in crumb hardness were strongly related to the observed changes in crumb density. Enzymatic and LAB fermentation promoted depolymerisation of the cell wall structure of bran resulting in solubilisation of AX and changes in the molecular structure of the soluble AX, as indicated by changes in A/X ratio. As indicated by sorption isotherms and water holding capacity characterization of the different brans, the depolymerization enhanced interactions with water at molecular level, as in soluble fibres, while reducing water absorption driven by morphological properties. LAB fermentation of bran showed the strongest effects on enhancing molecular binding of water. The strong depolymerisation effect of LAB fermentation was also reflected in the improved elongational behaviour of the dough as compared to the untreated bran. For both isolated soluble fibres and wheat bran, CLSM analysis of wheat dough showed substantial differences in gluten network structure depending on the characteristics of the dietary fibres added. Investigations are currently ongoing on the effect of the studied fibres on the extent of gluten polymerization in the wheat dough. Overall, this study provides new insights on the techno-functionality of different dietary fibres in relation to specific physical and compositional properties.

**Can the particle size of apple pomace modify the quality of enriched sugar-snap cookies?**

A. F. Rocha Parra (1), M. Sahagun (2), P. D. Ribotta (3), C. Ferrero (1), M. GOMEZ PALLARES (2)

(1) Universidad Nacional de La Plata, La Plata, Argentina; (2) University of Valladolid, Palencia, Spain; (3) Universidad Nac De Cordoba, Cordoba, Argentina

Apple pomace (AP) is a by-product, rich in dietary fiber, that is generated in large quantities by the juice industry. The objectives of the present work were to evaluate the effect of the particle size (d(4,3) = 362–840 μm) and the level of replacement (15% and 30%) on the quality of sugar-snap cookies with AP, in terms of dough viscoelasticity and physical properties, color, texture and overall acceptability of the final product. The present study used dehydrated AP that was ground to three different particle sizes (d (4.3) = 362, 482, 840 μm). Wheat flour (WF) showed lower values of hydration properties (WHC and WBC) than AP. Particle size had a strong influence on the hydration properties of AP since the water holding and water binding capacities significantly increased as the particle size decreased. The particle size of AP also influenced the viscoelastic behavior of dough at both levels of replacement, 15% and 30%; when the particle size decreased, the value of the dynamic moduli (G’ and G”) increased. This change in dough rheology can be associated with a reduced spread during baking. Cookies prepared with AP of the smallest particle size (d(4,3) = 362 μm) showed a significant increase in hardness compared to cookies with AP of the largest particle size (d(4,3) = 840 μm). The hardness significantly and positively correlated with both dynamic moduli and negatively with the loss tangent, indicating the strong influence of dough viscoelasticity on the hardness of the final product. Cookies with addition of AP showed lower values of L* and b*. The higher the level of replacement the lower values were obtained. There was not a clear trend when using different particle sizes. Addition of AP on sugar-snap cookies led to a similar global
acceptability than for control cookies. The sensory attribute that most differentiated the cookies with AP was their pleasant taste (the sensory evaluation was carried out only on the cookies with a 15% replacement level, since cookies with 30% replacement presented an excessively hard texture and also had an excessively sweet and bitter taste). These results suggest that the incorporation of a byproduct of the juice industry such as apple pomace could be a good alternative for fiber enrichment and improving taste.

The use of carriers for licorice root extract to improve dispersibility, solubility and overall oxidative stability in bakery products

J. WHITTINGHILL (1), B. Williams (1)
(1) ICL Food Specialties, Webster Groves, MO, U.S.A.

Extracts of plant materials and herbs rich in polyphenolics are increasingly of interest to the food industry because they have the capability to retard oxidative degradation of lipids and thereby improve the quality and nutritional value of food. Licorice extract has been used for centuries for medicinal and health purposes. Licorice extract has been shown to contain very powerful antioxidants. However, the solubility of licorice extract is poor in water and oil. The objective of this study was to evaluate different carriers to improve dispersibility and solubility of licorice extract. An additional objective was to evaluate synergistic potentials for enhancement of oxidative stability in oil. The effectiveness of licorice extract as an antioxidant in a high fat non-baked emulsion and a solid matrix baked model application was determined against control samples containing no licorice extract. The oxidative stability was measured using induction times on the Rancimat, while the Peroxide value and p-Anisidine value were used to validate the findings. Solutions containing 40% licorice extract in propylene glycol and 30% licorice extract in glycerol were prepared and used in the two bakery applications to achieve a concentration of 200 ppm, 500 ppm and 1,000 ppm in the product. The oils were then extracted from the applications and analyzed by Rancimat to determine the oxidative stability by induction time analysis conducted at either 110°C or 120°C and an airflow rate of 20 L/h. The results show that the oxidative stability in the bakery applications was significantly increased, ranging between 122% to 244% using propylene glycol and 148% to 270% using glycerol when compared to control. When compared to other natural antioxidants such as rosemary, green tea and mixed tocopherols, the effect was similar or better. Peroxide and p-anisidine tests showed significant improvement in the oxidative stability of the oils extracted from the bakery products containing licorice extract. Additionally, the use of ascorbic acid or citric acid with the licorice extract either doubled or tripled the induction times independent of the type of carrier. The licorice extract in either of the carriers had no impact on the sensory characteristics of the baked products. The findings from this study show that licorice extract can be made more soluble for improved functionality to increase oxidative stability to baked goods and thereby extending the shelf life.

Development of a method to assess wheat varieties for potential end use

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

The gluten quality and functionality needed in wheat and flour vary with the requirements of the end-products and their manufacturing process. Throughout the grain supply chain, assessment of these properties is essential to maximise process consistency, end-product quality and profit. Gluten properties and potential use of the wheat for a specific application is often assessed using a substantial quantity of grain or flour and the methods are often time-consuming. In many situations such as the early stages of a wheat breeding programme, the amount of grain or flour available maybe limited. Equally, in situations such as mill intake, the time for assessment of gluten quality is restricted. As a result, the availability of a quick and reliable analytical method allowing the assessment of gluten quality and potential end-product application with a small amount of grain or flour has been the focus of development activities. A method was developed involving the GlutoPeak instrument to test ground wheat and white flour samples. Less than 10g of sample was mixed with water under constant mixing speed and temperature conditions. The torque behaviour of the slurry including gluten aggregation and collapse was monitored over 5 minutes. The water to sample ratio as well as mixing speed were investigated. The potential for the method to discriminate between wheat varieties with different functionalities was studied in 50 wheat samples including a majority of established UK wheat varieties classified in groups based on their end-use and made of hard and soft wheat. Wheat samples from other European countries and from North America were also included. For UK wheat varieties, statistical analysis of the data indicated the potential for the method to predict the end-use grouping of a wheat variety in 90% of the cases and to provide valuable information when assessing potential end-use.
Stability of selected B vitamins in thermally treated and dried pinto beans
V. A. Porterfield (1), M. L. DUNN (1), L. K. Jefferies (1), D. L. Eggett (1), O. A. Pike (1)

(1) Brigham Young University, Provo, UT, U.S.A.

Cooked beans, that are subsequently dried, provide products that are more convenient for consumer preparation. Drying can be accomplished using various methods, and a limited amount of research has addressed the effect of drying on nutritional value. This study compared thiamin, riboflavin, folate and vitamin B6 contents of traditionally simmered dried pinto beans to those of retort-canned beans, and two varieties (flaked and extruded) of thermally-processed and dried beans. Subsequently prepared/reheated products from all treatments were also evaluated. Vitamin content on a dry-weight basis was measured using AOAC standard methods with minor modifications. Between the four process treatments, there were no significant differences in vitamin content at the most commonly consumed stages (simmered, canned reheated, dried-flaked reheated, and dried-extruded reheated), except that thiamin content was higher in simmered beans, and vitamin B6 content was higher in dried-flaked reheated beans. Within treatments, comparing the raw control to the most commonly consumed preparation stage, all treatments resulted in significant vitamin B6 losses, ranging from 59 to 84%. Other significant differences within treatments included 32% thiamin loss in dried-flaked reheated beans, and 43% folate loss in dried-extruded reheated beans. Compared to the initial processed stage of each treatment, subsequent reheating did not cause a significant decrease in vitamin content. Drying of pre-cooked pinto beans does not appear to have a detrimental effect on vitamin content beyond that observed in other thermal treatments, and provides products that may be consumed more frequently because they are more economical to transport and more convenient to prepare.

Current issues in Europe related to food allergens
B. POPPING (1)

(1) FOCOS, Alzenau, Germany

European regulations are one of the most extensive when it comes to labelling of food allergens as part of the ingredient list. What has not been addressed by the regulation is the adventitious contamination of products with allergens during transport, storage or manufacturing. As a consequence, there is a proliferation of “may contain” labelling (aka Precautionary Allergen Labeling or PAL). The European Food Safety Authority (EFSA) has failed to issue threshold values or agree at minimum to reference doses. Therefore, different standards exist in the industry, and most recently also food authorities in EU member countries have started to establish “safe level” reference doses. In the absence of a Europe-wide recommendation by EFSA, these reference doses differ between neighbouring countries by as much as 100 times. Some countries’ authorities have recommended reference doses so low that most analytical methods will not be able to detect at those levels. In addition, there is a lack of reference materials for such allergen testing methods, which increases the variability. Beyond this, between detection methods, results can vary by more than 50%, often due to different calibrators and different antibodies used. The presentation will look at these challenges and present current approaches to address them.

The impact of late maturity alpha-amylase and low falling number on baking quality
M. Newberry (1), A. Zwart (2), A. Whan (1), J. C. Mieog (3), D. Diepeveen (4), C. A. Howitt (1), J. P. F. RAL (1)

(1) CSIRO Agriculture and Food, Canberra, Australia; (2) CSIRO Data 61, Canberra, Australia; (3) CSIRO Agriculture and Food, Acton, Australia; (4) Department of Primary Industries and Regional Development, Bentley, Australia

Late maturity alpha-amylase (LMA) is a recently identified quality issue that is now receiving increasing attention and whose prevalence is now seen as impeding the development of superior quality wheat varieties worldwide. LMA is a genetic defect present in specific wheat genotypes and is characterized by abnormally elevated levels of the high pI TaAMY1 alpha-amylase, triggered by environmental stress at precise grain developmental stage. TaAMY1 remains present in the aleurone layer throughout grain maturity and harvest. To the exception of the elevated level of alpha-amylase, LMA affected grain does not present any visible detrimental effect on grain morphology, properties or germination. However, elevated level of alpha-amylase lowers Falling Number (FN) test (a test used to detect sprouted grain) at receival, causing a down-grading of the grain, often to feed grade, thus reducing the farmers’ income. In Australia, if grains present a low FN (below 300), there is a potential $20-50/t penalty to growers due to discounting superior milling wheat classes to feed grade. In the United States, the Pacific North West was severely affected during the 2016 harvest—with losses estimated to be in the order of US$140 millions. This severely impacts grower profitability through increasing risk of a reduced grain value. This downgrading is based on the assumption within the grain industry that a low FN represents poor quality grain. Consequently any wheat line possessing low FN or high alpha-amylase levels is automatically considered a poor bread wheat despite there being no published evidence to date, to show that LMA is detrimental to end product quality. To evaluate the validity of this assumption we performed a comprehensive evaluation of baking properties from over 200 RILs from Multi-parent Advanced Generation Inter-Cross (MAGIC) wheat population grown at three different sites. The rationale behind the use of tall lines was to take advantage of the high LMA
sensitivity of non-Rht background and to overcome the impediment of environmental stress required to trigger LMA. LMA levels were assessed along with quality parameters including end product functionality such as bread loaf volume and weight, crumb firmness, oven spring, slice area and brightness and gas cell number using AACC Approved Methods 10-09.01 and 10-10.03. No consistent or significant genetic or phenotypic correlation was found between LMA related Falling Number and any of the quality traits. This study provides the first direct evaluation as to whether elevated levels of alpha-amylase found in LMA impact baking quality.

Chemical changes over extended storage of intermediate wheatgrass (Thinopyrum intermedium) partially refined and whole flour

J. A. HAYEK (1), A. A. Schneider (1), B. Ismail (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Intermediate wheatgrass (IWG) is a perennial grain that has environmental benefits, and has shown promise in its development as an ingredient. However, rancidity and loss in antioxidants may occur during storage, due to high fat content in the grain and in resultant flour. The objective was to determine the impact of lipase and lipoxygenase on rancidity during storage as flour and impact of antioxidants mitigating oxidative rancidity. This study also explores steam treatment of grains to extend the shelf life of flour, by inactivation of lipase and lipoxygenase. IWG and hard red winter wheat (HRW) grains were stored for one year under refrigerated conditions and then were subjected to steam treatment or left as is. The grains were milled to flour with various degrees of refinement (whole and partially refined, 75% initial bran content) and stored at room temperature for an additional six months at 43% relative humidity. To determine an optimum steam treatment, grains were steamed for 0, 30, 60, 90, 120, and 180 seconds by steaming grains in a sieve over a boiling water bath. Resultant flour was analyzed over storage for enzymatic activity (lipase, spectrophotometrically; lipoxygenase, ferrous oxidation-xylene orange assay), rancidity (free fatty acids, titration; peroxide value, acetic acid-chloroform method), antioxidant content (carotenoids and hydroxycinnamic acids, both by high performance liquid chromatography), and antioxidant activity (1,1-diphenyl-2-picryl-hydrazyl, DPPH, radical scavenging and leucumethylene blue assays). Steam treatment of 120 seconds reduced enzymatic activity significantly (lipase activity decreased from 4.2 to 2.2 units activity/g flour dry basis, DB; lipoxygenase decreased from 6.0 to 5.7 units activity/g flour DB). A longer steam treatment time (180 sec) resulted in no significant reduction in enzymatic activity compared to 120 sec, and so 120 sec was chosen to preserve antioxidant content. Steamed flours had less hydroperoxide formation compared to not steamed flours over storage, suggesting less oxidative rancidity. Carotenoid content of IWG flours decreased significantly over time, both steamed and not steamed (initial lutein content of steamed whole IWG flour was 3.1mg/100g flour compared to content at six months 1.1mg/100g flour). However, a significant amount of antioxidants and their corresponding activity remained at the end of six months of storage (compared to HRW lutein at six months, 0.14mg/100g flour). The reduction of enzymatic activity by steam treatment along with the presence of antioxidants could help prolong the shelf life of IWG, ultimately protecting its properties and allowing commercialization of IWG with maximal economic gain.

The Wheat Initiative—An international view on wheat

F. ORDON (1)
(1) Julius Kuehn-Institute, Quedlinburg, Germany

With about 220 million ha worldwide, wheat is the cereal with the largest acreage and is of prime importance for human nutrition as it covers 18% and 20% of the daily energy and protein intake, respectively. With a predicted world population of 9.3 billion in 2050, the demand for wheat is expected to increase by about 60% in comparison to 2010. To meet this demand, international efforts in research and breeding are needed. Therefore, in 2011 the Wheat Initiative endorsed by the G20 agricultural ministers was founded consisting today of 16 countries, two CGIAR centers, 7 breeding companies and two observing countries. The Wheat Initiative aims at the development of a global public-private research community sharing resources, capabilities, data and game changing ideas to improve wheat productivity, quality and sustainable production. To achieve this, the Wheat Initiative, which consists of the Research Committee, the Institutions Coordination Committee and the Scientific Board, has published "An international vision for wheat improvement" in 2013 and in 2015 based on the expertise of 10 Expert working groups comprising 611 experts from research and breeding from 51 different countries today, a “Strategic Research Agenda” (SRA, www.wheatinitiative.org). In summary, the strategic research agenda states three game changers, i.e. (i) the availability of the wheat genome reference sequence, (ii) the availability of a wheat information system, and (iii) the increased deployment of natural and engineered genetic variability. Furthermore, research should focus on the following core themes (i) increase wheat yield potential, (ii) protect yield potential, (iii) protect the environment and increase the sustainability of wheat production systems, and (iv) ensure the supply of high quality, safe wheat, as well as on two cross-cutting themes, i.e. (i) enabling technologies and shared resources and (ii) knowledge exchange and education. To reach the overall goal of productivity improvement, research priorities for the short, medium and long term are defined for each theme and the SRA is the base for calls on wheat research in many countries, today. The importance of an international co-ordination is also shown by the fact that international projects have become associated
Production of protein-fibre hybrid ingredients from rye and wheat brans by dry fractionation

P. Silventoinen (1), N. SOZER (1), K. S. Poutanen (1), E. Nordlund (1)
(1) VTT Technical Research Centre of Finland Ltd., Espoo, Finland

Valorisation of protein-rich ingredients from the by-products of the current agro-food industry would improve food security, sustainability and resource sufficiency. Cereal brans, such as those deriving from wheat and rye are underexploited side-streams with relatively high protein and dietary fibre contents that are currently mainly utilised as animal feed. Due to the limited functionality of bran materials and most plant-based protein sources, fractionation and further functionalisation of the valuable components for improved performance in applications is needed. However, instead of aiming at pure isolates, the studies should be focusing on the complex food systems and hybrid-ingredients enriched in desirable components. Dry fractionation including milling and air classification provides a useful tool for production of such hybrid-ingredients. The aim of this work was to apply dry milling and air classification to produce protein-fibre hybrid-ingredients from wheat and rye brans. Additionally, the aim was to compare the techno-functional properties, such as foaming and colloidal stability of the protein-enriched ingredients with the fine-milled raw material brans. Dry milling of wheat and rye brans (14% protein) prior to air classification was carried out after pre-drying (48h at 40°C) which was shown to improve the protein separation efficiency from the raw material most probably due to the increased brittleness caused by drying. Air classification resulted in protein contents of 32 and 31% with mass yields of 10 and 14% for wheat and rye bran, respectively. The most significant changes were seen in the amount of insoluble dietary fibre that was decreased from 51 to 12% and 29 to 9% for wheat and rye bran, respectively, indicating removal of pericarp structures. The amount of soluble dietary fibre was increased for wheat bran and remained the same for rye bran whereas starch content was reduced slightly. Functional properties were shown to be greatly affected by the fractionation process revealing improved foaming capacity, foam stability and colloidal stability for the fine fractions when compared to the raw materials. The improved techno-functional properties can be partly linked with the increased protein and soluble fibre contents as well as with the decrease in the amount of insoluble dietary fibre. Additionally, the size-based separation of the smallest particles in air classification most probably improved the colloidal and foam stabilities as a result of reduced gravitational sedimentation. The results indicate that the produced dry fractionated protein-fibre hybrid-ingredients have elevated applicability in food products when compared to the non-fractionated raw material.

Precision agriculture for cereal production

J. TAYLOR (1)
(1) UMR ITAP, IRSTEA, University of Montpellier, France

As an introduction to this session a brief overview of the concepts behind precision agriculture and digital agriculture will be presented. The theory behind relevant sensor and IT technology will be introduce to illustrate what is possible, what is not possible and what should be possible with current and emerging agri-tech. This will focus on both remote-sensing (satellite, aerial systems) and proximal (on-combine, on-tractor) systems that provide spatial (and sometimes temporal) information on grain quantity and quality.

Comparative study of different extraction methods of beta-glucan from oat and barley

M. A. KUREK (1)
(1) Warsaw University of Life Sciences, Department of Technique and Food Development, Warsaw, Poland

The extraction of beta-glucan remains an issue due to the complexity and several difficulties. The aim of study was to compare three different methods of extraction (chemical, enzymatic and enzymatic assisted with ultrasounds) in terms of the physicochemical characteristics. Oat and barley whole grain flour was used as the matrix for beta-glucan extraction. Chemical extraction (CH) started with incubation of flour in 0.2 M NaOH at room temperature for 90 min with continuous stirring. After incubation, samples were centrifuged at 10,000g for 10 minutes, then carefully decanted. After ethanol precipitation, the pellet was used for analysis. Enzymatic one (EN) was based on starch hydrolysis with thermostable alpha-amyrase and protease treatment and centrifugation. Then, after ethanol precipitation, the pellet was then used for analysis. The third method was similar to EN, but prior to enzymatic treatment samples were incubated at 55°C in ultrasounds (EN-US) in 55°C and 7 min. The pellets from all methods were vacuum dried prior to evaluation. The parameters evaluated during the study were yield and purity of extract measured as the content of beta-glucan in raw material and obtained extracts with mixed linkage colorimetric method. Next, rheological parameters, gelling temperature, WHC, color parameters, molecular weight and stability of emulsions prepared with extracts were examined. The highest yield was observed in CH samples from oat and barley (29.6 and 29.5%). This showed that the impurities enlarged the
yield of extraction and could influence the mass of the final extract. The highest purity was observed in EN barley samples (81.5%) and lowest in CH oat samples (17.8%). This high purity could be a result of the low protein content in barley which formed complexes with beta-glucan in oat samples. The highest apparent viscosity was observed in an EN oat sample (154 mPa s) but there were low values of flow behavior index (n=0.63). Samples from EN-US gelled at the lowest temperature: 66.03°C. EN oat extraction resulted in the lightest color (L* - 78.88), so the final product could be a universal thickener when applied into various foods without changing color. Beta-glucan could act as viscosifier, which was proven by the stability study in which the highest stability was observed in barley EN extraction. Generally, barley samples had lower MW due to activity of endogenous beta-glucosidase. Results enzymatic extraction from barley is recommended to achieve high purity beta-glucan and from oat to achieve high MW and bright color extract.

Impact of processing conditions during thermomechanical extrusion of maize starches on their subsequent expansion behaviour
D. J. BEECH (1), S. E. Hill (1,2), J. M. Gould (1), J. A. Beech (3)
(1) University of Nottingham, Loughborough, U.K.; (2) Biopolymer Solutions, Loughborough, U.K.; (3) Real World Business Solutions, Melton Mowbray, U.K.

An understanding of starch structures, especially in terms of their impact on expansion, is an important factor for many industrial processes. To elucidate critical factors maize starches of different amylose compositions were extruded in a thermomechanical twin screw extruder where screw speed, solid feed rate and temperature profile were kept constant. Die temperatures were either set at 60°C or 120°C. Water flow rates were changed from 469.5 ml kg⁻¹ to 6.3 ml kg⁻¹, and samples, including replication, were taken throughout this range. These samples represent directly expanded snacks and pellets that would be dried, stored and then expanded. Processing parameters were tracked and resulting extrudates analysed (e.g. sectional expansion (SEI), water solubility (WSI), water absorption (WAI), density). During extrusion of the waxy samples decreasing moisture content led to increased energy input (as measured as torque) during extrusion. The set point for the die temperatures were not maintained at all water levels. As was expected the torque correlated positively with WSI and direct expansion, but the higher energies lowered the water absorption index. The effect of energy input, as measured as Specific Mechanical Energy (SME), on WAI and water solubility was more pronounced with the cool die temperature profile. Die temperature profile appeared to have little influence on density and sectional expansion index of the directly expanded samples. When waxy, normal and high amylose maize starches were extruded at high (120°C) die temperature with a water flow rate of 315 ml kg⁻¹ the extrudates differed in their structural stability and expansion. WSI decreased with increasing amylose content (i.e. waxy maize starch > normal maize starch > high amylose maize starch), while WAI was highest in normal maize starch, followed by high amylose starch then waxy starch. This challenges the concepts of starch conversion and molecular weights of the starches dominating the expansion behaviour of extrudates. These findings, along with the behaviour of the pellet forms of the extrudates, when subjected to “popping”, will be discussed in terms of the changes in structure of the starches.

Improvement of taste and shelf life of yeasted low-salt bread containing functional sourdoughs using Lactobacillus amylovorus DSM 19280 and Weisella cibaria MG1
E. ZANNINI (1), E. K. Arendt (1)
(1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland

Objective: The challenge remains for the baking industry to reduce salt levels in yeasted bread as directed by governments, retailers and consumers around the world. The two main problems associated with the reduction of salt are a lack of salty taste and the reduction in shelf-life. Both of these issues are addressed in the presented work. Material and Methods: A range of breads containing different levels of salt (0.0%, 0.3% and 1.2% of NaCl) in combination with various levels of sourdough (0%, 6%, 12%, 18%, 24%) were produced. The different doughs were analysed for their rheological behaviour using fundamental rheology. The bread quality characteristics such as loaf volume, crumb structure, staling rate and microbial shelf life were also determined. The sourdoughs were analysed for their different metabolites: organic acids, sugars, exopolysaccharides (EPS), antifungal compounds, pH and TTA. Results: A trained sensory panel was used to perform descriptive analysis of the bread samples. The object of this paper is to use functional sourdoughs, containing Lactobacillus amylovorus DSM 19280 and Weisella cibaria MG1 to compensate for the quality problems that occur when salt is reduced in yeasted bread. The application of functional sourdoughs containing exopolysaccharides and/or antifungal substances in salt reduced breads improved the quality significantly. The application of functional sourdoughs allows the reduction of salt to a level of 0.3%.
Available starch: From food process control to health impact
S. VINOY (1)
(1) Mondelez International, Saclay, France

Starch is one of the major daily source of carbohydrates contributing to about 50–70% of the energy intake in a human diet. Processed foods make up an important part of daily energy intake, especially in occidental countries. During food processing, starch undergoes dramatic changes when heated in the presence of water or high pressure. The objective of this review was to evaluate the importance of controlling the food processes on starch digestibility profile in cereal based foods and the interest of preserving starch in its native, slowly digestible, form for modulating postprandial metabolism. This short term effect may be linked to metabolic disease prevention. Using different food technologies, we evaluated the starch digestibility profiles, measured the impact of each process on its structure and linked both aspects to its in vivo metabolic fate. Control of both water content and cooking temperatures led to a preservation of starch in its native state. This lack of gelatinization translated in a higher slowly digestible starch (SDS) content. The imaging techniques corroborated these findings and showed that rotary molded technology preserved starch in its intact form and provided the highest SDS content in the product. In addition, the products using technologies which provided the lowest SDS content (rusk, soft cake and extruded product) showed the highest level of starch structure disruption which translated to a shift of the crystalline fractions into amorphous material. In several human studies, preserving high SDS content in cereal based foods has shown a strong relationship with lower postprandial plasma glucose and insulin responses. These metabolic responses were clearly explained by the slower appearance rate of carbohydrates in peripheral blood during the small intestinal digestion phase. The demonstration of the interest of SDS in humans has been evaluated in healthy normal weight subjects, but also in obese or insulin resistant subjects. The interest of long term interest of preserving lower postprandial glycemic responses has been investigated in the prevention of metabolic diseases. It has been shown that postprandial hyperglycaemia is an independent risk factor for Type 2 diabetes mellitus (T2DM), and reducing 2-h plasma glucose levels in prediabetic subjects is associated with a reduction in the evolution to T2DM. Modulation of postprandial glycemia is a meaningful target in the prevention of metabolic diseases and this can be achieved through the modification of dietary factors such as starch digestibility.

Wheat nixtamalization (hydrothermal alkaline process) on viscoelasticity of dough and Osborne protein fractions
J. D. D. FIGUEROA CARDENAS (1), A. Topete (1), L. Rodriguez-Lino (2,3), B. Ramírez-Wong (4), J. A. Rincon-Aguirre (1)
(1) CINVESTAV Unidad Querétaro, Querétaro, Mexico; (2) Universidad Tecnológica de Morelia, Morelia, Mexico; (3) Universidad Tecnológica de Morelia, Biotecnología, Morelia, Mexico; (4) Universidad de Sonora, DIPA, Hermosillo, Mexico

The effect of hydro-thermal and NaCl treatments on the functionality of wheat flours and doughs is well known. However, the effect of nixtamalization (alkaline hydrothermal process) on wheat proteins has not been reported. The nixtamalization process involves several steps such as cooking of wheat kernels with Ca-compounds (ions), steeping (annealing), quenching, and milling to produce flour and dough products. The alkaline hydrothermal process affects protein solubility, starch gelatinization and increases Ca–starch–protein interactions, protein conformation as well as arabinoxylans hydrolysis produce changes in dough viscoelasticity and bread quality. Several HRS (hard red spring) and Durum wheat samples as well as protein Osborne solubility fractions were evaluated in order to understand the effect of Ca compounds (ions and pHs) and heat treatments during all the nixtamalization steps on dough viscoelasticity. At room temperature (25°C), unfolding of proteins occur as indicated by the increment of alpha-helix, there were no differences with 40°C treatment. The temperatures of 40, 60 and 80°C increase the viscoelasticity of dough due to protein denaturation and aggregation (above 40°C) and starch gelatinization above 60°C, those changes also affect significantly the consistency coefficient K and flux index (n) of the doughs. The use of different Ca compound (ions) were evaluated in order to improve the functionality of poor breadmaking quality wheat (Glu-D3 HMW-GS 2+10, soft wheat or T. durum). Control (no Ca compounds or heat treatment), Traditional nixtamalization with lime [Ca(OH)2], Classic nixtamalization with wood ashes, CaCO3, and CaCl2, were evaluated. Most of the treatments increased the storage G′ and loss moduli G″ of the doughs, except the Classic that uses ashes that reduced the stiffness and viscoelasticity of the doughs from most wheat genotypes evaluated compared with the control and improved the dough functionality. Gliadins, glutenin and non-soluble proteins (glutenin-like) from residue were very sensitive to shear rate 360 (1/s) above 40°C and increases sharply the elasticity acting as a non-Newtonian dilatant fluid (shear thickening) forming aggregates in the dough. The nixtamalization processes using different Ca sources (ions and pHs) and temperatures showed different dough functionalities for the same wheat kernel or flour with wide range of applications on end-products.
Does wheat flour protein content influence gluten strength for breadmaking?
J. COURCELES (1), H. Sapirstein (1)
(1) University of Manitoba, Winnipeg, MB, Canada

There is general belief in the milling and baking trade that increasing wheat protein content results in increasing gluten strength. We examined the validity of this widely-held view in a study that assessed dough mixing properties in relation to protein content and composition for a set of high quality wheats exposed to a normal range of growing conditions in the Canadian Prairie region. Nine varieties of CWRS wheat were grown in replicated field trials in two years and nine locations spanning a growing area >400,000 km². Fields were optimally fertilized based on standard soil tests. Dough mixing properties were evaluated using a 10 g torque recording strain gauge mixograph. Work input to peak dough development (WIP) and dough development time (DDT) were the principal parameters of gluten strength that were evaluated. Flour protein (FP) was fractionated using a differential solubility protocol in 50% 1-propanol without and with reducing agent to distinguish a gliadin-enriched fraction (soluble prolamins or SP) from HMW glutenin (HMWG). Variable weather across field locations during crop development was the predominant factor contributing to a surprisingly large range in FP of 10–17%. SP content was highly correlated with FP (R² = 0.90) confirming the role of gliadins as the principal wheat storage protein fraction. For HMWG the corresponding relationship was weaker (R² = 0.54) and was absent above 13% FP. ANOVA indicated that location and location × year interactions were the main sources of variation for FP, SP and HMWG, accounting for 84%, 71% and 58% of total variance for each factor, respectively. There was no relationship between FP and WIP (R² = 0.02). The relationship between FP and DDT was stronger (R² = 0.21) but not practically relevant. The only protein composition parameters that were practically related to dough WIP involved HMW glutenin content normalised to correct for growing location effects on FP, e.g. HMWG/FP (R² = 0.73) and HMWG/SP (R² = 0.71). While the protein content of wheat or flour is a convenient specification that accommodates commercial grain/flour transactions and is relevant to predict absorption and loaf volume potential, results of this study indicated that protein content had no value to predict gluten strength. Results also point to a need for much greater understanding of the nature of growing location effects, especially weather, on gluten strength and wheat protein content in particular.

Fundamental rheology and instrumental texture of reduced-sugar baked products
E. GALLAGHER (1), L. Milner (1,2), J. Kerry (2), M. O’Sullivan (2)
(1) Teagasc Food Research Centre, Dublin, Ireland; (2) University College Cork, Cork, Ireland

High levels of saturated fat and sugar in foods present a great risk of obesity and type 2 diabetes. Therefore low sugar intake is strongly recommended by health professionals. Sweet baked products incorporate significantly high levels of sugar. The current study is focused on re-engineering novel, reduced sugar formulations in cake and cookie products. Sugar in the original cake and biscuit formulation were reduced and replaced with natural alternatives. Apple pomace, whey permeate, oligofructose and polydextrose were studied in cake formulations. Reduced sugar biscuits were formulated using a combination of bulking agents (polydextrose, maltodextrin and plant fibres) with extracts (yeast, apple) and flavourings. The resulting staling kinetics, crumb structure and sensory acceptance of the re-formulated cake and biscuit products were characterised. Dynamic oscillatory tests were undertaken at a constant strain (0.1%) and increasing frequencies (0.1–10Hz) to determine biscuit dough and cake batter rheological properties. A reduction of sucrose yielded batter with an increased storage modulus (G') and complex modulus (G*) indicating an increase in elasticity and firmness in the batter. In particular, the cake batter containing polydextrose and apple pomace showed a significantly increased G’ (3.45E+03Pa and 3.37E+03Pa respectively) and G* (3.94E+03Pa and 3.99E+03Pa respectively) compared to the control (P<0.05) at 10Hz. There were no significant differences found between the control and reduced sugar biscuits doughs. Texture profile analysis investigated the effect of reducing sucrose on the textural aspects of the baked goods. As expected, the cake and biscuit formulations containing 70% sucrose showed an increase in hardness compared to the control products. The crumb texture of cakes containing apple pomace was significantly harder than the control (P<0.05). The addition of the apple extract resulted in a harder cookie (49.5N)(P<0.05) compared to the control formulation. The cell structure was maintained in the baked cake: there was no significant difference observed between the control formulation and the reduced sugar cakes as reflected by 2-D imaging and confocal microscopy. A sensory panel ranked the products on a hedonic scale (1–9). Sensory trials revealed the reformulated cakes and biscuits were acceptable to panellists. In particular, biscuits containing polydextrose and a natural flavouring scored higher than the control for sweetness, aftertaste and overall acceptability.
Simultaneous fluorescent detection of gliadins, LMW, and HMW glutenins in wheat dough using specifically developed antibodies-quantum dots complexes

J. C. BONILLA (1), J. L. Kokini (1)
(1) Department of Food Science, College of Agriculture, Purdue University, West Lafayette, IN, U.S.A.

The importance of the gluten proteins, gliadins and glutenins in affecting the quality of wheat products is well known and has been studied for over 100 years. New available molecular biology and nanotechnology tools such as specific antibodies conjugated with nano-fluorescent quantum dots (QDs) have enabled researchers to study gliadin distribution in dough mixing and bread. We have developed specific antibodies for HMW and LMW glutenins using their proteomic information. The antibodies were found to be specific to each subunit by Western immunoblots. QDs were conjugated to carbohydrates groups found in the tails of the antibodies by a site-click conjugation, a new method to keep antibodies integrity. Fluorescence-Link Immunosorbent Assays tested the successful QDs conjugation. These new antibodies-QDs conjugates enabled us to perform simultaneous fluorescent tracing of the gluten fractions, gliadins, LMW, and HMW glutenins by using QDs with three different colors. Dough samples were stained with the antibodies-QDs conjugates using a previously developed method. The samples were analyzed under an A1R-MP Nikon Confocal microscope. The collected fluorescent images display the “in situ” localization of the three different gluten fractions among the starch matrix in dough for the first time in cereal science research. The relative intensity of each quantum dot color in areas where two or more of the gluten fractions were present was obtained with the Nikon NIS-Elements co-localization tool, which allowed us to study each gluten fraction distribution by itself, and the interactions of the three fractions in the dough. Visualizing and understanding the distribution of the gluten fractions during different dough processes will 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 and an extent in the variety of wheat products.

Digestibility of processed wheat with increased resistant starch

M. CORRADO (1), A. Cherta Murillo (2), E. Chambers (2), G. Frost (2), B. Hazard (3)
(1) Quadram Institute, Norwich, U.K.; (2) Imperial College London, London, U.K.; (3) John Innes Centre, Norwich, U.K.

Background: Refined starchy foods made from wheat are often seen as unhealthy because of their low dietary fibre content and rapid digestibility leading to poor blood glucose control; but not all starchy foods are the same. Complex carbohydrates like resistant starch, have been shown to exert clinical benefits by reducing risks factors that contribute to chronic diseases such as elevated blood glucose levels, insulin resistance, overweight and obesity. Thanks to modern breeding and new genomics technologies, wheat is an ideal candidate for genetic manipulation and generation of genotypes with higher levels of resistant starch. Increasing resistant starch content can increase dietary fibre content of wheat foods, providing both systemic and gut health benefits. Thus, enhancing the resistant starch content of staple wheat foods will provide consumers with healthier dietary choices. Methods: In this study, we evaluated starch physicochemical properties of semolina prepared from mutant SBEIIa/b wheat with increased levels of resistant starch (Hazard et al., 2014) during gelatinization and retrogradation. A retrograded wheat test meal (pudding) was developed to deliver 50g of total starch with constant liquid to solid ratio, for both SBEIIa/b and wild-type control semolina. The puddings were used to study the effect of increased resistant starch content on upper gastrointestinal digestion using established in vitro models. The puddings were then used in a randomized cross-over study to determine the effect of resistant starch on glycaemic response. Here, we served SBEIIa/b and the wild-type puddings to 10 healthy volunteers measuring postprandial blood glucose over a 2-hour period. Results: Raw semolina from SBEIIa/b wheat showed a 3–4-fold increase in resistant starch compared to the wild-type control. Resistant starch levels decreased after processing in gelatinized (boiled) and retrograded (boiled and cooled) semolina but still showed a ~1.5-fold increase in resistant starch compared to the wild-type control. In vitro digestion models showed significant differences in resistant starch content and digestion rate, possibly due to change in native structure of the starch. However, no glycaemic response differences were found by comparing the SBEIIa/b wheat pudding to wild-type. Conclusions: The present study highlights the importance of processing in designing functional foods with increased resistant starch. The increase in resistant starch and amylose in the SBEIIa/b semolina and pudding appears to alter the digestion kinetics in vitro without affecting the glycaemic response in vivo. These results will be used to develop new wheat foods and to inform future human studies using SBEIIa/b mutant wheat.

Anti-fungal properties of faba bean (Vicia faba) flour and water extract in wheat bread

T. MORSKY (1,2), T. S. Sontag-Strohm (2)
(1) Campden BRI, Chipping Campden, Gloucestershire, U.K.; (2) University of Helsinki, Helsinki, Finland

The anti-fungal properties of faba bean (Vicia faba) flour and water extract were studied in wheat bread baking. Half of the faba beans (Melodie, 2013) were microwave heat treated for 1.5 minutes. The beans were then dehulled and milled into flour. The faba bean water extract was made using untreated faba bean flour. In baking
trials, the wheat flour was substituted for 0% (control), 10%, 20% or 30% of faba bean flour, or the dough water was substituted for 47%, 74% or 100% of faba bean water extract. Faba bean flour or water extract addition increased the protein content of the breads from 8 g/100 g up to 12 g/100 g. Mould suspensions (400 cells/ml) were prepared using mould strains Penicillium verrucosum, Rhizopus stolonifer, Aspergillus niger or Penicillium roqueforti and 0.9% NaCl-solution. 10 μl of the suspension was added to the centre of each bread slice. The diameter of the mould colony was measured after seven days. In baking trials, the faba bean flour and the extracts slowed the growth of Penicillium roqueforti by 19.4–37.5%, Penicillium verrucosum by 19.9–33.0% and Aspergillus niger by 13.7–44.2% compared to wheat bread control. The higher faba bean content prevented the growth of moulds more than the lower contents. No difference in mould growth was seen in the baking trials between microwave treated and untreated flour. No inhibition activity was seen against Rhizopus stolonifer. The faba bean flour and the faba bean extract increased the pH of the breads slightly. The faba bean flour and the extract also decreased carbon dioxide production of the dough by 6.8–17.5% compared to the control. Faba bean water extracts also inhibited the growth of Penicillium roqueforti on malt agar. The microwave heat treatment seemed to decrease the inhibition activity of the faba bean flour. Inhibition activity of Penicillium verrucosum, Rhizopus stolonifer and Aspergillus niger on the agar plates was not detected. The faba bean flour and water extract both showed promising results as a novel clean label mould inhibitor for wheat breads.

Polymerization behavior of gluten during dough development and pasta cooking upon kansui treatment
G. Chen (1), Y. LI (1)
(1) Kansas State University, Manhattan, KS, U.S.A.

Pasta, a traditional Italian cuisine, has been a staple food with a market size of $23 billion in 2016. Pasta products play an important role in diet nutrition, in which salt (NaCl) was added to improve the texture and flavor. However, an average sodium intake of 3.6 g/day (> a 2.3 g/day recommended) for the American adults enlarges the risk of chronic diseases such as the heart disease. Therefore, it is in need of a salt alternative without causing any deleterious effects on pasta quality. Kansui (alkali solution) is widely applied to enhance the cooking quality of Asian noodles, but its effect on gluten polymerization and pasta quality was unclear. The objectives of the present study were to evaluate the impact of kansui on the dough rheology and cooking quality; to study the change of the gluten cross-linking reactions during dough production and cooking; to evaluate the potential of replacing NaCl with kansui in pasta products. Kansui (a 3:2 mixture of Na2CO3 and K2CO3) was added at 0.5%, 1.0%, 1.5%, and 2.0% (semolina basis) into a flour-dough system. The dough physical and rheological tests were conducted using TA.XTplus analyzer and Malvern Bohlin CVOR 150 rheometer. Gluten polymerization characteristics induced by kansui were investigated via RP-HPLC, FTIR-ATR, spectrophotometer, and SDS-PAGE, and pasta cooking quality was also evaluated. Dynamic rheological test showed kansui enhanced dough elastic property, and dough strength greatly increased based on the viscoelasticity measurement. Cooking loss of pasta was not significantly changed when adding 1.5% of kansui (P > 0.05). All these results may be attributed to the aggregation of gluten, which was confirmed by SDS-PAGE and HPLC performance. The ratio between extractable gliadin and glutenin fractions decreased from 1.3 to 1.0 with higher amount of kansui in the doughs. Alkali significantly reduced the amount of free sulfhydryl contents in gluten (P < 0.05); while more β-sheet secondary structure was found. In conclusion, the protein cross-linking induced by kansui (1.0 and 1.5%) improved the rheological properties of dough and texture properties of pasta without compromising its cooking quality. Considering the process convenience and food safety of reducing NaCl with natural alkali reagent in industrial pasta production, it is potentially an alternative approach of mitigating further health problems.

Exploring digestion of food structures in humans, understanding how cereals influence gastrointestinal signals
G. FROST (1)
(1) Imperial College London, London, U.K.

There is very little understanding of digestion in real time in humans. Much of our understanding in from animal or invitro models. Some of the difficulty in translation of observations made in animals to humans may be caused by fundamental differences in the gastrointestinal tract (GIT). Although in vitro models continue to improve they lack been able to model the impact on systems like the mesenteric nervous system makes on GIT flow. Over recent years we have developed systems to try and understand how digestion impacts on small molecule environment in different areas of the GIT. Of example our work on developing systems to deliver short chain fatty acids in humans is beginning to demonstrate not just the new understanding of how short chain fatty acids effect human physiology. This presentation will bring together recent data from several ongoing studies to make the case of interventional studies in humans to understand human physiology. I will highlight the importance of the metabolite environment in understanding gut hormone release.
Sulphur and nitrogen application affect wheat flour mixing characteristics and protein features
E. T. QUAYSON (1), D. Kaiser (2), G. A. Annor (2)
(1) University of Cape Coast, Cape Coast, Ghana; (2) University of Minnesota, St. Paul, MN, U.S.A.

Hard red spring wheat (Albany cultivar) was grown in soils applied with a combination of different nitrate (0, 60, 120, 180, 240, 300 lb per acre) and sulphur (0 or 20 lb per acre) levels. The mixing characteristics and protein features of flour and dough were studied using the Brabender Farinograph, and SDS protein solubility and thiol tests respectively. Application of nitrate alone did not affect protein arrangement in the flour. However, a combination of sulphur and nitrates, resulted in increased cold extractable proteins, evident of low protein compactness and exposure of features that allowed for increased extractability. When the flours were mixed into dough, nitrate application only resulted in similar cold protein extractability characteristics suggesting similar protein interaction. For samples with sulphur as an addition to the nitrates, mixing affected their protein compactness, except for those with 120 and 180 lb nitrates per acre respectively. Nitrate application compacted the protein in the flour resulting in its thiols not being exposed even in the presence of a chaotrope. Addition of sulphur further decreased the exposed thiols, giving a decreasing trend as nitrate levels increased, suggesting greater protein interaction. Mixing produced different effects on thiols with 0, 120 and 180 lb nitrates per acre respectively with no sulphur samples showing greater decrease in exposed thiols. Sulphur application alone increased exposed thiols but not in the presence of nitrates. It is concluded that application of nitrate in the soil up to 60 may be effective in producing more compacted protein network in flour and dough and that the addition of sulphur does not improve upon the interaction in the protein network in the flour and dough made from it.

Feruloylated arabinoxylans from nixtamalized maize bran as an antioxidant dietary fiber
D. D. Herrera-Balandrano (1,2), J. G. Baez-González (1), E. Carvajal (3), G. Niño-Medina (4), T. BETA (2)
(1) Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas, San Nicolás de los Garza, Nuevo León, Mexico; (2) University of Manitoba, Winnipeg, MB, Canada; (3) Centro de Investigación en Alimentación y Desarrollo A.C., Laboratorio de Biopolímeros, Hermosillo, Sonora, Mexico; (4) Universidad Autónoma de Nuevo León, Facultad de Agronomía, General Escobedo, Nuevo León, Mexico

Nixtamalization results in removal of outer pericarp layers of the maize kernel. The bran products were investigated for their potential as functional food ingredients. Feruloylated arabinoxylans were obtained from nixtamalized maize bran under alkaline conditions (0.5 N NaOH) at different times (2 h, 4 h and 6 h).

Quantification of ferulic acid was performed by RP-HPLC. Total phenols were determined using the Folin-Ciocalteu method. Antioxidant capacity was determined using the DPPH, ABTS, FRAP and ORAC assays. The yields of the arabinoxylans following alkaline extraction treatments were 4.89%, 8.23% and 7.17% respectively. The purity of arabinoxylans ranged from 55.58% to 61.16%, while arabinose to xylose (A/X) ratio ranged from 0.82 to 0.87 which indicated that all arabinoxylans had a moderately branched structure. Soluble dietary fiber accounted for more than 85% of the chemical composition of feruloylated arabinoxylans. Monomeric and oligomeric forms of ferulic acid were influenced by the alkali extraction time. The monomeric form was the main phenolic acid in feruloylated arabinoxylans (77.05% to 86.97%), followed by dimers (11.57% to 14.20%), and then trimers (0.93% to 9.36%). Total phenols ranged from 9.01 to 6.48 mg FAE/g, while antioxidant capacity ranged from 29.49 to 31.69 μmol TE/g, 16.60 to 21.27 μmol TE/g, 39.23 to 58.33 μmol TE/g and 17.03 to 60.65 μmol TE/g when assayed using the DPPH, ABTS, FRAP and ORAC method, respectively. The phenol content and antioxidant capacity were in the order: 2 h extract > 4 h extract > 6 h extract and in accordance to the ferulic acid content. The results indicated that alkali extracted feruloylated arabinoxylans can be considered as an antioxidant dietary fiber. Further studies are underway on their potential application in food, where the incorporation of antioxidant dietary fiber (feruloylated arabinoxylans) can increase the functional and nutraceutical quality of bread. It is likely that these polysaccharides can impart enhanced value to food products.

Effect of rice bran antioxidants on total antioxidant capacity evaluated in vitro and in vivo
I. RODRIGUEZ GARCIA (1), A. Quintero (2), P. Rayas-Duarte (3)
(1) CEPROBI-IPN, Yautepec Morelos, Mexico; (2) CEPROBI-IPN, Cuautla, Mexico; (3) Oklahoma State University, Stillwater, OK, U.S.A.

Antioxidants inhibit anion superoxide radicals present in many obesity related diseases, such as cardiovascular diseases and cancer. Rice bran is a rich source of antioxidants and contributes to the total antioxidant capacity (TAC in vitro) in cereal based foods. However, it is not yet clear whether the TAC in vitro is correlated with the amount found in human plasma after the intake of cereals foods (TAC in vivo). The aim of this study was to evaluate the TAC in vitro and in vivo at 0, 2, 4 and 6 hours after intake of a rice bran beverage. Rice bran A-2010 was milled and stabilized by wet heat. Proximal analyses were performed (AACC Approved Methods) and the main antioxidants determined by photochemiluminescent, HPLC and Folin-Ciocalteu methods. A base formula was developed with rice bran powder using a mix design for sensory evaluation of three flavors with a panel of 75 assessors for consumer acceptance testing. The rice bran beverage with highest acceptance score was
characterized and TAC \textit{in vitro} evaluated. Five healthy adults were selected to measure the TAC \textit{in vivo}. Rice bran composition was 12.9% lipids, 14.2% protein and 22.1% of total fiber, and its TAC \textit{in vitro} after 60 days of storage reduced by 33.3%. The antioxidant content of rice bran was 9.1 mg/g of gamma oryzanol, 339 mg/g of vitamin E and 721 mg of ferulic acid equivalents/100 g of the total phenolic compounds. The coffee mocha flavor beverage selected had a TAC \textit{in vitro} of 1,228.2 μg Trolox equivalents/g. TAC \textit{in vivo} was evaluated after intake two doses of 35.5 g of the formula mixed with 240 ml of water. No significant differences were found between the basal level and rice bran beverage intake after 2, 4 and 6 hours. TAC \textit{in vivo} at basal was 51.8 μg Trolox equivalents/ml of blood plasma, while TAC \textit{in vivo} was 50.7, 47.4, and 48.1 μg Trolox equivalents/ml of blood plasma at 2, 4, and 6 hours after intake, respectively. The results suggest that other biomarkers of oxidative stress should be analyzed.

**Simple method for estimating the 2nd Fick’s mechanism of oil uptake and water loss during deep-fat frying of tortilla chips**

A. TOPETE (1), J. D. D. Figueroa Cardenas (1), L. Rodríguez-Lino (2), E. Morales-Sánchez (3)

(1) CINVESTAV Unidad-Querétaro, Querétaro, Mexico; (2) Universidad Tecnológica de Morelia, Morelia, Mexico; (3) CICATA-IPN Unidad Querétaro, Querétaro, Mexico

Deep fat frying is one of the most important unit operations in food processing and a traditional cooking method for achieving desirable sensory attributes, such as flavor and texture in a variety of foods, the trend of consumers has changed to low-fat fried foods over the past years. A better understanding of the relationship between different parameters of deep fat frying, should provide ways to optimize the frying process. The aim of this research was to propose a simple equation for estimating the mechanism of oil uptake and release of water in tortilla chips (TC). Traditional nixtamalization (1% lime w/w) was used to obtain dough with different particles sizes during grinding (coarse particles 600 μm and fine particles 500 μm), which was molded into tortilla and baked for 40 s, finally, fried at 185°C for 0, 5, 10, 15, 30 and 60 sec. The exponential equation $M_t/M_\infty = Kt^n$ was used to describe the water release and oil absorption mechanisms during frying, this represents an easy way to classify the Fickian mechanism, instead of using advanced mathematics from the 2nd Fick’s law, $M_t$ is the mass of the TC at time $t$, and $M_\infty$ is the mass of TC when the curve becomes asymptotic, $K$ is a constant of the system, $t$ is the time used during frying and $n$ is the Fickian diffusion exponent; for Fickian mechanism is defined as $n \leq 0.50$ and in the range $0.5 < n < 1.0$ indicates non-Fickian mechanism. Therefore, the oil absorption showed Fickian mechanism for fine particle $n = 0.4539$ and for coarse particle $n = 0.3748$, but water release presented non-Fickian mechanism with $n = 0.7075$ for fine particles and $n = 0.6902$ for coarse particles. Larger water diffusion coefficient in tortilla chips compared to the oil diffusion indicates that water release and oil absorption during deep frying is not a simultaneous event. The behavior of the water and oil diffusion is an open topic which in this study was investigated by the exponential equation, however, there are few works about the oil absorption diffusion coefficient and the mechanism involved in the frying process in tortilla chips.

**Comparative studies on the aroma of gluten-free rice and gluten-containing wheat bread**

A. BOESWETTER (1)

(1) Leibniz-Institute for Food Systems Biology, Technical University of Munich, Munich, Germany

Persons suffering from celiac disease, non-celiac gluten sensitivity (NCGS), or wheat allergy depend on gluten-free products in their diet. However, also healthy people are increasingly consuming gluten-free foods as part of their lifestyle. In particular bread is an integral part of the daily gluten-free diet. Rice flour is a commonly used raw material for gluten-free bread making. Compared to wheat bread, especially the flavor of rice bread is less accepted by consumers. Therefore, the aim of this study was to elucidate the differences in the aroma of gluten-free rice bread and wheat bread. Sensory aroma profiles of the crumbs and crusts of freshly baked rice and wheat bread showed clear differences between the samples. For analyses on a molecular level the volatile fractions of these samples were obtained using solvent assisted flavor evaporation. Aroma active volatiles were detected by gas chromatography (GC) olfactometry. Furthermore, the aroma extract dilution assay, an analysis of stepwise diluted volatile isolates, was applied to estimate the relevance of individual aroma compounds on the aroma of the breads. All detected odor active substances were identified by their odor quality, retention indices on two different GC columns and mass spectra compared to reference compounds. Most of the detected aroma compounds were present in both gluten-free and wheat bread samples, but in different intensities. Compared to wheat bread, some aroma compounds were typical for rice bread, e.g. 2-aminoacetophenone. The analysis of the aroma of rice flour confirmed that many of the rice bread aroma compounds were already present in the flour. In addition, typical crust aroma compounds formed by the Maillard reaction were less intense in rice bread crust compared to wheat bread crust.
Effect of hydrothermal treatment prior to ultrasonication on starch properties
J. S. HONG (1), H. D. Choi (1)
(1) Division of Strategic Food Research, Korea Food Research Institute, Wanju-gun, Jeollabuk-do, South Korea
The effect of technical combination for producing physically modified starches still needs further investigation. Recently, ultrasonication has been employed in conjunction with an acid treatment or an enzyme treatment to produce nano-sized starch particles or porous starches, respectively. However, the effect of hydrothermal treatment on ultrasound treated starch has not yet been fully understood. In this study, the annealing or heat moisture treatment conditions were assessed to enhance capability of ultrasound treated starches which can interact with other molecules in a postprocess. Wheat (WS), potato (PS), and rice (RS) normal starches were either annealed [ANN, 60–80% moisture contents (M60–80), or 10–50°C (T10–50) and 16 h incubation], or heat moisture treated [HMT, 15–35% moisture contents (M15–35), 80–120°C (T80–120) and 16 h incubation] prior to ultrasonication [60% amplitude of 750 W, 20 kHz, 5–30 min (U5–30)]. Several ANN and HMT conditions were selected based on swelling power (SP) lower than the native starches. The ultrasonication condition which showed partial recovering in SP values and retained the original granule size has been selected for further investigation. The gelatinization temperature decreased as the native or ANN starches were treated by ultrasonication, while the HMT starch retained the gelatinization characteristics even after ultrasonication, confirming that the HMT compensated the corrosive effect of ultrasonication on the starch crystalline structure. The selected samples (WS T120M25U30, PS T100M25U5, and RS T120M35U15) were subjected to a model derivatization which react granular starches with a fluorescent reagent to assess interaction capacity of starch with other molecules. The distribution of fluorescence signal inside of the granule were more homogeneous for HMT and/or ultrasound treated WS and PS. The fluorescence intensity significantly increased for HMT and ultrasound treated WS and PS, while the intensity of HMT RS decreased after ultrasonication. There results suggest that the combination of hydrothermal and ultrasound treatments contributed to enhance capability of WS and PS granules for further molecular interaction, but for RS, the effect of the HMT process was predominant to alter RS functionality.

Mapping antioxidant activity of oat polyphenols using UHPL-online ABTS and LC Q-TOF
S. RAO (1,2), K. Chinkwo (1,2), P. Oli (3), C. L. Blanchard (2,4)
(1) School of Biomedical Science, Wagga Wagga, Australia; (2) ARC ITTC for Functional Grains, Wagga Wagga, Australia; (3) NSW Department of Primary Industries, Yanco, Australia; (4) School of Biomedical Sciences, Wagga Wagga, Australia
Oats have been reported to be a rich source of fibre as well as polyphenols that have exhibited antioxidant potential. Oat polyphenol antioxidant activity has been demonstrated to have considerable bioactivity on diseases such as cancer and cardiovascular diseases. In this study, eight varieties of Australian-grown whole grain oats were investigated for their phenolic composition and antioxidant potential. Phenolic compounds were characterised using colorimetric assays, ultra-high-performance liquid chromatography (UHPLC), online 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) antioxidant detection system and liquid chromatography quad time of flight mass spectra (LC Q-TOF). A substantial variation was observed in phenolic composition and antioxidant activity of the oat varieties at p < 0.05. Total phenolic composition ranged from 19.51 ± 1.20 to 52.49 ± 1.70 mg 100 g−1 gallic acid equivalence (GAE), while antioxidant activity using ferric reducing ability of plasma (FRAP) assay was found to be 160.80 ± 38.74 to 262.20 ± 23.61 mmol 100 g−1 Trolox equivalence. Furthermore, several avenanthramides (AVN) were detected such as AVN A, B, C, 2, L and their conjugates. These AVN compounds and their conjugates fundamentally contributed to the oat phenolic content and antioxidant activity. The highest abundance across all varieties of oats was exhibited by AVN A and C with a maximum of 1.71 ± 0.57 and 1.54 ± 0.38 mg 100 g−1 GAE in the variety Possum. In addition, quercetin-3,4′-di-beta-gluco-pyranoside and AVN C were found to be the most active antioxidants that potentially employed more than one mechanism for free radical scavenging. Moreover, it was observed that AVN C had the highest antioxidant activity followed by B and A. Australian grown oats rich in AVN and phenolic compounds with demonstrated antioxidant potential could add more value to the current nutritional status of oats.

Process for making resistant starch from pinto beans
C. W. SIMONS (1)
(1) Wright State University – Lake Campus, Celina, OH, U.S.A.
Resistant starch (RS) is a prebiotic. Consumers can improve their digestive health by including more of this ingredient in their diet. A potential source of RS is edible bean flours; given their high RS content. Unfortunately however, very little RS is retained in these flours after they have been exposed to high-temperature processing such as baking and extrusion. Therefore, utilizing pinto beans, a new process was developed to produce a type of RS called RS3, which is known to be resistant to thermal degradation. The process involved extracting native starch from the pinto beans, drying the starch, and then cooking to gelatinize. The gel was then cooled in a refrigerator for 4 days to allow retrogradation. After that, the retrograded starch cake was disintegrated and
digested using Amylex-3T alpha amylase at 80°C for 60 minutes. A series of washing, centrifugation and enzyme deactivation then followed to remove soluble starch. This process produced a concentrated RS3 which was then dried in a convection oven (60°C, 12 hours), and finally milled using a centrifugal mill. The product was analyzed to determine its RS content and expected glycemic index (eGI) using a Megazyme RS kit. The yield of RS3 from the pinto bean starch was 11.8%. This was significantly higher than a 5.1% yield obtained from corn starch purchased from a local grocery. The RS content was 62.9%, which was significantly higher than 9.9% RS found in the dried retrograded starch powder before enzymatic hydrolysis. The eGI was 29. This value is considered to be low, since glycemic index ranges from 0 to 100. Given its high RS and low eGI, this new RS3 product could be used as an additive to fortify raw edible bean flour ingredients, hence helping to retain their prebiotic property.

What is the role of dietary fiber in carbohydrate quality?
B. O. SCHNEEMAN (1)

Dietary fiber has been recognized as a component of carbohydrate quality since the 1800s primarily because of its contribution to roughage or bulk in the diet. Observational evidence from the 1970s indicated that the contribution of fiber to carbohydrate quality is broader than simply providing dietary bulk and that adequate fiber in the diet may be important for lowering risk of non-communicable diseases (NCDs). Experimental and clinical research has demonstrated that dietary fibers have physiological effects that provide certain health benefits associated with lower risk for NCDs. Examples of health benefits include reducing the concentration of cholesterol in the blood, moderating blood glucose responses, improving laxation, and enhancing mineral bioavailability. The properties of dietary fibers, such as viscosity or providing substrates for micro-organisms in the gut, may determine the physiological effects of fibers; however, methods for measuring the ability of these attributes to predict health benefits need to be developed and standardized. Another important aspect of fiber as a contributor to carbohydrate quality is that fiber is a component of plant foods that are recommended as part of a healthful dietary pattern (e.g. whole grains, fruits, vegetables, seeds, and legumes). Recommendations for fiber intake are based on these two qualities of fiber: fiber as a component of plant foods and fibers that have been demonstrated to have a health benefit.

Revisiting water transport during bread baking
M. Ureta (1), Y. Diascorn (2), M. Cambert (2), V. O. Salvador (1), T. LUCAS (3)

During baking, water migrates towards the centre of bread accordingly to the heat pipe mechanism and water vapour also escapes to the oven atmosphere, leading to crust formation and weight loss. The present study aimed at revisiting these mechanisms. Indeed, the literature reports of water gained in crumb were highly variable (Wagner et al., 2007). We tested different times elapsed between the slice cutting after the interruption of the baking process and the sample weighting for the determination of dry matter and water content (WC) in crumb. Likewise, reducing water loss (WL) is challenging since it represents about 23–26% of energy consumption (Le Bail et al., 2010) and favours crumb hardness consequently to the water redistribution during bread storage (Le Bail et al., 2009). The effect of the oven temperature (142, 182, 210°C) on WL and WC was also tested. Baking was interrupted at different times, the loaf was weighted for the determination of WL and crumb was sampled. WC obtained for the shortest sampling times showed that water accumulated at core until mid-baking, while the temperature gradient in the dough was pronounced; this was consistent with the theory of the heat pipe mechanism. At advanced baking times, WC decreased at a slow rate of 0.1% min⁻¹. Maximal gain in WC was 2.5% wet basis, independently of the oven temperature. No gain was noticeable for longer sampling times, a plausible explanation for controversial reports of WC at bread core. Likewise, we were able for the first time to monitor continuously during baking WC values higher than that of dough. Near infrared allowed the monitoring of WC only at advanced baking times due to the sensor sensitivity (Thorvaldsson and Skjöldebrand, 1998), while a previous study also based on sampling reported an increase of water content for baking times shorter than 7 min only (Wagner et al., 2007). Whatever the oven temperature, WL much accelerated in the last part of baking while crumb temperature was uniform, close to that of water ebullition. A better optimization of heat transfer between the surface (for coloration purposes) and the core (for inflation purposes) could help in this way, together with shorter baking duration. Le Bail, A., et al. (2009). Journal of Cereal Science, 50, 235-240. Le Bail, A., et al. (2010). Journal of Food Engineering, 96, 510-519. Thorvaldsson, K., Skjöldebrand, C. (1998). LWT, 31, 658-663. Wagner, M.J., et al. (2007). Journal of Food Engineering, 78, 1167-1173.
Impact of wheat bran physical properties and chemical composition on whole grain flour mixing performance and bread appearance
S. NAVROTSKYI (1), D. Rose (1)
(1) University of Nebraska–Lincoln, Lincoln, NE, U.S.A.

Wheat bran is a complex biological material with diverse chemical composition and physical properties. Performance of the whole grain flour in baked products depends on the physical properties and composition of bran. Therefore the objective of our study was to determine the reactive components and physical properties (particle size, water retention capacity) of bran that have the greatest influence on mixing and baking properties of whole grain flour. To pursue our objective 80 samples of bran from different wheat lines were ground into two particle sizes (fine, median 485 μm; coarse, median 776 μm) and analyzed for water retention capacity, protein, ash, lipoxygenase activity, and extractable phenolics. Brans were then mixed with one bulk refined flour in proportions to make reconstituted whole grain flour. Reconstituted whole grain flours were used for mixograph analysis, bread baking, and texture analysis. Mixograph torque at peak was significantly influenced by bran protein concentration ($r = 0.48; p < 0.0001$), ash ($r = 0.48; p < 0.0001$), and lipoxygenase activity ($r = -0.26; p = 0.03$). Mixograph peak time showed positive correlation with extractable phenolics ($r = 0.37; p = 0.003$) and particle size ($r = 0.31; p = 0.01$). For bread, water retention capacity of bran was significantly correlated with bread volume ($r = -0.564; p < 0.0001$). Bread hardness correlated with bran particle size ($r = 0.29; p = 0.02$) and protein concentration ($r = 0.28; p = 0.02$). Therefore our study showed significant correlations between bran components and mixograph peak time and torque as well as bran water retention capacity and bread volume.

Effect of tannins on gluten film formation and stabilization
A. L. GIRARD (1), T. F. Teferra (1), J. M. Awika (1)
(1) Texas A&M University, College Station, TX, U.S.A.

Tannins, especially condensed tannins (proanthocyanidins, PA), can strongly complex wheat gluten through hydrogen bonding and hydrophobic interactions, which alter gluten functionality. This study aimed to determine the effect of PA (mean DP = 19.5) and tannic acid (hydrolysable tannins) on strength and stability of gluten films and foams. Gluten films (with 0–10 mg catechin, tannic acid, or PA/g gluten) were solution-cast and assessed for extensibility (TA.XT2 Texture Analyzer) and in vitro digestive stability. Batter (with 0–25 mg catechin, tannic acid, or PA/g flour) viscosity was assessed with Brookfield rheometer and Rapid ViscoAnalyser (RVA). In gluten film, PA (at 10 mg/g gluten) increased force to extend film by 2.1×, but interestingly, did not significantly decrease extensibility compared to the control, suggesting PA strengthened gluten film. Tannic acid did not alter gluten film strength or extensibility. In vitro protein digestibility of the PA-gluten film was 32% lower than control at pH 2.0, while catechin and tannic acid had insignificant effect. This suggests PA, but not tannic acid, increased gluten network density which limited protein digestion. Within batters, PA and tannic acid (5 mg/g flour) increased viscosity (2.0× and 1.4×, respectively) compared to control, implying tannins, especially PA, increased gluten polymer size, thus decreased mobility. This effect also increased batter stability: batters with PA or tannic acid (25 mg/g flour) exhibited 81% less volumetric liquid separation after 15 min floor time versus control. PA increased batter peak (53%) and final (35%) viscosity to a greater extent than tannic acid (16% and 6%, respectively) during an RVA cook-cool cycle. PA have elongated structures compared to tannic acid, with sites for non-covalent interactions in close proximity, which likely enabled PA to have stronger interactions with wheat gluten and starch. PA could be useful to modify gluten films and foams to benefit various food applications.

The Food Authenticity Network and available tools to combat food fraud
M. WOOLFE (1)
(1) Food Authenticity Network

The Food Authenticity Network is a UK government funded initiative that was born out of the 2013 horsemeat issue and brings together all those with an interest in food authenticity testing. In addition to the focus on food authenticity testing best practice, links to the major global food fraud mitigation guides have been placed on the Network so that supply chain integrity (mitigation) and testing is covered. The network aims to raise awareness of the tools available to check for mislabelling and food fraud, and to ensure that stakeholders have access to a resilient network of laboratories providing fit for purpose testing to check for food authenticity so consumers can have confidence in the food they buy. The Food Authenticity Network (www.foodauthenticity.uk) is a free open access toolkit for the detection of food fraud that can help to fight food fraud and build a more resilient food supply chain. This talk will highlight the key features of the Network and how the information can be of use to the cereals and grains stakeholder communities. It will also look at food authenticity methods for cereals and grains including the application of multi-spectral imaging.
Starch structure-based methodology for selecting grains with improved functional properties
H. Li (1), W. Yu (2), K. Tao (2), S. Prakash (2), C. Li (4), R. G. GILBERT (2,3)
(1) Beijing Technology & Business University, Beijing, China; (2) University of Queensland, Brisbane, Australia;
(3) Yangzhou University, Yangzhou, China

Amylose molecular structure is an important parameter controlling many properties of starch-based foods. Amylose content is not the only important parameter for such properties: for example, cooked rices with similar amylose content can have significantly different sensory properties. Amylose has a small but significant number of long-chain branches. Many functional properties are influenced by amyllopectin and amylose fine structures (which comprise the chain-length distribution, CLD, of the debranched starch). The objective is to see which structural properties, including those of amylose, control an important sensory quality, the stickiness of cooked rice. Determining an accurate amylose CLD has previously been impossible. This has to be obtained by size-exclusion chromatography (SEC, a type of GPC), which shows that the amylose CLD usually has two or more distinguishable regions. However, SEC suffers from band broadening, which smears out fine features. Recently (Nada et al. Analytical and Bioanal. Chem. 409 6813 2017), a method was derived to overcome this problem, reducing the amylose CLD to a small number of biologically meaningful parameters. New results to be presented here relate these parameters to the amounts of different amylose components and to biosynthetic enzyme activities. Combining with a method for doing this with amyllopectin CLDs (Wu et al. PLoS ONE 8 e65768 2013) leads to a statistical treatment to find causal relations between molecular structural parameters and desired functional properties. This is by looking for statistically valid correlations (e.g. p < 0.05) between structural parameters and a property of interest (Yu et al. Food Chem. 264 2842 2018). This methodology is here applied to extensive data on the stickiness of cooked rice, measured both by human sensory panels and by instrumentation. We find that stickiness is controlled by the structure of starches leached out of the grain during cooking and then adsorbed on the grain surface. High stickiness is when the leached amyllopectin has more short chains and larger molecular size, together with more leached short amylose chains; mechanistic reasons for these observations are then deduced. These structural characteristics are relatively easy to determine. Now, consumers in different regions and cultures have different preferences for stickiness. This discovery shows that a new way of choosing rices to cater for these preferences is with starches showing these molecular characteristics if high stickiness is preferred, with appropriate changes for different preferences. The new methodology can be applied to many other functional properties of interest in starch-based foods.

Variation of protein molecular weight distribution parameters and their correlations with gluten and mixing characteristics for waxy winter wheat
J. B. OHM (1), L. Dykes (2), R. A. Graybosch (3)
(1) USDA-ARS, ETSARC, Cereal Crops Research Unit, Hard Spring & Durum Quality Lab, Fargo, ND, U.S.A.;
(2) USDA ARS ETSARC Cereal Crops Research Unit, Fargo, ND, U.S.A.; (3) USDA-ARS, Lincoln, NE, U.S.A.

Gluten is a valuable by-product in wheat starch separation. A limited level of waxy wheat, which is a unique source of amyllose-free starch, may be used in commercial starch production due to technical difficulties with gluten extraction. Protein molecules are the main components of gluten and have great influence on gluten quality. Particularly, molecular weight distribution (MWD) of proteins has been reported to be significantly associated with gluten strength for non-waxy wheat, whereas little data has been reported for waxy wheat. In this research, fifty waxy winter wheat breeding lines were analyzed for protein MWD parameters using a size exclusion HPLC to investigate their variations and associations with traits related to gluten strength. Among waxy lines, statistically significant (P < 0.001) variations appeared for protein MWD parameters including sodium dodecyl sulfate buffer extractable polymeric protein (EPP) and unextractable polymeric protein (UPP) fractions, which are major components of gluten proteins that have significant influence on gluten elasticity. When compared to mean values of non-waxy hard winter wheat cultivars, waxy wheat lines showed significantly (P < 0.05) higher mean values for both EPP and UPP content values. The allelic variation of HMW glutenin subunits appeared to influence polymeric protein content in waxy lines. Specifically, allelic variation at the Glu-D1 locus, HMW glutenin subunit pair 5+10 and 2+12, appeared to have distinct influence on polymeric protein content. Waxy lines that possessed the HMW glutenin subunit pair 5+10 had a significantly (P < 0.001) greater mean value for UPP content and lower value for EPP content when compared to waxy lines with 2+12. The polymeric proteins were significantly (P < 0.05) correlated with gluten strength related traits, such as mixograph peak time and gluten index. Negative correlations for EPP and positive correlations for UPP were observed for waxy lines and non-waxy wheat cultivars. In particular, highly significant (P < 0.001) correlation appeared between mixograph parameters and the proportion of EPP in total protein for waxy lines. Overall, these results indicate that waxy lines had wide variation similar to non-waxy winter wheat cultivars for protein MWD distribution parameters, and that waxy wheat cultivars that have favorable protein composition, and consequently acceptable gluten quality, could be developed.
Designing Future Wheat
G. MOORE (1)
(1) John Innes Centre, Norwich, U.K.

Designing Future Wheat research is organised into four separate work packages (WP), WP1 and 2 focusing on trait dissection and characterisation, WP3 on germplasm development for trait dissection, and WP4 on data access and analysis. Traits identified for dissection and characterisation were agreed by the wider private and public international research communities, highlighted in the G20 Wheat Initiative Strategic Research Agenda and the BBSRC 5 year Wheat Research Strategy 2013. The germplasm work package (WP3) is developing near isogenic lines carrying chromosome segments derived from landraces or wild relatives and associated markers to facilitate trait dissection. The germplasm developed forms the basis of breeders’ toolkits, which will be refined and expanded during the programme, and provided to the breeders together with associated genotyping and trait data. The information and germplasm generated within the programme will also allow breeders to provide wheat processors, food manufacturers and retailers with sources of grain with enhanced health benefits. WP4 organises the data and resources developed in a readily accessible form, allowing analysis and full integration with that more widely available. This will also facilitate the translation of research information from wheat to other crops, and vice versa.

Evaluation and validation of Raman spectroscopy as a screening tool for detection of antimicrobials in animal and human foods
K. M. LEE (1), Y. Yarbrough (2), T. J. Herrman (1)
(1) Texas A&M AgriLife Research, College Station, TX, U.S.A.; (2) Texas A&M University, College Station, TX, U.S.A.

The feasibility of standard Raman and surface-enhanced Raman spectroscopy (SERS) was investigated to develop more accelerated and more efficient analytical method for determination of antimicrobial additives in animal feeds, including chlortetracycline, decoquinate, lasalocid sodium, monensin, virginiamycin, oxytetracycline, and salinomycin. The collected Raman spectra clearly showed the difference in spectral profiles among tested samples and reflected the level of antimicrobial concentrations. Chemometric classification models evaluated with a cross-validation method via k-nearest neighbor, linear discriminant analysis, and partial least squares discriminant analysis algorithms displayed acceptable correct classification rates with above 90% regardless of the type of antimicrobials. Quantification models developed using multiple linear regression and partial least squares regression also exhibited acceptable coefficients of coefficients (R² of 0.85), a good quality of linear regression (slope close to 1.0), and lower prediction errors with no statistical significant difference between model predicted and reference (HPLC) values at a significance of P < 0.05. The results indicate that the proposed Raman spectroscopic method could be a promising and convenient analytical tool for early detection and identification of antimicrobials in animal feeds and possibly human foods. The method can serve as a valuable screening and management tool which can help enhance health and productivity of animals as well as humans who consume the animals and their products.

Effect of physicochemical conditions on formation of nano-composite between starch and fatty acid
H. Y. SHIN (1), J. Y. Kim (1)
(1) Department of Food Science and Biotechnology, Kangwon National University, Chuncheon, South Korea

Starch is a suitable candidate for shell materials of encapsulation technology for food and cosmetic and pharmaceutical industries, due to their biocompatibility and biodegradability. A starch nano-particle partially consisting of amylose inclusion complex can be generated by precipitating starch in an aqueous paste using ethanol, and the inclusion complex has a void space within the central helical core. So it was hypothesized the formation of the starch nano-particle may be applied to encapsulation technique. And stearic acid is a typical guest compound readily forming composite with amylose. In this study, this encapsulation approach using stearic acid was investigated to simplify encapsulation process using starch. To prepare the nano-sized composite between starch and stearic acid, the alcoholic solution of stearic acid (in 95% ethanol) was dropwisely added into starch solution. Effect of addition rate (2, 8, 16, 25 mL/min), reaction temperature (70, 80, and 90°C), starch concentration (0.5, 1, and 3%), and fatty acid content (5, 10, 25 mg) on recovery of fatty acid, hydrodynamic volume, and crystalline characteristic of the composite was investigated. Fatty acid content of composite increased as reaction temperature rises, starch concentration increases. Also, that of composite was higher with addition rate and content of fatty acid were medium level. Fatty acid content of 10 mg and starch concentration of 3% resulted highest fatty acid recovery (37.5%). X-ray diffraction (XRD) analysis revealed that all composites possessed typical V-type crystalline structure but higher reaction temperature (80–90°C) resulted significantly higher XRD peak intensity relative to that of the composite resulted from the reaction temperature at 70°C. At a given same reaction condition (3% starch, 10 mg stearic acid, 8 mL/min addition rate), a hydrodynamic volume of the composite was decreased (835.3 to 240.5 nm), as the reaction temperature increased (from 70 to 80°C).
Temperature and water-associated changes of cereal starch monitored by TD-NMR and microimaging
C. RONDEAU-MOURO (1), R. Kovrlija (1)
(1) IRSTEA, Rennes, France

Time domain NMR (TD-NMR) method has been widely used to characterize starch, the major storage carbohydrate of cereals, as evidenced by the numerous relaxometry and diffusometry studies available in literature [Kovrlija, R. and Rondeau-Mouro C. Food Chemistry, 2017]. When starch is heated and then cooled in the presence of water, it undergoes a series of changes known as swelling, gelatinization and retrogradation that induce variations in water distribution, in starch structure and interactions between them. These biochemical transformations can be investigated and quantified using TD-NMR, also convenient for the continuous monitoring of products during processing up to their final structure. Magnetic resonance microimaging (MRμI) is a complementary technique that can be applied to investigate, with a spatial resolution, the water penetration in cross-linked starch blends and cereal foodstuffs. NMR and MRI techniques could help cereal scientists to better understand the behaviors of macro-molecules in baked products and their interaction with each other and water, and to make products with better quality and shelf-life. This presentation will be focused on the applications of these two methods for characterizing at molecular or millimetric scales, cereal starch-water systems under hydration and/or heating and cooling. We will show TD-NMR results on starch-water systems and dough at various water levels (40–55% wb). Relaxometry measures permitted to simultaneously quantify water transfers and starch changes induced by a thermal processing between 20 and 90°C (10°C steps) followed by a cooling at ambient temperature. In another hand, the application of MRμI to monitor the water sorption kinetics in starch-glycerol extrudates allowed going ahead in the multi-scale approaches by distinguishing between various water diffusion behavior (Fickian or case II case), in relation with different physical and mechanical properties of starch-based products.

Sensory evaluation of gluten-free fresh pasta from proso millet
C. Tyl (1), L. Inamdar (1), Z. Vickers (1), B. Ismail (1), A. MARTI (2)
(1) University of Minnesota, St. Paul, MN, U.S.A.; (2) DeFENS, University of Milan, Milan, Italy

Despite being gluten-free and exhibiting favorable agronomic properties, millet is underutilized in North America and Europe. To promote its use in food products, we previously reported on the suitability of proso millet for preparation of gluten-free pasta, focusing on cooking quality, compositional and nutritional aspects. The aim of this study was to gain insight into consumer evaluation of pasta, and relate compositional attributes to sensory perception. Fettuccine-type fresh pasta was prepared from four millet varieties with different amylose content (from 7.8% to 35.7%) and prolamin profile. Samples were compared to two commercial fettuccine products, one wheat-based, and the other gluten-free. Freshly cooked samples were evaluated by a sensory panel trained on descriptive analysis. Data were analyzed via ANOVA, Student-Neuman-Keuls tests, and principal component analysis that included instrumental data as supplementary variables. Several attributes related to appearance, taste and texture differed significantly among samples. One millet pasta (from variety Earlybird) was ranked as more yellow than the commercial gluten-free pasta, but not different in yellowness to wheat; all other millet varieties resulted in pasta that was rated more yellow than commercial gluten-free, but less yellow than wheat pasta. This assessment is in agreement with instrumental analysis of carotenoids via HPLC and color via chromameter. All millet samples were perceived as more uniform, but also more gray than commercial samples. Regarding taste, Earlybird millet pasta received higher bitterness and aftertaste scores than other millet and commercial samples. In terms of texture, millet pasta was significantly starchier, less elastic and grainier than both commercial samples. The presence of high molecular weight prolamins corresponded to lower perceived stickiness, but higher graininess. Higher amylose contents increased firmness and chewiness, but reduced stickiness. Earlybird millet pasta was significantly stickier, but less chewy and firm than all other samples, in agreement with low instrumental firmness. Principle component analysis differentiated commercial samples from millet pasta, as well as Earlybird pasta from other millet samples. Earlybird and wheat pasta were characterized by high yellowness, low firmness and low chewiness; the other millet samples were of intermediate yellowness and firmness, and commercial GF pasta exhibited high firmness and low yellowness. Graininess, starchiness, and uniformity were characteristic for all millet pasta; high tensile strength and elasticity were characteristic for both commercial controls. Our study reveals which attributes distinguished millet from commercial pasta, and highlights parameters that warrant improvement by recipe or processing optimization.

Processing for reduced phytate content and increased mineral bioavailability in cereal products
A. S. SANDBERG (1)
(1) Chalmers University of Technology, Gothenburg, Sweden

Phytate is a potent inhibitor of iron, zinc and calcium absorption in cereal and legume based diets. Low bioavailability and absorption of iron and zinc from plant based diets is considered a major factor in the etiology of iron and zinc deficiencies in low income countries. According to WHO around 2 billion people worldwide suffers from iron deficiency. The magnitude of zinc deficiency is probably of the same order. A dose dependent
inhibition of Fe, Zn, Ca and Mg absorption by phytate (inositol hexaphosphate InsP₆) has been demonstrated in humans. During food processing enzymatic or non-enzymatic hydrolysis of phytate occurs forming less phosphorylated inositololphosphates. Inositol pentaphosphate inhibits Fe and Zn absorption, and inositol tri- and inositol triphosphate contribute to the inhibiting effect in processed foods. Thus there is a need for sustainable methods to improve the bioavailability of minerals in plant foods. Dephytinization by biological processing techniques such as malting, fermentation, addition of phytase is a means to improve Fe and Zn absorption. Yeast or lactobacillus strains with high phytase activity can be used in fermentation processes. To substantially improve iron absorption the dephytinization has to be virtually complete. Cereal based foods then can become good sources of dietary iron and zinc, but the necessary process optimization without changing food palatability is often difficult to obtain. However, in a balanced diet containing animal protein a high intake of whole grain cereals high in phytate is not a risk in terms of iron supply as demonstrated in a recent intervention study in humans.

The effect of sugar concentration and particle size on the rheological properties of biscuit dough
T. MOLINA (1), P. Bouchon (1), S. M. Vaz (2)
(1) Pontificia Universidad Catolica de Chile, Santiago, Chile; (2) Nestlé Chile, Santiago, Chile

Sucrose is the most important sugar used in biscuit manufacturing; nevertheless, dietary concerns about the effect of high sugar consumption is driving the food industry to reduce the amount of added sugar in the products. Accordingly, the aim of this study was to analyze the effect of sucrose concentration and sucrose particle size on the rheology of a biscuit dough model during mixing and heating. Soft wheat flour and sucrose with two particle sizes (granulated sucrose: 99% of particles > 150 μm; Powdered sucrose: 5% of particles > 150 μm), at three different concentrations, were used to prepare the dough. The flour-sucrose blends were analyzed using Mixolab Chopin+, a system that allows analyzing the rheological properties of the dough during mixing as well as the changes in consistency under heating. Minor modifications of the standard protocol were performed in order to mimic the biscuit baking process. Results showed that both the addition and the type of sucrose affected the way the dough develops the desired consistency (1.1 Nm). During the first minutes of mixing, doughs made with granulated sucrose first increased their consistency above 1.1 Nm, which decreased after ~3 min up to 1.1 Nm. On the other hand, the dough prepared with powdered sucrose gradually increased the consistency up to 1.1 Nm. This behavior could be attributed to the effect of sucrose dissolution before dough formation. Moreover, doughs with 16 or 23% of sucrose increased the stability during mixing compared to the dough without sucrose. On the other hand, in the systems with 36% of sucrose, although the dough with powdered sucrose was somewhat stable during mixing, the dough with granulated sugar was significantly weakened even before heating. During the heating process, the onset temperature of starch gelatinization was delayed in dough with 16% of sucrose, but this phenomenon was inhibited when the sucrose concentration was increased to 23 or 36%. As a consequence, the final consistency of these two last systems was significantly lower (1.4 and 0.6 Nm, respectively) than those with 16% of sucrose and those without sucrose (about 5.0 Nm). These results shows that sucrose reduction produce a rheological profile similar to flour alone, and how the effect of high sugar consumption is driving the food industry to reduce the amount of added sugar in the products.

Creep recovery test: Comparison between dough and wet gluten and its relationship with the breadmaking quality of wheat
Z. J. HERNANDEZ-ESTRADA (1,2), P. Rayas-Duarte (1), J. D. D. Figueroa Cardenas (3)
(1) Oklahoma State University, Stillwater, OK, U.S.A.; (2) Tecnológico Nacional de México, Unidad de Investigación y Desarrollo en Alimentos, ItVer, Veracruz, Mexico; (3) CINVESTAV Unidad Queretaro, Queretaro, Mexico

Effects of HMW-GS on viscoelasticity of wet gluten and wheat dough, and its relationships with mixing, extensibility and breadmaking parameters were investigated by creep-recovery using Kelvin-Voigt model on hard red winter wheats. Gluten samples with Glu-A1 1 and 2* only show significant differences in retardation time λ0. Samples with subunit 17+18 in Glu-B1 showed higher elastic moduli G0, G1 and G2 and viscosity coefficients η0, η1 and η2 compared to subunits 7+8 and 7+9, with both having almost twice the deformation than 17+18. Wheat samples with Glu-D1 5+10 had higher values of G0, G1, G2, η0, η1 and η2 compared to samples with Glu-D1 2+12. Gluten samples were on average 5.5, 3.1 and 1.6 times less stiff than their respective dough when comparing G0, G1 and G2, respectively. These differences suggest that the non-gluten components have high influence in the instantaneous and first Kelvin elements of the model and they are manifested faster compared to gluten components. Higher explanation of variance of loaf volume was found in parameters η0, G1; (r=0.57 and 0.58, P < 0.0001) compared to η1 and G1; (r = 0.45 and 0.56, P < 0.01 and P < 0.0001, respectively). These findings indicate that glutenins of long-chain sizes (2nd Kelvin-Voigt element) had major effects in quality compared to short-chain sizes (1st element).
Development of a method to evaluate the quality of vital wheat gluten for bread baking using a high shear based technique

J. E. Bock (1), S. GALL (2), J. Wiertz (2)
(1) C.W. Brabender Instruments, Inc., Cincinnati, OH, U.S.A.; (2) Brabender GmbH & Co. KG, Duisburg, Germany

Vital wheat gluten is commonly used as an ingredient in commercial bread production to improve the overall strength characteristics of the base flour. However, few methods exist that successfully discriminate among vital wheat gluten samples in a manner that is correlated to baking performance. The GlutoPeak is an instrument that has been proposed as a means of evaluating gluten quality of wheat flour samples. It utilizes a high shear rate to aggregate gluten in a wheat flour + solvent slurry and measures the resultant torque over time. The torque curve can then be evaluated for peak torque, time to peak torque, energy of aggregation, and other parameters to discriminate among samples. A method was therefore developed to evaluate the quality and potential baking performance of vital wheat gluten samples using the GlutoPeak instrument. Initial trials included variations on solvents (distilled water vs. salt solutions), speeds (constant speeds vs. varied speed profiles), and other additions (e.g. starch and sucrose). In the final method a 2.1 g sample of vital wheat gluten was added to 4.41 g of distilled water solution in the sample cup. The sample was then sheared at 500 rpm for 1 min followed by a rest period of 2 min. After the rest period, shearing resumed at 3,300 rpm for 10 min. Temperature was held at 36.0°C for the duration of the test. Relative standard deviations of repeatability ranged from 1.4–2.7% for peak maximum time, 2.1–7.9% for maximum torque, and 3.6–6.6% for aggregation energy. Baking trials were conducted with rye and wheat formulations. Rye breads showed strong correlations between specific loaf volume and GlutoPeak parameters (e.g. peak maximum time, r = 0.954). This was expected because the quality of the added vital wheat gluten largely determined final bread performance in the rye formulations. Wheat breads showed more mixed correlations (stronger correlations with loaf height:width and pore density; slightly weaker correlations with specific loaf volume) because of the interactions between native wheat flour gluten and added vital wheat gluten. Overall, the method is acceptable for discriminating among vital wheat gluten samples, and a larger validation trial is in progress to further elucidate correlations between GlutoPeak parameters and baking performance in wheat breads.

Thermo-reversible inhibition makes aqualysin 1 a potent tool for studying the contribution of wheat gluten to the crumb texture of fresh bread

A. E. VERBAUWHEDE (1), M. A. Lambrecht (1), E. Fierens (2), O. Shegay (3), K. Brijs (1), J. A. Delcour (1)
(1) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium; (2) Flanders’ Foods, Brussels, Belgium; (3) Competence Center for Fermentation, Puratos Group, Andenne, Belgium

The thermo-active serine peptidase aqualysin 1 (Aq1) of Thermus aquaticus was applied in bread making as a tool to study the relative contribution of thermoset gluten to bread crumb texture. Aq1 activity with and without the presence of wheat flour extract was colorimetrically measured in assay. The impact of Aq1 on the gluten structure during bread making was evaluated with size exclusion chromatography and rapid visco analyzer. Under assay conditions, Aq1 is active between 30°C and 90°C with an optimal activity at 65°C. However, this peptidase is inactive during mixing, fermentation and the initial baking phase as it is inhibited by wheat endogenous serine peptidase inhibitors. Therefore, it starts hydrolyzing gluten proteins during baking above 80°C when the enzyme is no longer inhibited. Most of the starch is then gelatinized and a thermoset gluten network is formed. As both phenomena coincide, it is difficult to evaluate the relative contribution of the physico-chemical changes in both polymers on final bread crumb texture and structure. Protein extractability with sodium dodecyl sulfate containing medium from bread crumb increased with 20% when Aq1 was added to the recipe and the molecular weight (MW) distribution of gluten proteins shifted from higher to lower MW. This suggests a less coherent gluten network structure in bread with Aq1. However, no differences in specific volume nor in crumb structure were observed between breads containing Aq1 and control bread. Texture profile analysis showed a rather small but significant impact on textural parameters such as hardness, cohesiveness, resilience, springiness and chewiness. In addition, Aq1 clearly impacted crumb coherence as the crumb was perceived to crumble more easily. The discrepancy between the impact of Aq1 on the gluten network on the one hand and the small textural differences on the other hand suggests a key role for starch in bread crumb texture, whereas thermoset gluten seems to be important for the crumb coherence.
Slowly digestible carbohydrates reduce gastric emptying rate in humans suggesting activation of the ileal brake
M. Chegeni (1), A. M. R. HAYES (1), T. D. Gonzalez (2), M. M. Manderfeld (2), R. Menon (2), N. Holschuh (2),
J. Lim (1), B. R. Hamaker (1)
(1) Whistler Center for Carbohydrate Research, Purdue University, Department of Food Science, West Lafayette,
IN, U.S.A.; (2) General Mills, Inc., Minneapolis, MN, U.S.A.

Diets containing slowly digestible carbohydrates (SDCs), in the form of starch-entrapped microspheres that
digest into the ileum, were previously shown to reduce food intake in a diet-induced obese rat model by
activating the gut-brain axis. These results suggested that SDCs trigger the ileal brake, which is a feedback
mechanism controlling stomach-mediated transit of a meal. The ileal brake is characterized by delayed gastric
emptying rate and increased satiety. The goal of this work was to determine if common SDCs trigger the ileal
brake in humans, using gastric emptying rate as a proxy indicator. In a human study, SDCs were delivered
through a semi-solid yogurt matrix, and gastric half-emptying time and postprandial glycemic response were
assessed. The study was a five-arm, double-blind, crossover design with a one-week washout period between
treatments (n = 20, 9 females, 11 males). Four different carbohydrate ingredients (SDCs: isomaltoligosaccharides (IMO), Xtend® sucromalt, and raw corn starch; and non-SDC: maltodextrin) were incorporated
individually, or in combination, into yogurt products matched in energy density and viscosity. Participants
consumed 300 g test meals of yogurt formulated with one or a combination of the carbohydrate ingredients after
an overnight fast. Gastric emptying rates and glycemic response were measured using a 4¹³C-labeled octanoic acid
breath test and continuous glucose monitors, respectively. Glucose readings were continuously monitored 24 h
prior to and 48 h after test meal consumption, and breath samples were collected for a 4 h period following test
meal consumption. Results showed that yogurt containing IMO and raw corn starch elicited significantly longer
gastric half-emptying times (2.7 h) compared to other test products (2.3 h) (p < 0.05), with a subset of female
subjects showing a more highly pronounced effect (up to > 4.5 h gastric half-emptying time). Differences in
postprandial glycemic response were found between males and females (males: no differences in glycemic
response among the different SDCs tested; females: lower post-prandial glycemic response (area under the curve,
0–120 min) after consumption of yogurts supplemented with maltodextrin, IMO plus Xtend® sucromalt, and raw
corn starch). Taken together, we reason that the delay in gastric emptying rate observed for IMO and raw corn
starch, two types of SDCs, is indicative of a triggering of the ileal brake.

Bioprocessing of bread waste to create a functional ingredient: Assessment of antifungal effect and impact
on bread shelf-life
L. Nionelli (1), P. Bautista Espinoza (1), M. O. Immonen (1), N. H. Maina (1), K. K. Katina (2), R. CODA (2)
(1) University of Helsinki, Department of Food and Nutrition, Helsinki, Finland; (2) University of Helsinki,
Helsinki, Finland

Bakery industry is one of the major contributors to food but also waste production, with an estimate of about
20 million Kg/year of discarded bread only in Finland. A great part of this waste is caused by the short shelf-life
of bread, due to bread staling and microbial spoilage. Bread staling only results in poor sensory quality, making
unsold bread due to staling still fit for consumption. The increasing development of circular economy systems
courage processes in which resources are kept within the value chain as long as possible. Currently, bakery
waste is incinerated, discarded in landfills, used as feed or for biofuel/chemicals production. Up to date, no other
solution for bread recycling is used in food industry, highlighting the need for alternative ways for an efficient
exploitation of bread waste. The objective of this study is to recycle bread waste through bioprocessing
technologies by transforming it into a novel ingredient able to increase the mould-free shelf life of bread without
compromising its safety. Procedures for bread hydrolysis with carbohydrases and proteases have been set up,
followed by fermentation with selected strains of lactic acid bacteria (LAB) and propionic acid bacteria (PAB),
singly or in combination. The antifungal effect of the bioprocessed bread slurry was assessed in vitro on different
moulds originating from bakery environment. The presence of spore formers (e.g. Bacillus) was monitored
throughout the processing steps. Baking trials to assess the shelf-life of bread containing the best performing
bioprocessed slurries are ongoing. Bread hydrolysis protocols were optimized to respond to the metabolic need of
the starters. The fermented slurries displayed antifungal effect on the indicator moulds to different extent. LAB
fermented slurries inhibited the growth of various Penicillium spp. from 20 to 75%. PAB had the highest
inhibitory effect (up to 60%) on A. niger growth, most likely due to the production of propionic acid. For all the
selected processes, the presence of the toxigenic specie Bacillus cereus was below the risk level or not found.
Baking tests with the best performing fermented slurries are undergoing to confirm the effect on bread mould-
free shelf life. Thanks to this recycling approach, it will be possible to set up feasible technologies to generate a
novel ingredient with improved functionality to be used at the bakery site.
Mineral, phenolic acid and enzyme profiles of hard red spring wheat varieties released in the last 100 years
K. WHITNEY (1), C. Schwebach (2), J. B. Ohm (3), S. Simsek (1)
(1) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.; (2) North Dakota State
University, Fargo, ND, U.S.A.; (3) USDA-ARS, ETSARC, Cereal Crops Research Unit, Hard Spring & Durum
Quality Lab, Fargo, ND, U.S.A.

Wheat is the third most produced cereal crop, and is cultivated on more land and in more locations than any
other food crop in the world. Wheat breeding efforts have focused on increasing yield. However, it has not been
determined if the nutritional properties of HRSW were affected. This research study was conducted to determine
if there were any significant differences between the ash, phenolic acid, and enzyme activity of 30 HRSW
cultivars released over a span of 100 years. Ash and mineral contents were determined using AACC and AOAC
approved methods, respectively. Enzyme activities were measured using substrate tablet test kits and phenolic
acid profiles were evaluated using high performance liquid chromatography. In terms of mineral content,
calcium and sodium were not significantly different (HSD, P < 0.05), but there were significant differences (HSD,
P < 0.05) between decades for the total ash, phosphorus, potassium, and zinc; genotypes were clustered in two
primary groups—1910s to 1970s and 1980s to 2010s. No significance (HSD, P > 0.05) was found in either the
total free or bound phenolic acids or any of the specific phenolic acids, except for p-coumaric and caffeic acid
which showed significant differences (HSD, P < 0.05). Cluster analysis was less defined than the ash, since the
two primary groups (1910–1990 and 1970–2010) had more overlap. The dendogram for enzyme activity
demonstrated some significant (HSD, P < 0.05) grouping, however it cannot be concluded that this separation is
due to release year. All ash, mineral, enzyme activities and phenolic acid values that demonstrated significance
were negatively correlated with release year; these differences do not indicate a change in the wholesomeness of wheat.

Dietary carbohydrates, the gut microbiota and host health: Frontier science or fool’s gold?
D. J. MORRISON (1)
(1) University of Glasgow, East Kilbride, U.K.

Technological innovation in recent years has opened a window into the highly complex world of the gut
microbiome and its impact human health. The early excitement across many disciplines that the gut microbiome
might be a key determinant of host health has been tempered by the lack of clinically effective interventions to
prevent or treat disease. Nuances in the links between dietary intake of carbohydrates, protein and fat and gut
microbiota activity are slowly emerging and what is clear is the critical role that diet plays in regulating the
metabolic activity of the gut microbiome. This provides a significant challenge however because of the
heterogeneity of human dietary intake patterns, which overlap with complex environmental and genetic factors.
On the other hand, with a greater understanding of the pivotal role of fermentable carbohydrates, this also
provides opportunities to shape, through the diet, the microbial landscape in the gut towards profiles that can
effectively prevent and treat human disease. This talk will explore the links between dietary carbohydrates, the
gut microbiota and host health.

Functional high value syrup from wheat bran
V. Pihlajaniemi (1), J. Taskinen (1), O. MATTILA (1), T. Koitto (1), E. Nordlund (1)
(1) VTT Technical Research Centre of Finland, Espoo, Finland

In the spirit of circular economy, food industry should pursue efficient exploitation of food raw materials and
processing of by-products. Wheat bran is a major underutilized side stream created during milling, and it is
currently used for low value applications such as combustion, animal feed or as a substrate for biofuel
production. Currently there are no industrial processes that recycle wheat bran back to human consumption as a
high value ingredient for food industry. The aim of Wastebake project is to create functional syrup from wheat
bran, containing prebiotic arabinopyro-oligomers and antioxidant properties, with equivalent baking quality
compared to commercial syrups. The novel technology has been developed around alkaline pretreatment and
enzymatic hydrolysis, allowing sugar yields up to 80% and arabinopyro-oligomer yields up to 30% of
carbohydrates, with considerable release of antioxidant compounds. The present study focuses on comparison
between the developed alkaline process with several mechanical and thermochemical pretreatments previously
studied for bran processing to evaluate the most efficient pre-treatment for the functional syrup production.
These pretreatments include wet- and dry-milling, steam explosion, acidic and ultrasound treatment. The
processes are evaluated in terms of mono- and oligomeric sugar yields, antioxidants and energy consumption,
and the industrial scale applicability of the processes is evaluated. Based on the comparative and multi-
disciplinary approach the presentation will conclude the most feasible pretreatments for bran syruring.
Application of sorghum (*Sorghum bicolor* L. Moench) and effect on the technological properties of gluten-free bread

M. Gava, Jr. (1), N. C. STEINMACHER (1)

(1) Federal Technological University of Paraná (UTFPR), Medianeira, Brazil

The market for products aimed at the celiac public is still very restricted, generating the gluten intolerant consumer difficulties in maintaining a diet. Thus, the present work aimed to develop gluten-free breads with sorghum flour added with psyllium. The grains underwent physical characterization and were ground to determine the grain size and the physicochemical analyzes of the flour. In the preparation of the loaves a factorial design was elaborated where the variables were the thickeners (psyllium, xanthan gum and HPMC) and the analyzes were firmness, specific volume, color, water activity, microbiological analysis and sensorial analysis of the 3 formulations chosen 100% psyllium, 100% xanthan gum and control). The obtained flour has a thick granulometry of 1.18 mm. The proximate composition of the dry basis flour was 12.44 g protein, 2.82 g ashes, 0.44 lipids, 17.40 g of total fibers, of which 17.40 g insoluble fiber and 1.30 g fiber soluble and 56.91 g of carbohydrates. The sensorial analysis was performed with the formulations of 100% psyllium, 100% xanthan gum and the control (without addition of additives). All formulations in the hedonic scale test presented values above 6 for all the questions. In the intent-to-purchase test the formulations with additives were preferred and the same was repeated for the acceptability index.

Effect of heat moisture treatment on the physicochemical properties of whole wheat flour

W. L. BAO (1), X. Zhou (1)

(1) Jiangnan University, Wuxi, China

Heat moisture treatment (HMT) on wheat flour and the application of HMT-wheat flours have been investigated in several studies. But investigation of HMT on whole wheat flour seems to be limited. Therefore, this paper focused on the HMT on the whole wheat flour and explored the quality changes in crackers. On the other hand, many reports of HMT on flours and starch were conducted for several hours, which could decrease the brightness of flour. In this study, HMT was applied on whole wheat flour with 20%, 24%, and 28% moisture content at 100°C, 110°C, and 120°C for only 50 min. The Scanning electricity microbiology (SEC) results showed that the surface of starch granule was damaged under higher moisture and temperature. When it referred to thermal properties, the onset temperatures (T<sub>c</sub>), peak temperatures (T<sub>p</sub>) and conclusion melting temperatures (T<sub>m</sub>) of most samples were increased as increasing moisture content and heating temperature indicating the increasing resistance of flour to heat. HMT-28%-120°C flour had highest T<sub>c</sub> (71.04 ± 0.0°C), T<sub>p</sub> (73.87 ± 0.2°C), T<sub>m</sub> (75.95 ± 0.4°C). Farinograph analyses showed that the longest development time and stability time of HMT-28%-120°C whole wheat flour were 17.6 ± 0.6 min, 15.2 ± 0.1 min (native whole wheat flour: 4.2 ± 0.7 min, 2.7 ± 0.4 min) respectively, but volume of bread made by it didn’t get improved. So this paper focused on the quality changes in crackers. And it found that crackers made by HMT-whole wheat flour, the HMT-samples...
hardness decreased largely especially the HMT-28%-100°C crackers hit the lowest hardness (519.85 ± 72.15 g) and whole-wheat-flour-crackers was 2,218.21 ± 374.93 g. The fracturability of HMT samples was improved slightly compared with native whole wheat and weak strength flour and HMT-20%-100°C crackers earned the highest fracturability (17.45 ± 0.16). Finally the SRC (solvent retention capacity) values showed that LA-SRC (lactic acid-SRC) values of HMT-24%-110°C (146 ± 0.0%) and HMT-24%-120°C (146 ± 0.0%), HMT-28% whole wheat flour (100°C : 144 ± 0.1%, 110°C : 157 ± 0.0%, 120°C : 143 ± 0.0%) were higher than the native (119 ± 0.1%), which can be used to explain the longer development and stability time in farinography. But the mechanism behind the phenomenon needs further tests. There was a gap between SC-SRC (sodium carbonate-SRC) values of modified and native whole wheat flour as the heating temperature increased to 110°C or 120°C, which reflects the increasing level of damaged starch and that maybe the reason why the water absorption of HMT whole wheat flour was higher than the native in farinography. Therefore, moderate HMT conditions were suitable to have the quality of whole-wheat-flour crackers improved.

Developing phenolic-mediated stable protein matrices in cereal grains for potential control of starch digestion
L. C. R. SCHMIDT (1), B. R. Hamaker (1)
(1) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.

A shift away from whole foods has increased available dietary carbohydrate, with long-term consumption of high glycemic carbohydrates linked to adverse health consequences. Reducing starch digestion rate mitigates glucose response by slowing glucose release and absorption. Sorghum porridges are less nutritive compared to other cereals, with kafirins implicated as the causative factor. 3-Deoxyanthocyanidins in sorghums are thought to be responsible for forming stable disulfide crosslinked protein matrix during cooking, surrounding gelatinizing starch granules, while nascent matrices in other cereals collapse. Matrices may be key to the slow starch digestion characteristic of cooked sorghum by hindering carbohydrase access. Understanding contributions of phenolics to matrix construction advances the potential to control starch digestion. Using ovalbumin (OVA) as a model protein system (pH 6.8), extracts from white sorghum, corn masa, and white rice flours, and select phenolics, were examined for heat-induced polymerization effects by SDS-PAGE and compared to a control without redox active compounds added. Sorghum extracts developed greater amounts of a wider range of molecular weight (MW) products, suggesting dynamic disulfide interchanges, while masa and rice tended towards aggregates. Apigeninidin (APG, 2 ng-2 μg/mg OVA) resulted in higher monomers, and lower APG showed higher concentrations of a greater range of MW products, again suggesting a dynamic system. Gallic, p-coumaric, sinapic acids, and catechin had subtle effects on MW outcomes in ranges found in grains. Adding APG to corn flour before porridge preparation increased matrix stability, observed by confocal microscopy. Relationships between phenolic components and dynamic matrix formation are complex, but unraveling contributions of specific compounds may lead to designed foods for slowly digestible starch.

Elucidating the biochemical change in wheat flour aging dictating rheological properties and its processing performance
(1) University of Guelph, Guelph, ON, Canada; (2) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium; (3) KU Leuven, Leuven, Belgium

The aging of wheat flour is a biochemical process by which various flour components undergo significant changes post-milling. Wheat flour aging noticeably affects the functionality of flour in processing and end product quality. It is crucial to identify the main driver(s) of flour aging with the goal of developing a rapid method to track flour aging in commercially relevant settings. Freshly milled wholemeal and refined wheat flours were stored at 25°C and sampled at different aging times to monitor changes in flour lipids and gluten proteins. In order to decouple any interactions between lipids and gluten proteins, a portion of flours was defatted immediately post-milling with petroleum three times to completely remove the lipids. An additional sample with the defatting solvent (petroleum) was evaporated with no lipid extraction to monitor the effect of the solvent on other flour components (such as gluten proteins). The lipid distribution profile was tested by HPLC-ELSD to determine which lipid fractions are most prone to hydrolysis and oxidation. Flour functionality indicators including batter viscosity and dough rheological properties, and thiomic patterns related to gluten cross-linking were monitored during aging. Lipid composition played a key role in wheat flour functional properties during aging. The TAG, MGDG and PC decreased remarkably, while DAG, FFA and MGDG significantly increased with aging time in wheat flours. The presence or absence of lipids had a significant impact on the thiol profile, which significantly affected the flour functionality. Accessible and available thiol content decreased with increasing aging time. The peak torque, water absorption, stability, peak viscosity, final viscosity, and setback of wheat flours increased with increasing aging time, whereas the development time and pasting temperature did not significantly change. Results indicate that changes in the lipid profile during aging drive the changes observed in available thiols and thus the functional properties of aged flour.
Phase transfer of Ag-nanoparticle for the detection of organic-based samples with SERS technique
J. Park (1), J. A. Thomasson (1), K. M. LEE (2), T. J. Herrman (2)
(1) Texas A&M University, College Station, TX, U.S.A.; (2) Texas A&M AgriLife Research, College Station, TX, U.S.A.

Surface-enhanced Raman spectroscopy (SERS) are becoming a promising technique for the detection of many analytes up to low concentration level in agriculture field. However, many SERS applications have been based on the use of any metal-based nanoparticle which can be well dispersible in water phase, so if we need to try to detect many organic-based samples from agricultural field, there would be a huge problem that they cannot be well mixed with water-dispersible nanoparticle. In this study, the water-dispersible Ag-nanoparticle including anionic surfactant were tested to make it successfully transferred to organic phase for the SERS application. First, three different kinds of cationic surfactants were prepared and dissolved into water or organic solvent. Second, each surfactant solution was added into the already prepared Ag-nanoparticle and vigorously mixed together. Lastly, each of them was centrifuged and only concentrated nanoparticle was re-dispersed with organic solvent. The optimized condition that can maximize the phase transfer of the particle was finally confirmed by transmission electron microscopy (TEM) and some analytes miscible with organic solvent were tested for the proof of SERS application. As a result, they were very well mixed with organic solvent and the SERS signal detection from ppb level samples were achieved. Therefore, we expect that the newly proposed protocol for SERS application can be widely utilized for the determination of many types of organic-based samples.

Digestibility and physicochemical properties of processed Australian rice
M. R. TOUTOUNJI (1,2), A. Farahnaky (1,2), V. Butardo (3), P. Oli (4), C. L. Blanchard (1,2)
(1) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (2) School of Biomedical Sciences, Wagga Wagga, Australia; (3) Department of Chemistry and Biotechnology, Swinburne University of Technology, VIC, Australia; (4) NSW Department of Primary Industries, Yanco, Australia

Rice is a staple crop to over half the world’s population which makes it an ideal target food for the prevention and management of obesity-related illnesses, especially type II diabetes and colorectal cancer. So far, the Australian rice industry has relied on plant breeding to develop low GI rice varieties such as Doongara, however data on the impact of processing on rice starch digestibility are lacking. This research aimed to investigate the effect of industrial-scale thermal processing on the starch digestibility of Australian medium and long grain rice varieties. Thermal processing involved heating with steam under pressure. The total starch, resistant starch and in vitro starch digestibility of five processed samples were measured. Textural, cooking and physicochemical properties of the samples were also determined. Processed samples were found to have a statistically significant reduced rate of starch hydrolysis as compared to the controls (non-thermally processed rice) and the magnitude of this change was found to be variety dependent. The outcome of this project provides important information on the physicochemical and digestibility properties of processed Australian rice. Manipulating the digestibility of rice by processing may be an effective way to improve the health outcomes of consumers.

Glycemic index and texture of bread containing pinto bean starch
C. W. Simons (1), N. B. HENRY (1)
(1) Wright State University – Lake Campus, Celina, OH, U.S.A.

Pulse starches are known to have a low glycemic index due to starch conformation which resists digestion. This attribute can be potentially exploited to produce low-glycemic index foods to meet the needs of diabetics and/or obese individuals. Hence, pinto bean starch was extracted from pinto beans, dehydrated and added to bread formulations in triplicate at 5%, 10%, and 15% concentrations. The pinto bean fortified breads were compared against control bread treatments containing 100% wheat flour. Texture profile analysis (TPA) was completed using a CT3 Texture Analyzer 24 hours after baking. Following texture analysis, breads were dried in a convection oven for 12 hours at 50°C, and then milled. Expected glycemic index (eGI) was determined on the native pinto bean starch and bread treatments. TPA results indicated that inclusion of native pinto bean starch in breads did not significantly alter textural characteristics (hardness, springiness, and chewiness), except for cohesiveness which was significantly higher in control bread (0.61) compared to breads containing pinto bean starch (0.52–0.54). The eGI of native pinto bean starch was 37.5 which was significantly lower than eGI in bread treatments. For example, bread with 5% pinto bean had an eGI of 91.4 which was significantly higher than bread with 10% pinto bean starch (89.2), but not significantly different from bread containing 15% pinto bean starch (89.7). This significant increase in eGI was likely due to starch gelatinization during baking which increased accessibility to digestive enzymes. The poor retention of eGI indicates a need to develop new baking technologies to retain eGI in pulse-based bakery products or the need to fortify these products with resistant starch made from pulse starches.
Where does sugar fit related to carbohydrate quality?
L. TAPPY (1)
(1) Physiology Department, University of Lausanne, Lausanne, Switzerland

Dietary sugars are mono- and disaccharides naturally present in fruits, vegetables and natural syrups, or added as refined sucrose or high fructose corn syrup. They are absorbed in the blood stream as glucose (indistinguishable from that issued from starch), fructose and galactose. Galactose is converted into glucose, and fructose into glucose, lactate and fatty acids in splanchnic organs. The main nutritional function of sugars is to provide usable energy to all cells of the human body. No universally accepted tool exists for evaluating the quality of a nutrient. Such evaluation requires to take into consideration a large amount of parameters, related to how this nutrient exerts its function(s) in the body, whether it has direct or indirect adverse effects, what are the nutritional properties of foods which contain it, how its consumption affects the consumption of other dietary nutrients, etc. Sugars are dispensable nutrients, and their main function is to transfer usable energy to the body’s cells. Dietary sugar intake is known to alter cardio-vascular and metabolic risk factors, however. The quality of sugars and of sugar-containing foods may therefore vary according to their efficiency in transferring usable energy to the body’s cells on one hand, and to their impact on risk factors for non-communicable diseases on the other hand. The efficiency of usable energy transfer to body’s cells is very high for glucose, lower for galactose, lactose and sucrose, and still lower for fructose. High dietary sugars intake may be associated with an increased risk for cardiovascular and metabolic diseases. This is essentially true for fructose and sucrose, which increase blood lipids and impair hepatic insulin sensitivity when consumed at high doses. Effects of sugar-containing foods vary according to food groups: fruit and vegetable consumption significantly protects against cardio-vascular and metabolic diseases, while sugar-sweetened beverages consumption is associated with an increased risk. Quality of sugar-containing foods should be assessed, not only based on their sugar content, but also on their overall energy, dietary fiber, and micronutrients content.

Wheat versus maize as the major ingredients in noodle manufacture
M. ANAWACHKUL (1), B. Wolf (2), S. E. Hill (1)
(1) The University of Nottingham, Loughborough, U.K.; (2) The University of Nottingham, School of Biosciences, Loughborough, U.K.

As the world market of noodles expands, due to the great demand of convenience food, the development and improvement of noodles that are made from non-wheat cereals is an important topic. The aim of this study was to comprehend the critical factors that differentiate wheat noodles from those created from maize. A series of assessments was therefore developed that included both uncooked and cooked noodles. As an approximation gross differences between the maize and the wheat could be considered as: particle size, level of starch damage and protein level and type. These factors were investigated singularly and in combination to establish if a better maize-based noodle could be formed. Reduction of the maize powders to a similar particle size as the wheat flour increased the strength of the uncooked noodle, but this factor alone did not allow for the creation of robust noodles. Maize noodles were produced with different levels of substitution of pre-gelatinized maize starch and vital gluten (0, 5, 10 and 15% wwb). With increasing level of pre-gelatinized starch and dry gluten, a stronger texture of the uncooked noodles in terms of resistance to extension and extensibility were observed. However, the firmness of the cooked noodles tended to decrease with increasing level of pre-gelatinized maize starch. Noodles prepared with added dry gluten showed higher values for their textural attributes. However, despite the addition of starch and protein, the maize based noodle’s texture would still be considered as very poor compared to the wheat examples. On cooking a notable loss of solids occurred for the maize noodles (24% wwb) compared to that of the wheat noodles (9% wwb). Without the additives the structure of the maize-noodles was insufficient to hold together during the cooking step and matter was lost from the formed noodle. Addition of maize starch raised the moisture level after cooking to as high as 73% wwb, while the noodles with dry gluten addition absorbed less water as the level of gluten increased. This study has shown that the balance of structural integrity when formed cold and loss of matter and hydration when submerged in hot water needs to be considered when designing noodles. The next stages for this work will endeavour to understand the microstructure of the different noodles so that it can be targeted to provide the textures required.

Dry processing of fava bean for value-added utilization
B. JEGANATHAN (1), J. Gao (1), T. Vasanthan (1), F. Temelli (1)
(1) University of Alberta, Edmonton, AB, Canada

Fava bean (*Vicia faba* L.) is a widely-grown, protein-rich, gluten-free, GMO-free, low-priced, nitrogen-fixing bioresource, which is underutilized for human consumption. It has the potential to partially supplement the global protein requirement. Prior to optimizing the fractionation techniques to isolate protein from fava beans, it is important to study the component distribution pattern to determine the raw material preparation method. This study focuses on the sequential pearling process for value-added utilization of fava beans for the efficient separation of grain components, targeting protein isolation in subsequent processing steps. Both high-tannin
variety, Athena (HT) and low-tannin variety, Snow Bird (LT) fava beans were dehulled in a tangential abrasive
dehuller and were then sequentially pearled by time control for 9 cycles (each with 6% removal) in triplicate. The
derived fractions were analyzed for their moisture, ash, protein (Leco-Analyzer), starch (Megazyme procedure
adapted from AOAC 996.11 and AACC 76-13.01), dietary fibre (Megazyme procedure adapted from AOAC and
AACC methods) and flatulence-causing compound (Megazyme procedure) contents on a dry weight basis.
Protein was classified based on Osborne’s classification. Based on the compositional analysis and scanning
electron microscopy imaging of these fractions, proteins were more concentrated in the outer layers, which
gradually reduced towards the inner layers, ranging from 42.55 ± 1.02 to 35.03 ± 0.45%(w/w) for LT and 38.89 ±
0.66 to 33.21 ± 0.59%(w/w) for HT, whereas the starch content showed an inverse trend. Taking advantage of this
distribution, a 60% pearling flour was produced, which showed a significantly (p < 0.05) higher protein content
[39.86 ± 0.08 and 38.12 ± 0.13% (w/w)] compared to dehulled whole beans [34.42 ± 0.30 and 33.67 ± 0.07%
(w/w)] for both LT and HT, respectively. The remaining pearls showed a significantly higher (p < 0.05) starch
content compared to the whole beans regardless of the variety. Thus, the 60% pearling flour has the potential as a
raw material for subsequent processing with Air Current Assisted Particle Separation technique to separate
dietary fibre concentrate, resulting in a starch and protein concentrate as a co-product for protein isolation.
These data suggest that inclusion of sequential pearling as an upstream processing step in fava bean fractionation
has the potential to generate novel value-added food ingredients for protein isolation to meet the nutritional
requirements of the growing population by enriching the nutritionally imbalanced gluten-free flours, while
producing a starch-rich by-product.

Effects of MC and HPMC on rheological properties of wheat flour
E. J. LIM (1), S. Y. Lee (1)
(1) LOTTE Fine Chemical, Incheon, Korea
The object of this study was to investigate the rheological properties of wheat flour gels containing methyl
cellulose (MC) and hydroxypropylmethyl cellulose (HPMC). MC and HPMC are a kind of food additive used as the
binder, emulsifier, thickening agent, film former in food processing. Wheat flour used extensively in diverse
products like breads, noodles, pasta, cakes, biscuits and cookies, soups, pet foods, and aquatic feeds as the main
ingredient. Through the study on the relation between cellulose derivatives and flour, it would be possible to
predict the characteristics of the final product and determine which cellulose derivatives are best suited for the
flour based goods. MC and 3 types of HPMC such as 2910, 2906 and 2208 (USP39) were selected for determining
interaction with flour. MC, containing 29% methyl group, and various degree of substitution (DS) of HPMC,
containing 19–30% methyl group and 4–12% hydroxypropyl group, mixed with flour. Each of cellulose
derivatives was added in flour at 0.5% (w/w), and total solid content in the gel was adjusted to 14% (w/w) with
flour. Rapid visco analyzer (RVA), water activity (Aw) meter, texture analyzer (TA) and scanning election
microscope (SEM) were employed in the analysis. All data were analyzed using Minitab software to test the
significance with a 95% confidence interval. The pasting profile was measured by AACC Approved Method 76-
21 (AACC 2000b) using RVA. For setback, which is used to predict starch staling and syneresis, MC and HPMC
2910 types showed lower values, while HPMC 2906 and 2208 types showed higher values than control (p < 0.05).
The patterns were similar to each other. The results of water activity in the control and test groups were above
0.9 and there were no significant differences between them (p > 0.05). The addition of cellulose derivatives
chosen for this experiment had no effect on reducing Aw. The hardness of the test groups which include selected
cellulose derivatives stored at 10°C during 7 days was lower values than control (P < 0.05). The hardness slope
of flour gel with cellulose derivatives was increased slowly than control. SEM showed that the starch granule of
the control and test groups had collapsed when samples were heated at 90°C. In conclusion, the proper choice of
cellulose derivatives can help play a decisive role when preparing the flour based product with optimum quality.

Navigating the UK future food safety system
C. STEWART (1)
ROF is a major transformation programme aiming to modernise and re-shape the regulatory regime for food.
The programme will improve the way regulatory controls are delivered by developing a modern, resilient system
for ensuring that businesses meet their responsibilities. It will take account of all available sources of information
and be flexible enough to keep pace with technological change in the food industry, and able to adapt to the
changing environment. This presentation will provide an overview of ROF and what it aims to achieve.
Structural changes and in vitro digestibility of starches in intact pulse cellular structure subjected to heat treatment
B. ZHANG (1), W. Xiong (1), M. Wang (1), X. Fu (1), Q. Huang (1)
(1) South China University of Technology, Guangzhou, China

Heat treated pulses are widely accepted as a low glycemic food with potential health benefits of reducing the risk of obesity and type 2 diabetes. However, the structural basis for the variation in digestion rate and extent of pulses subjected to heat moisture (varying moisture content at 15%, 25% and 35%, keeping at 100°C for 4 h) or dry heating (keeping at 120, 140, 160°C for 4 h) treatment is still unclear. In this study, intact cotyledon cells and starch of a commercial pulse, i.e., pinto bean, were isolated under mild conditions. We investigated the macrostructure of intact cells and structural features of entrapped starch granules, such as crystallinity (by X-ray diffraction – XRD) and thermal parameters (by differential scanning calorimetry), and diffusion of fluorescein isothiocyanate (FITC)-tagged amylase conjugates into intact cells. It was found that cell wall could preserve more ordered structure of starch granules from melting during heat treatment compared to the isolated starch counterpart, which was confirmed by X-ray diffraction and thermal analysis. In vitro digestion kinetic profiles of pulse cells were monitored by a reducing sugar assay with a fixed α-amylase activity. The kinetic data were fitted into a first order model to obtain the apparent rate coefficient. After heat moisture or dry heating treatment, it was found that most fluorescence retained within the protein matrix, suggested that the protein matrix might bind with the enzyme and inhibit the digestion rate of the entrapped starches rather than the barrier function of the outer cell wall. Compared with heat moisture treated counterpart, the dry heat treated intact cells showed lower digestion rate and extent. These findings will help develop functional pulse ingredients with desirable digestion behavior and attenuated postprandial glycemic responses.

Nutritional and technological characterization of proso millet (Panicum miliaceum L.) varieties grown in northern Italy
S. CIANI (1), O. Polenghi (1), E. Bernhart (1), D. D’Introno (1), V. L. Cerne (1)
(1) Dr. Schaer AG/SPA, Trieste, Italy

The continuous growth of the gluten-free sectors in Europe has prompted grain producers and processors to consider reintroducing previously cultivated gluten-free crops. Among crops being re-evaluated, proso millet (Panicum miliaceum L.) has significant potential due to its rich nutritional profile and its adaptability to low input agriculture. The crop was widely present in Italy until the second half of the 20th century when farmers adopted more profitable but intensive crops such as corn and wheat, resulting in the loss of several proso millet lines. Four proso millet varieties were retrieved from three countries, namely Austria (Lisa and GLRH 16106), USA (Horizon), and the Russian Federation (Quartet). These varieties had not been previously tested in Italy but were chosen based on their agronomic results in their countries of origin. The objective of this work was to assess the nutritional and technological characteristics of the four millet varieties and to identify suitable candidate(s) varieties for the production of gluten-free bread products. Grains were dehulled on an impact dehuller, with Lisa showing the highest yield, before being milled on an ultra centrifugal mill (Retsch Zm 200). Nutrient composition (starch, protein, fat) was similar among the different varieties. Pasting properties were measured on a microviscoamylograph (Brabender) and significant differences in setback, final viscosity, gelification viscosity, breakdown among varieties were noted. A model bread recipe was then used to test the baking properties of each variety. Significant differences were seen for bread compactness as measured with a texture analyzer (Stable Micro Systems). Additionally, loaf specific volume, number of cells and average cell size were significantly different among breads obtained from different millet varieties. The present study found significant variation in the technological characteristics of four proso millet varieties; differences were also noted in bread products obtained from the tested varieties. The data presented will inform choice of proso millet varieties for applications by the gluten-free industry.

New marker technologies
K. EDWARDS (1)
(1) University of Bristol

In 2012 the first large-scale sequence data for the hexaploid wheat genome was published in the journal “Nature”. About that time there were no more than a few hundred single nucleotide polymorphism-based molecular markers available to breeders for routine genotyping. Since then, despite the complex nature of the wheat genome, there has been an explosion in the availability and number of markers and genotyping platforms with the result that costs to breeders have reduced and sample throughput has increased. Many of these developments have taken place via public–private partnerships including Designing Future Wheat. In my presentation I will highlight how these partnerships, specifically those involving Bristol University, have revolutionised the high throughput genotyping of wheat and how this development work is continuing to aid wheat breeding.
Getting progress from precision in agriculture: Elephants in rooms, carts before horses, and genes in fields
R. SYLVESTER-BRADLEY (1), D. Kindred (1)
(1) ADAS, Cambridge, U.K.

The physiology explaining how cereals grow is uncontroversial, and predicts potential grain yields of ~20 t ha⁻¹ in the UK – far exceeding current farm yields (4). In keeping with many other regions, UK cereal yields have not increased for more than 20 years, yet neither the industry nor academia has reached a conclusive diagnosis of the shortfalls. Instead they have placed their faith in genetic improvement. However, analyses of multiple variety trials over many site-seasons show genetic effects to be small, with low heritabilities (1); environmental effects and variety-x-environment interactions are more important. The static yield conundrum thus requires environmental analysis more than genetic analysis, and it is opportune that “precision farmers” are now generating large datasets which relate crop yields to soil and other environmental conditions, and that new statistical techniques are enabling precision farmers to test husbandry effects and their interactions with soil characteristics (2,3). The immediate challenge is for stakeholders in farm productivity to realise the new scope for farmer-centric research and to establish the digital and social infrastructures that will enable farmers to cooperate in “idea groups”, posing vital questions, collecting and sharing trustworthy data, drawing reliable conclusions and disseminating useful messages (5). Yield Enhancement Networks (4) exemplify such cooperation, and the replication of such networks is crucial to deducing and designing sustainable routes to progress in the productivity of cereals. References: Clarke, S. and Sylvester-Bradley, R. (2015) Understanding wheat yield improvements to equip breeders for the future. Aspects of Applied Biology 124, Breeding Plants to Cope with Future Climate Change, 29-35. Kindred, D., Sylvester-Bradley, R., Milne, A., Marchant, B., Hatley, D., Kendall, S., and Berry, P. (2017). Spatial variation in nitrogen requirements of cereals, and their interpretation. Advances in Animal Biosciences: Precision Agriculture 8(2), 303–307. Rudolph S., Marchant P.B., Gillingham V., Kindred D., Sylvester-Bradley R. (2016). "Spatial Discontinuity Analysis” a novel geostatistical algorithm for on-farm experimentation. In Proceedings of the 13th International Conference on Precision Agriculture. Monticello, IL: International Society of Precision Agriculture. Sylvester-Bradley, R. and Kindred, D.R. (2014). The Yield Enhancement Network: Philosophy, and results from the first season. Aspects of Applied Biology 125, Agronomic decision making in an uncertain climate, 53-62. Sylvester-Bradley, R., Kindred, D.R., Marchant, B., Rudolph, S., Roques, S., Calatayud, A., Clarke, S. and Gillingham, V. (2017). Agronômics: transforming crop science through digital technologies. Advances in Animal Biosciences: Precision Agriculture 8(2), 728–733.

Porous high amylase rice starch prepared using amylglucosidase and maltogenic alpha-amylase
T. KEERATIBURANA (1), A. R. Hansen (1), S. Tongta (2), A. Blennow (1)
(1) University of Copenhagen, Frederiksborg C, Denmark; (2) Suranaree University of Technology, Nakhon Ratchasima, Thailand

Porous starch finds many applications by providing new and active surfaces for modification of starch for foods, pharmaceuticals, cosmetics and chemical purposes. Enzyme-assisted modification using hydrolases has been used for producing porous starch but uses of enzyme combinations are restricted. The two most stable hydrolases amylglucosidase (AMG) and maltogenic alpha-amylase (MA) exert very different hydrolytic mechanisms and were therefore investigated separately to elucidate potential effects in producing porous starch using granular high amylase rice starch as substrate. Both enzymes generated pores at the surface as shown by scanning electron microscopy (SEM). However, internally, only minor effects were seen, as judged by confocal laser scanning microscopy (CLSM) using fluorescent protein probes with different molecular size. The enzyme treated granules had higher relative crystallinity compared to control rice starch as deduced by wide angle X-ray scattering (WAXS). MA treatment, but not AMG treatment, resulted in a significantly increased number of short amylpectin chains. The MA treated starch had higher solubility than control, but the AMG treated starch showed an opposite trend. Swelling power slightly decreased for both treatments. Both enzyme treatments resulted in decreased pasting peak viscosity, final viscosity, breakdown and setback values compared to control. Pasting temperature increased with enzyme incubation time and enzyme treatments for 24 h resulted in pasting temperatures in the range 78.8 to 79.6°C for the control and 80.8 to 85.6°C for the enzyme treated samples. The data demonstrate that porous high amylase rice starch can be produced by AMG and MA treatments thereby specifically altering its functionality, extending the range of applications and facilitating further chemical modification.

Functionality of yeast and its metabolism by-products on properties of fermenting dough
M. N. REZAEI (1), F. Auger (1), C. M. Courtin (2)
(1) Lesaffre International, Marcq-en-Barœul, France; (2) KU Leuven – Laboratory of Food Chemistry and Biochemistry, Leuven, Belgium

General belief about yeast functionality during breadmaking process is mostly limited to the production of carbon dioxide (CO₂) and addition of aromatic notes to the final baked product. However, the role of yeast in breadmaking is not limited to gas production or flavor formation. During dough fermentation, yeast converts
sugars into CO₂ and ethanol as primary metabolites and produce secondary metabolites such as acetic acid, succinic acid and glycerol. In recent years, significant progress was made in demonstrating the functional role of yeast during fermentation and more specifically, underpinning the role of yeast metabolites produced during the proofing step on rheological properties of fermented dough. In this overview, we will focus on recent advances on the yeast functionality during dough fermentation and how the yeast metabolism impacts the rheological properties of fermenting dough and the implications of these actions on industrial bread production.

Development of probiotic foods for Chinese consumers utilizing Canadian pulses: Yogurt study
J. HAN (1), C. Bansema (1), M. Sigvaldson (1)
(1) Food Processing Development Centre, Alberta Agriculture and Forestry, Leduc, AB, Canada

The explosive growth of China’s emerging middle class has brought sweeping economic change and social transformation in recent years. Consequently, urban households with high disposable incomes are paying more attention to their health and are looking to consume more nutritious and healthy food products. The purpose of this study was to develop healthy products employing fermentation techniques familiar to Chinese consumers. The targeted products were probiotic non-dairy yogurt and yogurt drinks suitable for the urban Chinese consumer palate. These products were developed utilizing various pulses grown in Canada and feedback was gathered from both product development and consumer sensory evaluations of prototype yogurts. Non-dairy yogurt was formulated using faba bean, and yellow dry pea fractions. Pulse fractions accounted for approximately 45% of the formulation on a dry weight basis. One serving (125 g) of yogurt offered 6.25 g of protein. Ingredient mixes were heat treated followed by fermentation at 43°C for 46 hours, using vegan yogurt starters (i.e. *Lactobacillus* sp.). Resulting pulse protein yogurts yielded pH 4.0–4.2. Results from the first product development sensory evaluation demonstrated that textural acceptance of pulse protein yogurts were not significantly different (p < 0.05) than a commercial non-dairy market control yogurt. Following the flavour development process, the haskap berry and mango flavour treatments were further evaluated in a larger consumer study. Results showed yogurts made with faba bean fractions received higher mean liking scores for overall acceptability, flavour and aftertaste acceptability compared to the yogurts made with yellow pea fractions. These differences were more evident with the milder mango flavour treatment compared to the haskap flavoured yogurts. A greater percentage of panellists indicated they “would purchase/definitely would purchase” the haskap berry flavoured faba bean based yogurt compared to the yellow pea based yogurt and the mango flavoured yogurts. Yogurt prepared using a yellow pea base require strong flavour systems to mask unattractive flavours characteristic to yellow pea. Overall results suggest with modification optimizations pulse based yogurts may be an accepted addition to the non-dairy yoghurt food category. Consumer feedback suggested the Haskap berry faba bean yoghurt formulations are market ready. While the mango flavour may not appeal to as great of a percentage of the population, with the application of suggested optimization modifications these yoghurts may have the potential for market success.

Fermentation from beer to bread
E. ZANNINI (1) E. K. Arendt (1,2)
(1) School of Food and Nutritional Sciences, University College Cork, Cork, Ireland; (2) APC Microbiome Institute, University College Cork, Cork, Ireland

Yeasts have been used for thousands of years to produce fermented foods and beverages, and among them beer and bread. However, the choice for a particular yeast strain or species for a specific food application is often based on traditions, rather than scientific knowledge. Yeast fermentation can be used to improve technological, nutritional and sensorial quality characteristics of cereal-based food and beverage products. However, less attention was drawn on the desired baker’s yeast performance during dough fermentation step, whereas yeast selection is an established part of the production process in beer making. Surprisingly, our knowledge about the dough fermentation step in correlation to product quality parameters is scarce and still not completely understood. Additionally, new biotechnological yeast applications, such as the production of functional beverages, beside beer, or the development of special dietary foods products, expose yeast with environments and challenges that differ from those encountered in traditional food fermentations. In this presentation, the impact of yeast fermentation in different food and beverage systems will be reviewed. Special emphasis will place on the influence of the raw substrate (wheat and gluten-free) and ingredients (salt, sugar) on different yeast culture performance and the aroma modulation. The increasing fundamental knowledge about yeast fermentation generates new opportunities for their functional use in the brewery and baking industry to replace or reduce the amount of expensive additives, processing aids or improvers. This knowledge’s also opens alternatives to better satisfy the high demand of consumers for an increasing variety of bakery products with added value.
The hydrolytic capacity of wheat \( \alpha \)-amylase and the degradation of wheat starch of soft white wheat during pre-harvest sprouting

M. H. TSAI (1, Y. He (2), Y. Shao (1), A. H. M. Lin (2)
(1) Bi-State School of Food Science, University of Idaho and Washington State University, Moscow, ID, U.S.A.; (2) Bi-State School of Food Science, University of Idaho, Moscow, ID, U.S.A.

The low falling number (FN) issue continues hurting the wheat industry, especially the Pacific Northwest region in the United States. Pre-harvest sprouting (PHS), stimulated by rains after physiological maturity, and late maturity \( \alpha \)-amylase (LMA), triggered by temperature shocks during grain filling period, are major causes of low FN. Idaho is known for producing premium soft white wheat (SWW) for the exporting market; however, SWW is relatively more vulnerable to low FN issue, and its biochemical changes during sprouting has not been reported. In this study, we investigated the changes of wheat \( \alpha \)-amylase and starch of two SWWs—Ovation and UI Sparrow—grown in Tammany, Tensed and Genesee, during PHS with a long-term goal of developing strategies in preventing low FN and utilizing low FN wheat in human foods. Wheat were induced to sprouting in a greenhouse with controlled mist until reached sprouting score three. FN was measured following AACC 56-81.03. Starch was quantified following AACC 76-13.01, and its morphology was examined by SEM. Starch paste viscosity with the presence of AMY was measured by an RVA. Wheat AMY was obtained and purified before and after sprouting; its molecular size and activity were determined by the SDS-PAGE, Zymogram, and increased amount of reducing power during amylolysis. Experiments were performed in replicates. Data were analyzed with one-way ANOVA and Student’s t-test. Our data showed FN decreased significantly after sprouting and the change differed upon varieties. Both varieties in all locations had similar FN (340 s) before sprouting; sprouted Ovation and UI Sparrow had a decrease of 113 and 205 s, respectively. However, the total AMY activity in Ovation (9.4 U) was significantly higher than in UI Sparrow (7.2 U). AMY in Ovation (6.5 U/mg protein) also had a higher absolute activity than AMY in UI Sparrow (5.8 U/mg protein). Nevertheless, AMY in sprouted UI Sparrow decreased starch paste peak viscosity (2,739 cP) more than AMY in Ovation (2,545 cP). Starch amount maintained the same after sprouting (58–62% w/w) but the number of small particles (diameter < 10 µm) increased. SEM confirmed the increase of small particles was starch fragments. In conclusion, the AMY hydrolytic capacity differs in varieties, and the visualized scoring of sprouting does not reflect FN or biochemical change in spraying wheat correctly. We continue characterizing wheat AMY in various spraying stages and varieties to understand its mechanism of the decrease of FN from a substrate-enzyme relationship perspective.

Effect of pearl millet extrusion on the formation of amylose-lipid complexes and their slow digestion property

P. C. TORRES AGUILAR (1), A. M. R. Hayes (1), X. Yepez (1), M. M. Martinez (2), B. R. Hamaker (1)
(1) Whistler Center for Carbohydrate Research, Purdue University, Department of Food Science, West Lafayette, IN, U.S.A.; (2) University of Guelph, Guelph, ON, Canada

The prevalence of obesity and diabetes has steadily risen in Africa, as sociocultural and economic shifts have prompted changes in physical activity and dietary patterns. Consumption of whole grains might have potential beneficial effects on carbohydrate digestion by delaying glucose release. Here, we examined the effect of a small-scale, low-cost single-screw extruder (35 kg/hr) on the formation of amylose-lipid complexes and their subsequent effect on in-vitro digestion of an indigenous African grain, pearl millet (\textit{Pennisetum glaucum}) var Tifleaf 3. The variety used was a hybrid with resistance to disease and drought. Extrusion processing is a physical treatment during which ingredients are subjected to high temperature and shear, and in this study was used to produce convenient instant flours for thick and thin porridges in West Africa. Pearl millet (7% lipid) with high concentration of mono (25%) and polyunsaturated (54%) fatty acids was used as whole and decorticated flours (30 and 32% moisture content of feed stock). Extractable lipids were reduced from 7.5 to 4.2% in whole flours concentration of C16:0 and C18:2 were preferentially complexed with amylose despite the low relative concentration of C16:0 in the native flours. Extruded flours demonstrated a lower rate of \( \alpha \)-amylose digestion and total glucose release compared to native cooked flours, 1.57 ± 0.12 and 1.80 ± 0.15 mg maltose equivalent for whole extruded and decorticated extruded flours respectively. Whole grain extruded flour presented the lowest rate of digestion and slowest glucose release compared to other treatments. After thermal exposure at 100°C for 20 min to dissociate amylose-lipid complexes, extruded flours exhibited the highest rate of digestion and glucose release. Our findings show that extrusion of whole grain pearl millet flour substantially reduces in vitro starch digestion rate due to complexation of free fatty acids with amylose.
Evaluation of the impact of cricket powder incorporation on the rheological properties of wheat doughs and on the final products characteristics
G. VERICEL (1), O. Le Brun (1), L. Bosc-Bierne (1)
(1) CHOPIN Technologies, Villeneuve la Garenne, France

Flours made from insects are an alternative source of proteins. They may be added to cereal products. However, they certainly have important impacts on doughs rheological properties. It is then necessary to assess the rheological behavior of cricket powder alone and to evaluate the impact of cricket powder addition on the quality...
of doughs and the characteristics of breads. Four cricket powders provided by two suppliers were tested alone using the Mixolab thanks to a specific protocol (“Cricket protocol”). One sample was added at different levels into wheat flour (0%; 1.5%; 2.5%; 3.5%; 5%; 6.5%; 7.5% and 10%). Those blends were analyzed thanks to the Mixolab (“Chopin+” protocol; AACC 54-60.01) and the French bread making method (NF V 03-716). The analysis of cricket powder alone reveals that the rheological quality of the samples can vary a lot according to the supplier but also within the samples from one supplier. The analysis of the blends show that the quality of the flour decreases gradually when cricket powder is added. The dough stability decreases as well as the stability of the hot formed gel (~166% on the C4-C3 value). The volume decreases (from 1,562 ml at 0% to 598 ml at 10%) as well as the total score. These phenomena become significant from 3.5% incorporation. Finally, correlations prove that Mixolab gives a good prediction of the bread making data (R² = 0.99 between the volume and the C3 values).

Mixolab is able to analyze the rheological properties of various cricket powders, alone and blended to wheat flour. The use of the Mixolab can help define and adapt this limit according to the respective quality of cricket and wheat flours used.

Effect of in situ synthesis of exopolysaccharides on the quality of southern-style Chinese steamed bread

X. TANG (1), X. Cheng (1), W. Huang (1), N. Li (2), F. R. Arnaut (3)
(1) Jiangnan University, Wuxi Jiangsu, China; (2) GZ Puratos Food CY Ltd., Guangzhou, China; (3) Puratos NV, Groot Biggaarden, Belgium

In this study, five exopolysaccharides (EPS) producing lactic acid bacteria (LAB), Weissella cibaria (WCI), Weissella confuse (WCO), Leuconostoc mesenteroides (LM), Leuconostoc citreum (LC) and Lactobacillus fermentum (LF) were isolated from Chinese traditional fermented rice starters and fermented pickle. Southern-style Chinese steamed bread (CSB) was prepared with 30% added sourdough fermented with the five EPS producing LAB. Rheology, rheofermentation, emulsifying and microstructure properties of dough, specific volume, crumb hardness, and sensory properties of the CSB were compared with the control CSB prepared without sourdough. All sourdoughs significantly influenced the rheological properties of the dough, with LF fermented sourdough exhibiting the strongest impact. Dough proofing performance significantly improved after addition of sourdoughs fermented by WCI, WCO and LM. However, only LF fermented sourdough exhibited increased (P < 0.05) dough emulsifying properties. Laser scanning confocal microscopy results showed that LF starters produced an optimum CSB dough structure. Steamed bread leavened with WCO starters had the highest specific volume and softest crumb texture. All sourdough CSB showed a good overall acceptance than the control CSB. Sourdoughs containing in-situ synthesized EPS may have potential application in the southern-style CSB manufacture and thereby fulfill consumers’ increasing demand for “clean labels”. Among the five EPS producing LAB, Weissella confuse and Lactobacillus fermentum showed the greatest potential for improving the quality southern-style CSB.

Evaluation of starch composition and quality in hard red spring wheat varieties released since 1900

K. WHITNEY (1), C. Schwebach (2), J. B. Ohm (3), S. Simsek (1)
(1) North Dakota State University Department of Plant Science, Fargo, ND, U.S.A.; (2) North Dakota State University, Fargo, ND, U.S.A.; (3) USDA-ARS, ETSARC, Cereal Crops Research Unit, Hard Spring & Durum Quality Lab, Fargo, ND, U.S.A.

The United States of America is the third largest producer of wheat in the world and North Dakota is the largest grower of hard red spring wheat (HRSW). Anti-wheat trends are becoming more popular due to the opinion that modern wheat cultivars are less “healthy” than historic cultivars; if continued; these trends could seriously impair global food security efforts. As part of a larger study evaluating changes in wheat components and chemistry, this research study was conducted to determine if there were any significant differences in the starch composition and quality of 30 HRSW representative cultivars released from public and private breeding programs during the last 100 years. Amylose content and starch molecular weight were measured using high pressure size exclusion chromatography with multi angle light scattering. Bread was baked using AACC method 10-09.01 and in vitro starch digestibility was determined using the Englyst assay. The amylose content of the flour ranged from 24.2% (Faller, released 2007) to 25.9% (Waldron, released 1969). The average molecular weights of amylopectin and amylose in these samples were 9.3×10⁶ and 2.1×10⁶, respectively. The amylose and amylpectin contents, and molecular weights were not significant (HSD, P < 0.05) between release years. The estimated glycemic index (eGI) of the samples ranged from 88.7 (Granite, released in 2002) to 99.3 (Stoa, released in 1984). The starch digestibility results were also not significant (HSD, P < 0.05) among release years. Only the total starch content of the flours had significant (P < 0.05) correlation with release year. However, the starch digestibility was not significantly (P < 0.05) correlated to release year. Therefore, even though the TS in bread made from HRS wheat increased, the amount of digestible starch did not increase. These results are important because many believe that an increase in starch content in bread would lead to a higher glycemic index and a more pronounced glycemic response.
Controlled sprouting of durum wheat: Effects on starch and protein characteristics

G. CARDONE (1), A. Scipioni (1), A. Marti (2)
(1) University of Milan, Milan, Italy; (2) DeFENS, University of Milan, Milan, Italy

Grain sprouting leads to the development of specific enzymatic pattern that may improve both micronutrient bioavailability and sensory characteristics. On the other hand, high accumulation in enzymes is usually associated with dough weakening and stickiness. Thus, a controlled wheat sprouting process could be useful to assess the perfect balance between nutritional advantages and technological performance. The aim of this study was to evaluate the effects of durum wheat sprouting under controlled conditions on both starch and protein characteristics. Durum wheat kernels were sprouted at 20°C and 90% relative humidity, and sampled after 24, 36, 48, and 62 hours. After sprouting, samples were dried and milled into semolina flour. The effects of sprouting time were assessed on gluten aggregation kinetics by the Glutopeak® and starch pasting properties by the Rapid Visco Analyzer®. In addition, amylase activity was evaluated by using the falling number. Despite the proteolytic activity developed during sprouting, the gluten proteins were still able to aggregate. However, the decrease in maximum torque and energy required for gluten aggregation suggested gluten weakening. Moreover, after sprouting proteins required more time for aggregation (i.e. high peak maximum time). No significant differences were detected between 36 and 48 h, whereas the worst aggregation properties were measured after 62 h of sprouting. As regards starch, sprouting led to drastic decreases in viscosity during both the heating (i.e. peak viscosity and breakdown) and cooling (i.e. final viscosity and setback) phases, due to the increase in amylase activity (i.e. decrease in falling number). Adding silver nitrate—a strong amylase inhibitor—peak and final viscosity greatly increased, indicating that the pasting and gelation properties of starch were not compromised by sprouting. Further works are ongoing to evaluate the effects of using sprouted durum wheat on bread characteristics.

Amylase resistance of pulse and corn starches as influenced by three different phosphorylation techniques

H. DONG (1), T. Vasanthan (1)
(1) University of Alberta, Edmonton, AB, Canada

Fast growing global demand for plant proteins enhanced pulse processing activities in Canada including production of protein isolates/concentrates from field pea (FP) and fava bean (FB). Crude starch is the major byproduct (~50%, w/w) of pulse processing and therefore innovations in pulse starch refining and utilization is necessary to ensure business viability. Although the characterization of native pea and fava starches is adequately performed, little information is available on pulse starch chemical modification. The objective was to study the effect of phosphorylation of pulse starches from pea and fava, by three different methodologies, on the starch physicochemical properties and in vitro amylase resistance (AR). Since chemical modification of corn starches has been widely researched and commercially used, the study compared the properties of the native and modified pulse starches to those of corn starch counterparts. Native pulse starches were isolated by an aqueous technique, and corn starches of different genotypes (i.e. waxy, WC; regular, RC and high-amylose, HAC) were obtained commercially. All native starches were phosphorylated by the following three methods: a) POCl3-aqueous: 1–2% POCl3 in aqueous slurry at 25°C; b) STMP-semidry: 2–4% sodium trimetaphosphate/sodium tripolyphosphate (STMP/STPP 99:1, w/w) in a semidry state at 130°C; and c) STMP-aqueous: 5–12% STMP/STPP (99:1 w/w) in aqueous slurry at 45°C. The native and modified starches were characterized for composition, morphology by scanning electron microscopy, physicochemical properties such as gelatinization, pasting and crystallinity by differential scanning calorimetry, rapid viscometry and X-ray diffractometry, respectively, and AR by the Englyst method. Chemical modification imparted marginal differences in the starch granular morphology and significant differences in the physicochemical properties. The phosphorous content of modified starches (0.01–0.19%) was higher than native counterparts and significantly differed with starch source (WC > FP > FB > RC > HAC) and the method of phosphorylation (STMP-semidry > STMP-aqueous > POCl3-aqueous). The degree of cross linking (DC) for different phosphorylation methods when determined by the % reduction in the peak viscosity of the pasting curves followed the order as POCl3-aqueous > STMP-semidry > STMP-aqueous. The DC when compared between phosphorylation methods did not proportionately correlate to % phosphorous content. Perhaps this is due to phosphorous in the modified starches prepared by both STMP methods exists in cross linked as well as substituted forms. In regard to in vitro amylase resistance, POCl3-aqueous modified corn and pulse starches with the lowest phosphorous content had the highest amylase resistance. Overall, the data indicated that phosphorylation by POCl3-aqueous is an efficient chemical modification method to influence amylase resistance of corn and pulse starches.
Effects of thermal treatment and storage on dough functionality and development of flavor compounds in intermediate wheatgrass flour

B. Ismail (1), M. LUU (2), G. A. Reineccius (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.; (2) University of Minnesota, Food Science and Nutrition, Minneapolis, MN, U.S.A.

Thinopyrum intermedium, commonly known as intermediate wheatgrass (IWG), is a novel perennial crop that has garnered attention for its environmental and nutritional benefits. Wheat is typically processed into flour and stored until use. Thus, it is important to monitor changes during storage of the flour. Grains are stable up to 8–12 years; however, flour has a significantly lower shelf-life due to the increased surface area for chemical activity. Thermal treatment may increase the shelf life of grains, such as oats, by inactivating enzymes that are involved in rancidity, which is the primary mode of failure. Rancidity is one of the major pathways for the formation of volatile organic compounds (VOC) and precursors for other flavor pathways. Our objective is to evaluate the effect of steam treatment on the rheological properties and flavor development of refined, partially refined and whole IWG flour stored at various relative humidity levels. IWG and hard red wheat (control) were subjected to steam treatment and stored at room temperature and at 43 and 65% RH. Gluten quality and water absorption were measured using Brabender® GlutoPeak and Farinograph-AT, respectively. Gluten extensibility and resistance were measured using Kieffer Rig® and a texture analyzer. Starch pasting profile was analyzed by micro-viscoamylograph. VOC was extracted from flour following a dynamic headspace purge and trap protocol using a Tenax® absorbent resin and analyzed by gas chromatography-olfactory-mass spectrometry. Steam treated samples had lower starch pasting peak viscosity, breakdown, and final viscosity compared to non-steam treated flour. Gluten quality and water absorption were not significantly impacted by steam treatment and was maintained during storage. Determination of dough extensibility and resistance are underway. Lipid oxidation compounds namely hexanal, (E)-2-nonenal, and 1-octen-3-ol were detected in IWG with higher abundance in flour sample stored longer. Further flavor characterization is underway. Steam treatment may be a viable option for enhancing the storage stability of IWG flour. The interruption of enzymatic activity by steam treatment could help prolong the shelf life of IWG, ultimately protecting its properties and rendering it marketable.

Feed moisture influences the pasting and viscoelastic properties of pre-gelatinized pearl millet flours

E. O. AYUA (1,2), S. Nkhata (1), O. Campanella (1), B. Hamaker (1)
(1) Whistler Center for Carbohydrate Research, Department of Food science, Purdue University, West Lafayette, IN, U.S.A.; (2) Department of Food science and Nutrition, University of Eldoret, Eldoret, Kenya

Millet is commonly consumed as thin or thick porridges in many parts of Africa, because it is adaptable to semi-arid agro-ecological zones and is readily available and affordable. We have introduced and used low-cost extrusion technology in Kenya, Senegal, and Niger to produce instant millet, sorghum, and maize porridge flours. A continuous single screw extruder, developed by engineers at Purdue, has been used to provide a variety of extrusion technology in Kenya, Senegal, and Niger to produce instant millet, sorghum, and maize porridge flours. Understanding changes in components in instant millet flours during extrusion is necessary to select appropriate conditions that can be used to create competitive flours at reasonable cost to consumers in Africa. In this regard, we processed whole grain pearl millet at different feed moisture contents (27, 29, 31, 33 and 35%) and assessed pasting profiles and viscoelastic properties of the instant flours. Lower moisture contents are desirable as extrudates require less drying energy and time. Examination of the instant flours using differential scanning calorimetry showed their complete gelatinization. Feed moisture of 35% resulted into highest extrudate moisture content before drying compared to flours extrudated at 27% moisture conditions (p ≤ 0.05). Our results from rapid visco-analyzer (RVA) showed that 35% feed moisture resulted in highest peak, trough, and final and set back viscosities compared to non-steam treated flours (p ≤ 0.05). Moreover, the instant flours had greater storage modulus than loss modulus suggesting that single screw extrusion produces viscoelastic instant flours with stronger gels, especially at higher feed moisture. Electron micrographs suggested that higher moisture conditions allowed for greater starch expansion during extrusion. Overall, we observed that we could lower feed moisture to 31%, and produce extrudates with good pasting profiles comparable to 35% feed moisture, and that took less time and energy to dry, thus reduce on the energy cost involved in drying and processing instants flours.

From crop fields to baker’s shop, data science at every step

Y. BROSTAUX (1)
(1) Université de Liège – Gembloux Agro-Bio Tech, Gembloux, Belgium

If “data science” is a recent expression, one of its parents, experimental statistics, lies back to the early 20th century. And from the beginning, it has been deeply linked to cereal science, thanks to the work of Ronald A. Fisher at the Rothamsted Experimental Station where he developed some of the fundamentals of experimental designs and data analyses, still widely used in every field of sciences, like the maximum likelihood principle, and the analysis of variance. As the time passed, new challenges arose. With the industrialisation came the need for optimisation of the processes, standardisation and quality control of the products, … ; the digital revolution
introduced real time monitoring in the fields and in the factories, massification of the data collection, access to aerial imagery, …; and the -omics breakthrough recently opened the pandora box of the billions of jigsaw pieces which build each living individual. Each of these (r)evolution came with their own questions, their own new problems to solve, their own data to process, resulting in new advances in the toolbox of data analysis methods. We’ll take a quick trip through time and processes to illustrate how, from crop fields to baker’s shop, now more then ever, data science is everywhere.

Study of the mechanism of improvement due to waxy wheat flour addition on the quality of frozen dough bread

C. JIA (1)

(1) Jiangnan University, Wuxi, Jiangsu, China

Frozen dough is increasingly being produced worldwide in recent times. This has been attributed to the great advantages related to use of frozen dough such as time and energy saving for baking company, standardizing quality of final products and decreasing financial loss caused by staling. However, some undesirable changes in frozen dough and final products have been found. For instance, increase in dough fermentation time and decrease in specific volume of final products. Waxy wheat flour (WWF), a new functional ingredient richer in amyllopectin (99–100%) than regular wheat flour (RWF) (75%). WWF dough exhibited less change after suffering frozen treatment, compared to RWF dough. However, there are limited studies on the underlying reasons on why frozen WWF dough stability was higher than RWF dough. Therefore, the aim of this study was to lay out the reason why addition of WWF caused an increase in frozen dough stability by investigating and correlating physiochemical properties of starch and protein and frozen dough bread-making properties. WWF was substituted for 10% RWF in frozen doughs and the physicochemical properties of starch and protein isolated from the frozen doughs stored for different time intervals (0, 1, 2, 4 and 8 weeks) were determined to establish the underlying reasons leading to the effects observed in WWF addition on frozen dough quality. Using nuclear magnetic resonance (NMR), differential scanning calorimeter (DSC) and X-ray diffraction (XRD) among others, the gluten content, water molecular state, glutenin macropolymer content, damaged starch content, starch swelling power, gelatinization properties, starch crystallinity and bread specific volume were measured. Compared to RWF dough at the same frozen storage condition, 10% WWF addition decreased dry gluten and glutenin macropolymer contents and T23 proton density of frozen dough, but increased the wet gluten content, T21 and T22 proton density. 10% WWF addition also decreased damaged starch content, but increased starch swelling power, gelatinization temperature and enthalpy, crystallinity of starch and bread specific volume (which increased by 6.67%) of frozen dough. Results in the present study showed (that the improvement observed due to WWF addition in frozen dough bread quality might be attributed to its inhibition of redistribution of water molecules bound to proteins, increase in damaged starch content and decrease in starch swelling power. This study provided a basic theory for the application of WWF in frozen dough and would inspire the application of more novel ingredients in frozen dough.

Evaluation of milling of the first Japanese-developed durum wheat cultivar (Triticum turgidum L. var. durum) and evaluation of its pasta

H. OKUSU (1), T. Tamaka (2)

(1) Nippon Flour Mills Co., Ltd., Kanagawa, Japan; (2) Nippon Flour Mills, Kanagawa, Japan

Pasta products made from durum wheat constitutes a popular category of noodles in Japan. But there has been no domestic supply of durum wheat in Japan, because it has long been held that agronomic conditions in Japan are totally unsuitable for growing durum wheat. However in 2016, the National Agriculture and Food Organization (NARO), in response to a request of Nippon Flour Mills, released the first Japanese durum wheat cultivar, ‘Setodure’, whose early maturity allows it to escape unsuitable growing conditions. The objectives of this research were to determine the quality characteristics of ‘Setodure’: protein content and yellow pigment in the grain, milling yields of low-speck semolina, and total pasta quality including cooking character, firmness by TA-XT2 texture analyzer, and sensory evaluation. Those quality tests also were conducted on a major imported durum wheat, namely, Canada western amber durum (CWAD). The results of our tests showed no significant difference between the new Japanese durum wheat and the Canadian durum wheat, except for a reduction in yellow pigment and a reduction of firmness in cooked pasta. Judging from the results of a questionnaire to Japanese consumers, they are not so concerned about the deficiency of yellow color or reduced firmness of pasta made from the new domestic durum wheat. Thus, the Japanese consumers’ requirements for the quality of domestic durum wheat seem somewhat different from those for imported durum wheat.
Effect of transglutaminase and maltogenic amylase in gluten-free breads of quinoa (Chenopodium quinoa) and amaranth (Amaranthus caudatus)

C. H. CORNEJO HURTADO DE MENDOZA (1), R. A. Repo-Carrasco-Valencia (1)
(1) Universidad Nacional Agraria La Molina, Lima, Peru

Absence of gluten in baked goods for coeliac disease subjects represents a major challenge for the industry. The aim of this research was to study the effect of the transglutaminase (TG: 0 ppm; 10 ppm; 20 ppm; 30 ppm) in rheological and thermal properties of quinoa flour (Q), kiwicha flour (K) and native potato starch (A) mixtures (M1:60Q:40K:40A; M2:40Q:20K:40A; M3:20Q:40K:40A; and M4:0Q:60K:40A) and the maltogenic amylase (AMG: 0 ppm; 10 ppm; 50 ppm; 100 ppm), on the best transglutaminase/mixture treatment, to predict the bread making performance of high value nutritional gluten-free clean label products. After performing proximate and starch (amylose, damaged and total starch) analysis in raw materials and mixtures, rheological behavior in Mixolab using the Chopin protocol with the slight modification in dough weight from 75 g to 90 g to achieve representative plots for gluten-free doughs was studied. It showed that the mixture with only quinoa was able to absorb more water (M1:58%; M2:55%; M3:55%; M4:56%), and no effect by adding the chosen enzymes. Mixture with only kiwicha revealed stronger protein (M4TG0: 10.78 min of stability) than the other mixtures (M1; M2; M3 less than 0.53 min), although the best value (12.60 min) was achieved by adding the highest dose of transglutaminase (M4TG30ppm). The effect of using different ratios of quinoa and kiwicha are more significant in protein weakening (C2) and thermal weakening (C1-C2) than the effect of adding transglutaminase. By increasing kiwicha in the mixtures, peak of viscosity when hot (C3) is clearly reduced (from M1:2.67 Nm to M4:1.54 Nm) confirming its lower amylose content (0.26%) than quinoa (8.35%). Different starch behavior was shown after including maltogenic amylase; significant pronounced amylolysis (C3-C4) and reduced set back torque (C5-C4) for M4 and every enzyme dose, evidenced in crumb evaluation. Standard formulation for bread making was used; blend of flours, water, yeast (6%), sugar (3%); salt (2%) and shortening (3%). According to different protein behaviors at the Mixolab and expected better gas retention when increasing kiwicha proportions, different proofing times were used; 55 min (M1); 45 min (M2); 35 min (M3); 25 min (M4) in which temperature (30°C) and relative humidity (85%) were controlled. Increasing the amount of kiwicha and the dose of transglutaminase resulted in value increase of specific volume (AACC 10-05; 2000) although a large cell was observed in M4 in all cases. M3TG30ppm showed the best results by achieving better rheological properties, more specific volume and better crumb structure. Significant difference in crumb firmness (AACC 74-09; 2007) between the four mixtures were obtained, value decreasing when using more proportion of kiwicha flour, and when using the maximum dose of maltogenic amylase. This enzyme demonstrated effects the third day of sensory evaluation on quantitative descriptive analysis. Thus, adequate doses of transglutaminase and maltogenic amylase could improve rheological, textural and baking properties in gluten-free products of these Andean grains.

Anti-inflammatory and antioxidant potential of rice-derived polyphenols in endothelial dysfunction and obesity

E. T. CALLCOTT (1,2), A. B. Santhakumar (2,3), P. Oli (4), C. L. Blanchard (1,3)
(1) ARC ITTC for Functional Grains, Charles Sturt University, Wagga Wagga, NSW, Australia; (2) School of Biomedical Sciences, Charles Sturt University, Wagga Wagga, NSW, Australia; (3) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, NSW, Australia; (4) NSW Department of Primary Industries, Yanco, NSW, Australia

Global obesity rates are of epidemic proportion. Anti-obesity treatments are in high demand and many have adverse side effects. Obese populations have higher levels of inflammation and oxidative stress. The antioxidant and anti-inflammatory properties of polyphenols in coloured rice varieties could have potential to neutralize oxidative stress and modulate inflammatory responses in obese populations. Three coloured rice varieties were chosen based on previous polyphenolic and antioxidant screening and their antioxidant and anti-inflammatory potential were investigated. Human umbilical vein cells (HUVECs) were incubated with polyphenol extract (PE) from three coloured rice varieties: Reiziq (brown), Purple (purple) and Yunlu29 (red) and subsequently subjected to oxidative stress conditions. The production and/or expression of reactive oxygen species (ROS), pro-inflammatory cytokines, inflammatory cell adhesion markers, intracellular adhesion molecule (ICAM) and vascular cellular adhesion molecule (VCAM) and a naturally occurring intracellular antioxidant (SOD-1) were quantified by fluorescence spectroscopy, flow cytometry and ELISA respectively. Furthermore, fasting blood samples obtained from 21 obese human participants was treated with PE from the same three coloured rice varieties. Malondialdehyde a biomarker of lipid peroxidation, interleukin-6 (IL-6) and tumour necrosis factor-a (TNF-a) were quantified using high performance liquid chromatography and flow cytometry respectively. ROS and SOD-1 were significantly reduced and upregulated (p < 0.001) in HUVECs treated with Purple rice PE respectively. Interestingly, Yunlu29 extract exhibited the highest anti-inflammatory potential in HUVECs with a significant (p < 0.001) reduction in IL-6 and interleukin-8 production and ICAM and VCAM expression. Coloured rice PE incubated with plasma from obese participants, demonstrated a significant dose-dependent reduction in MDA and TNF-a levels (p < 0.0001). Purple PE particularly reduced malondialdehyde the most
compared to the red and brown rice PE. Furthermore, Yunlu29 (red) PE reduced the amount of TNF-α the most compared to the purple and brown PE. The PE’s did not have an effect on IL-6 levels. Anthocyanins, are the predominant polyphenols present in Purple rice which may be attributed to the reduced ROS and malondialdehyde observed in this study. Yunlu29 and Reiziq PE are primarily comprised of phenolic acids which have associated anti-inflammatory properties, that may contribute to reduced cytokine production. The polyphenol profile of coloured rice varieties may play a key role in targeting specific therapeutic pathways in obesity-related oxidative stress and inflammation. Study outcomes may facilitate selective breeding of coloured rice varieties to contain polyphenols of therapeutic benefit which may serve as a potential functional food in combating the obesity epidemic.

How does processing affect carbohydrate quality?
K. K. Katina (1)
(1) University of Helsinki, Helsinki, Finland

Grains are excellent source of energy and carbohydrates due to starch and fibres present in all cereals. From the energy perspective, it is well known that starch is poorly digested in its native form. Most commonly used processing operations include thermal treatments which induce starch gelatinization which increase digestibility. Starch can also have varying degree of digestibility (resistant starch) depending on chosen processing conditions (sourdough fermentation, long time baking). The most interesting and most studied carbohydrates are currently dietary fibre as daily use of whole grain cereals/bran is generally recommended due to strong epidemiological evidence of reduced risk of chronic diseases. Whole grain cereals (e.g., wheat and oats) and especially bran layer of the kernel has high content of dietary fibre and health related compounds such as minerals, vitamins and phenolic compounds, which are associated to health promoting properties of grains. Due to increased consumer interest, where is growing number of bran/whole grain enriched products on the market in various product categories. Processing of grains, however, will induce significant changes in both amount and quality of fibre components (molecular weight, branching, and viscosity forming properties) as well as associated compounds. This presentation focus on impact of milling/fractionation, enzymatic treatment, fermentation and thermal treatments on the quality of starch, arabinoxylans and beta-glucan.

Elucidating fungal contamination impact on rice discoloration
Z. Mohammadi Shad (1), G. G. Atungulu (1), J. Karcher (2), R. E. Kolb (3)
(1) Department of Food Science, University of Arkansas, Fayetteville, AR, U.S.A.; (2) Frigor Tec Inc., Houston, TX, U.S.A.; (3) FrigorTec GmbH, Amtzell, Germany

Rice quality is greatly affected by drying and storage conditions. The aim of this study is to find the relationship between microbes and discoloration of rice kernels in different storage conditions. Therefore, in this study, the effect of storage temperature, moisture content, rice cultivar, length of storage and fungal suppression treatments (natamycin and salt (NaCl)) on fungal population, rice discoloration were determined. Moreover, the morphological properties of non-discolored and discolored rice kernel were observed using an environmental scanning electron microscope (ESEM). Fungal concentration varied based on storage condition and treatments. At higher temperature, fungi were more deactivated compared to lower temperature; and the fungi population decreased along with storage duration. However, mold population and discoloration of rice kernels were dependent on rice cultivars. Also, rice kernels stored at cold temperatures (20°C) had lower discoloration level compared to the kernels stored at higher temperature (>30°C). It was elucidated through high resolution electron microscopy that there exists a link between fungal growth on rice kernels and the resulting kernel discoloration. Fungal hyphae densely populated discolored rice kernels compared to non-discolored kernels. Notably, excessive discoloration occurred in rice kernels stored at high temperatures (>30°C) and high moisture content (>18%); fungal hyphae could be located to have penetrated the endosperm of discolored rice kernels, but not much in case of the non-discolored kernels. Depending on the storage temperature, postharvest treatment of the rice with antifungal agents such as with Natamycin and Salt significantly reduced discoloration as well as mold growth. It was therefore concluded that coupled with cooling of rice, the postharvest treatment measures may silence the activity of mesophilic microbes (i.e. activity between 10°C and 40°C) in cold storage thereby enhancing the quality of cold stored rice. In the future, this study will demonstrate using next generation sequencing methods the mesophilic microbes of concern over a wide range of rice storage conditions; especially those responsible for rice kernel discoloration.
Compositional and functional properties of germinated wheat as influenced by the duration of germination and drying temperature

R. POUDEL (1), D. Rose (1)

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

Due to physiological processes that occur during germination of wheat kernels, the nutritive value and functional properties of the resulting flour are likely affected. Furthermore, drying conditions of the germinated grains before milling may also affect flour properties. Therefore, the first objective of this study was to quantify the compositional (free asparagine using NMR, lysine content and thiamin using colorimetric methods) and functional (dough mixing properties using mixograph, falling number, and colorimetric measurements of lipase, esterase, and lipoxygenase activities) properties of germinated whole grain flour obtained from kernels germinated for 24 h, 48 h, or 72 h and dried at either 40°C or 60°C. Four commercially obtained wheat grains germinated at room temperature under dark conditions each with two replicates showed a significant three-way interaction of wheat sample × germination duration × temperature for lipase, esterase, and lipoxygenase activities. The variance component analysis showed the observed differences in enzymatic activities was primarily due to the germination time (>80% variation) rather than wheat samples and drying temperature. Similarly, mixing properties significantly declined due to germination time but no effect of drying temperature was observed. An increase in lysine content and free asparagine concentration was observed, whereas phytic acid was decreased with respect to germination time. A secondary objective of this study was to observe the changes in bread characteristics (loaf volume, bread firmness, and bread crumb properties as given by C-cell image analysis), mixing properties, and falling number of whole wheat flour mixed with germinated flour (24 h, 48 h, and 72 h) at a different (2, 5, and 10%) proportion. The addition of germinated flour decreased the mixing properties and falling number with increasing amount of germinated flour and higher germination duration in the formulation. The first three principal components (PCs) explained 78% of total variation on bread variables (PC1 = 43% variance), mixing properties (PC2 = 25% variance), and falling number (PC3 = 10% variance). In conclusion, lipase, esterase, and lipoxygenase activities, lysine content, and free asparagine were increased, whereas phytic acid, mixing properties, and falling number was decreased with increased in germination time. Furthermore, the loaf volume and bread crumb characteristics were improved by the addition of optimum germinated flour, however, a higher proportion of germinated flour lowered the loaf volume and degraded bread crumb characteristics. The findings from this study may provide important information to the food industry while launching or formulating sprouted/germinated grain-based products.

Development on detection methods of rice habitats and adulteration by Raman spectroscopy combined with multivariate analysis

X. LI (1), L. Zhu (2,3,4), H. Zhang (2,3,4), J. Sun (2,3,4), X. G. Qi (2,4,5), C. G. Wu (4)

(1) Jiangnan University, Wuxi, China; (2) State Key Laboratory of Food Science and Technology, Jiangnan University, Wuxi, China; (3) School of Food Science and Technology, Jiangnan University, Wuxi, China; (4) National Engineering Research Center for Functional Food, Jiangnan University, Wuxi, China; (5) School of Food Science and Technology, Jiangnan University, Wuxi, Ghana

Rice is well known for the quite extensive habitats and varieties in China. The qualities of rice are affected not only by the genetic characteristics but also by geographical environment. Therefore, there are exist differences among rice samples from different geographical origins. However, the discrimination of rice habitats and varieties is a difficult and time-consuming task. Meanwhile, with the wide acceptance of rice in Northeast China, an effective detection method is needed for avoiding adulteration in rice. In this study, the whole rice kernel was directly measured by Raman spectroscopy, which providing a better compositional representation of rice since the constituents are heterogeneously distributed in the grain. A total of 525 spectrums were collected from different rice samples (294 *Japonica* rice from 7 provinces, and 231 *Indica* rice from 5 provinces). The obtained spectral features were similar, only a minor spectral difference could be recognized for identification. Therefore, several multivariate data analysis methods were used to visually display the differentiations. Principal component analysis (PCA) was used to realize the preliminary classification of habitats and the screening of main fingerprints. Then, different pattern discernment models were established by hierarchical cluster analysis (HCA), the Sartorius Stedim Data Analytics (SIMCA) and partial least squares discriminant analysis (PLSDA), respectively, showing high recognition and prediction rates of samples from different habitats. Finally, an effect recognition model was established basing on a total of 117 rice samples set (87 ‘Daohuaxiang’ rice, 30 adulteration rice) by PLSDA, and results show that the established model had high recognition rate for adulteration of habitats and varieties. This study provided a novel approach for the rapid and non-destructive detection of rice adulteration.
An effective extraction and potential utilization of sorghum proteins from distillers grains
W. Li (1), L. XU (1), B. Mu (1), Y. Yang (1)
(1) University of Nebraska–Lincoln, Lincoln, NE, U.S.A.

A green aqueous system has been developed to extract densely crosslinked protein from sorghum distillers grains (SDG) with high efficiency. The proteins thus extracted were used to make films and biocomposites reinforced by cellulose nanowhiskers using solution casting method. Due to the nature of high crosslinking degrees, products derived from sorghum protein are expected to possess good tensile properties and aqueous stabilities. However, highly crosslinked proteins are difficult to be extracted from the grains with high yield and low damage. In this study, proteins have been extracted from SDG with purity and yield increased by 14% and 42%, respectively, compared to the most widely adopted method. The success is attributed to the employment of urea, which not only facilitates unfolding of polypeptide chains by breaking inter- and intramolecular hydrogen bonds but also forms a good solvent system with solubility parameters close to sorghum proteins. Based on amine, carboxyl and thiol group analyses, the green aqueous system assures better preserved backbones and more thiol groups of the proteins to rebuild crosslinked networks than the previous methods, leading to higher molecular weight of reclaimed protein films. As a result, tensile properties and water vapor barrier properties of sorghum protein films from the green aqueous system are 27% and 28% higher than those from the previous methods. X-ray diffraction analysis shows the crystallinity of films is also higher than that of films from sorghum protein reported in literature. Films reinforced by cellulose nanowhiskers are also studied to explore the possibility of using sorghum proteins as biocomposites. The biocomposites have a more than twofold increase in tensile strength with an excellent retention of tensile elongation. Our results suggest that proteins from SDG have very good properties for potential applications in various industries.

Australian sorghum: Differences in ethanol fermentation between varieties
(1) ARC ITTC for Functional Grains, Wagga Wagga, Australia; (2) Sydney Institute of Agriculture, Sydney, Australia; (3) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia

Sorghum is an important raw material for the production of Baijiu—a major distilled spirit produced and consumed in China. Baijiu typically has an ethanol content of 40–60 vol% and is most often consumed neat. This Chinese grain liquor is the most-consumed spirit in the world, and has the highest market value by turnover. Baijiu is produced in very large quantity in China with Sichuan, Guizhou, Shandong, Jiangsu, Anhui and Henan provinces collectively claimed to produce more than 90% of the total liquor output. This represents a potentially large and valuable market for Australian sorghum. This study investigates the effects of different Australian sorghum varieties on ethanol fermentation performance. Six major commercial sorghum varieties were fermented using a dry-grind method. These varieties were reported previously to have significantly different field performance and physico-chemical properties. Fermentation profiles of all six varieties were similar, with a lag phase in the first 12 hours, followed by an exponential phase till 60–80 hours and finally a stationary phase. Fermentability of all six varieties was in the range of 87.3–89.1%. Sorghum varieties of higher starch content had higher glucose content, which was translated into higher alcohol content in fermented samples. Yeast assimilable nitrogen content affected the fermentation rate but not final alcohol content. No correlation was observed between alcohol content and other physico-chemical properties. This study characterizes fermentation performance of Australian sorghum systematically. The outcome of this study paves the way for further study into solid state fermentation of sorghum under simulated conditions for Baijiu production in Australia.

Fibre and health – The exploitation of natural and induced variation in dietary fibre content and composition of wheat grain for improved human health
A. LOVEGROVE (1)
(1) Rothamsted Research, Harpenden, U.K.

In most temperate countries, including Europe and North America wheat is the major staple food and is consumed globally. It makes a significant contribution to the human diet, providing energy and protein and also a number of essential or beneficial components, including B vitamins, minerals and dietary fibre. There are established benefits of cereal dietary fibre in reducing the risk of several chronic diseases, including type II diabetes, cardiovascular disease and some types of cancer. Consumption of fibre however is well below the recommended daily intake in most countries. Improving the content and composition of wheat grain fibre is therefore an attractive strategy to improve the health of large populations at low cost. The major dietary fibre components of wheat grain are arabinoxylan and β-glucan which both vary in their amount, composition. White flour is lower in total fibre than bran but has a higher proportion of soluble fibre. Objectives: We are developing new types of wheat with high arabinoxylan and β-glucan fibre in white flour, by exploiting natural variation in composition and content. Methods: Enzymatic fingerprinting, monosaccharide analysis, relative viscosity and
spectrophotometric assays have been used to screen a range of wheat germplasm to identify variation in dietary fibre content. Results: We have screened a historical collection of cultivars grown in the UK over the past 200 years, exotic lines from different regions of the world and the Watkins collection of land races representing global diversity in the 1920s and 1930s. We have carried out classical Mendelian genetic analysis to identify major QTLs for the high fibre trait in four mapping populations. Relevance: Although variation in fibre content is known to be highly heritable, practical improvement of elite wheat lines has been limited by the lack of simple biochemical screens or molecular markers for breeders and grain laboratories. The work described will enable improved wheat varieties to be developed which could have global beneficial impacts on human health.

Opportunities in using 3D printing for multi-textural customized food structure design
M. Lille (1), S. Metsä-Kortelainen (1), N. SOZER (1)
(1) VTT Technical Research Centre of Finland, Espoo, Finland

3D printing is an agile food manufacturing technology, which would allow sustainable and efficient customization. Most 3D printing applications have been developed for non-food sector, and 3D printing is now an emerging technology for food applications. The aim of this study was to understand the effect of rheological properties of various ingredients and their mixes (e.g. oat protein concentrate, faba protein concentrate, milk powder, nanocellulose) on printability of healthy customized food structures. nScrypt technology (nScrypt, Inc, Orlando, Florida) was used to enable the deposition of 3D structures in a layer-by-layer approach. The viscoelastic properties of selected pastes were measured by oscillatory stress sweeps to predict the printability of the materials. Both freeze-drying and oven drying was done to understand the impact of post-processing on 3D printed food structure and texture. The results show that all samples had an elasticity dominating gel-like structure ($G' > G''$, phase angle < 45°). The highest elastic modulus ($G' ~ 36,000$ Pa) was obtained for skimmed-milk powder paste which had 60% solids content and was the most challenging sample for printing. The best performing sample during printing by paste extrusion was the semi-skimmed milk powder (60% solids content) sample which had an intermediate level of elastic modulus ($G' ~ 1,500$ Pa) as compared to other measured samples. The materials which were easy to extrude but spread to some extent after printing were starch based paste which had relatively low storage modulus values (~300 Pa). The semi-skimmed milk based samples had the highest hardness (43 N) after oven drying whereas replacing part of the milk powder with nanocellulose resulted in softening of the samples. The oven dried faba structures were much softer than the oat protein based structures. Freeze-drying of samples resulted in more fragile and porous structures compared to oven-drying; therefore optimization of post-processing technologies is required to have desired mechanical responses. Development of customizable multi-textural low energy dense, healthy snacks, high in fibre and protein, by using 3D printing technology will create new business opportunities for ingredient, food and equipment manufacturing industries within the global ingredient, product market and retail business.

Valorisation of bakery waste into added value bakery ingredients containing microbial β-D-glucan
N. H. MAINA (1), M. O. Immonen (1), R. Coda (1), K. K. Katina (2), H. Nihtilä (1)
(1) University of Helsinki, Department of Food and Nutrition, Helsinki, Finland; (2) University of Helsinki, Helsinki, Finland

The Europe 2020 strategy for smart, sustainable and inclusive growth is based on development of circular economy systems where resources are kept within the value chain as long as possible. Therefore, smart and innovative solutions for efficient exploitation of food raw materials and processing of waste and by-products is needed. The food processing industry must be at the forefront of facilitating this shift through development of innovative solutions that minimize and/or recycle food waste. In the bakery industry, excess production leads to waste bread that is still microbiologically safe and therefore recyclable. The aim of this study was to hydrolyze bread waste into syrup and further functionalize it by bioprocessing with exopolysaccharides (EPS) producing bacteria. The functionalized waste bread was then utilized for baking. 37 lactic acid bacteria strains were screened for EPS production in glucose-rich MRS medium. Consequently potential strains were cultivated on hydrolyzed bread waste and EPS production evaluated. Among the screened strains, Pediococcus clausenii able to produce high viscosity and extreme sliminess in waste bread hydrolysate. The strain was shown to produce 2-substituted (1,3)-β-D-glucan as has previously been reported. The study showed that the functionalized bread waste hydrolysate was suitable not only for replacing sugar added in baking but also contributed to the quality parameters of the final bread. The in-situ produced β-glucan acts as a hydrocolloid and therefore contributes to retardation of bread staling and bread loaf volume.
Gluten-free rice-based pasta made with β-carotene biofortified sweet potato flour: Technological and nutritional quality

M. SCARTON (1), H. T. Godoy (1), A. R. Ferreira (1), E. C. A. Neves (1), M. P. S. Clerici (1)
(1) UNICAMP/FEA, Campinas, Brazil

Gluten intolerance or celiac disease is a chronic digestive disorder characterized by an immune-mediated enteropathy, related with difficulties with absorption of many nutrients and vitamins. In this context, this study aimed to produce gluten-free pastas (GFP) based on rice flour (RF) and biofortified sweet potato flour (BSPF), with addition of hydrolyzed soy protein concentrate (HSPC) and sodium carboxymethylcellulose gum (CMC), evaluate the cooking quality of these GFP and select the better GFP for quantification of β-carotene. For GFP formulation, a 2° rotational central composite design with 17 experiments was used. The “fusilli type” GFP was made by conventional extrusion and dried until less than 12% of moisture. The ratio of RF (76.6 to 93.4%) and BSPF (6.6 to 23.4%), HSPC (3.6 to 10.4 g/100 g of RF:BSPF) and CMC (0.3 to 3.7 g/100 g of RF:BSPF) were used as independent variables, while the optimum cooking time (OCT), solid loss (SL), increase in weight after cooking (IW), and firmness of cooked pasta were evaluated as dependent variables. The results were evaluated by analysis of variance, and the significant models were expressed in response surface (p < 0.10; R² < 0.80). For GFP selection, it was also used a visual evaluation of the GFP structure before and after cooking. The β-carotene content of the selected GFP was quantified using a high-performance liquid chromatography. No significant differences were observed for the variables OCT, SL, and firmness, with mean values of 2.58 minutes, 6.96%, and 2.83 N, respectively, what highlight the good cooking quality of all the obtained GFP. Significant model for variable IW was obtained, which reduced with a decrease in RF and an increase in both BSPF and CMC. Three formulations containing different proportions of RF:BSPF with better visual characteristics were selected: E1 (90:10; 5 g/100 g HSPC and 1 g/100 g CMC), E2 (80:20; 5 g/100 g HSPC and 1 g/100 g CMC) and E12 (85:15; 10.4 g/100 g HSPC and 2 g/100 g CMC). The formulations E1, E2, and E12 presented 3.71 μg, 7.87 μg and 4.67 μg of β-carotene per gram of dry sample, respectively, and the GFP with the highest amount of BSPF (E2) presented the highest β-carotene level. It is shown that the use of the BSPF can improve cooking quality and nutritional value of GFP, and promote the valorization of this biofortified ingredient as a new β-carotene source.

Young Scientist Research Award Presentation – Cereal proteomics to improve gluten analysis

K. SCHERF (1)
(1) Leibniz-Institut für Lebensmittel-Systembiologie, Freising, Germany

The analysis of gluten from wheat, rye and barley poses several analytical challenges, because gluten is a heterogeneous mixture of more than one hundred proteins with variable composition depending on genetic and environmental factors and modifications due to food processing. To guarantee the safety of products for patients suffering from celiac disease, non-celiac gluten sensitivity or wheat allergy, products with a gluten-free label must contain less than 20 mg of gluten per kg of the product to comply with Codex Alimentarius Standard 118-1979. Polymerase chain reaction and enzyme-linked immunosorbent assays (ELISA) are most frequently used to assess regulatory compliance in routine analytical practice. Although its application is currently mostly limited to research purposes, state-of-the-art high-resolution liquid chromatography-tandem mass spectrometry (LC-MS/MS) opens up exciting new possibilities to explore the cereal proteome. Untargeted shotgun LC-MS/MS analyses of the wheat protein fractions albumins/globulins, gliadins and glutenins revealed changes in the protein distribution due to processing from wheat flour to dough and bread crumb and crust. Targeted LC-MS/MS of specific gluten marker peptides was suitable to differentiate between wheat, rye and barley and allowed the quantitation of gluten in a variety of samples including wheat starch, beer and raw materials for sourdough fermentation. Further work will aim to establish a targeted screening method for all known celiac disease-active and allergenic epitopes that can be used to study the influence of various processing parameters on the contents of these epitopes.

The influence of manure application on wheat falling number

(1) Bi-State School of Food Science, University of Idaho and Washington State University, Moscow, ID, U.S.A.; (2) Bi-State School of Food Science, University of Idaho, Moscow, ID, U.S.A.; (3) United States Department of Agriculture-Agricultural Research Service, Kimberly, ID, U.S.A.; (4) Department of Soil Science, Oregon State University, Corvallis, OR, U.S.A.; (5) Department of Entomology, Plant Pathology and Nematology, University of Idaho, Twin Falls, ID, U.S.A.; (6) Idaho Wheat Commission, Boise, ID, U.S.A.

The low falling number (FN) issue continues hurting the wheat industry, especially the Pacific Northwest region in the United States. Enhancing FN performance through an agronomic practice has been asked for by growers. In this study, manure was applied (10, 20 and 30 lb/acre) prior the growth of hard red spring wheat (i.e., Jefferson) with a goal to enhance the wheat quality (i.e., falling number and yield) in 2015 and 2017. Control was conducted without applying any fertilizers. Falling number was measured by the AACC Approved Method 56-81.03, starch and protein were quantified by the AACC Approved Methods 76-13.01 and AACC, 39-25.01. Each
Resistant starch delivering exogenous acetate into the gut attenuated hyperinsulinism via microbial conversion of acetate to butyrate

Z. ZHOU (1)
(1) College of Food Engineering and Biotechnology, Tianjin University of Science and Technology, Wagga Wagga, Australia

Objectives: A recent publication revealed the accumulation of gut microbiota-produced acetate (GMPA) led to insulin over-secretion and obesity symptom. To develop this scientific point, this study utilized the conversion of short-chain fatty acids (SCFAs) via gut microbiota stimulated by resistant starch to avoid the acetate accumulation in the gut. Methods: Acetate was attached to high amylose maize starch (RS) under a substitution reaction, obtaining acetate esterified high amylose maize starch (RSA) with the degree of acetyl substitution of 2.08, which further enhanced the delivery of exogenous acetate directly to the gut. The effect of RS and RSA in the gut on metabolic syndrome was investigated using high-fat diet (HFD)-induced obese rats. Results: RSA supplement generated more butyrate both in serum and feces rather than acetate compared to RS supplement. The plausible interpretation from the metagenomics results suggested an enrichment in butyrate-producing bacteria and a promotion in key butyrate synthesis enzymes. In particular, butyrate-synthesizing bacteria with acetate as substrate, including Coprococcus, Faecalibacterium, Roseburia and Eubacterium, was highly promoted by the dietary resistant starch fraction, which drove the microbial conversion of both exogenous acetate and carbohydrate-metabolic acetate into butyrate. This regulatory manner benefits the gut environment through suppressing the production of indole and phenol from the fermentation of aromatic amino acid, thus preventing the thinning mucous barrier. Meanwhile, the inhibited excretion of gastrin and ghrelin also demonstrated the attenuating effect of RS and RSA on insulin resistance via the suppression of parasympathetic activation. Therefore, the conversion of acetate to butyrate can be a feasible regulatory approach for controlling body weight and attenuating hyperinsulinism. Based on metagenomics and transcriptomics studies, this is the first report to reveal the accumulation of gut microbiota-produced butyrate (GMPB) but not GMPA significantly enriched AMPK signaling pathway with reduced expressions of lipogenesis-associated genes for suppressing sphingosines and ceramides biosynthesis to enhance insulin sensitivity. This study highlights the potent application of the delivery of both exogenous SCFAs and resistant starch for controlling metabolic syndrome induced by high-fat diet.

Taro starch spherical aggregates as microencapsulating starch-based matrix: Partial characterization

L. A. BELLO-PEREZ (1), J. D. Hoyos-Leyva (1), F. Gutierrez-Meraz (1)
(1) CEPROBI-IPN, Yautepec, Mexico

The global food encapsulation market was $32 billion in 2016 and 6.48% of growing potential until 2021. The microencapsulation is a technique used to protect compounds. There is continuous interest in the development of wall materials with high versatile and low cost. The spherical aggregates of starch with small granule size have been few studied as wall material. The aim of this study was to determine physical characteristics of taro starch spherical aggregates from microencapsulation approach. Starch was isolated from the corms. The solid concentration was adjusted to 30% (w/w) in the starch slurry before spray drying process. Moisture, water activity, starch and protein content were determined using AACC methods. The spherical aggregates morphology was observed by scanning electron microscopy (SEM) and confocal laser scanning microscopy (CLSM). The sorption isotherms and glass transition temperature were determined by dynamic vapor sorption analysis and modulated differential scanning calorimetry, respectively. Taro starch spherical aggregates showed 83.3% starch content, 3.7% protein content, moisture of 6.6% and water activity (wa) of 0.33. The aggregation of relative high quantity of starch granules formed a porous structure which could be filled by core materials. The mean size diameter of the spherical aggregates observed in the SEM was 16 μm. The CLSM images showed that protein was located between the surface of starch granules aggregates, which suggest that protein influence positively the starch granules aggregation. The Tg of the starch aggregates was in range between 75°C to 176°C.
under water excess and 0.1 wa, respectively. The Tg at 0.72 wa was 89°C, which suggest that the material retain its glassy state above 0.72 wa at ambient temperature (25°C) protecting a potential core material with high encapsulation efficiency. The sorption isotherm at different temperatures assessed (25 to 45°C) shown Type II isotherms, characteristic of macroporous materials. The GAB sorption parameters shown Xm values from 6.91 to 7.22 g H2O/100 g dry solid, C value from 5.04 to 7.24 and K from 0.77 to 0.78 at all tested temperatures. The taro starch spherical aggregates shown Tg and sorption characteristics similar to hydrocolloids commonly used as wall materials.

Identification and characterization of modified mycotoxins in plant cell suspension culture
B. Kohn (1), J. SCHAEFER (1), M. Bunzel (1)
(1) Karlsruhe Institute of Technology, Karlsruhe, Germany

The genus *Alternaria* contains many species that produce several groups of toxins, which contaminate food and feed. *Alternaria* toxins pose a potential health risk, e.g. they have been associated with an increased incidence of esophageal cancer in certain areas of China. Alternariol (AOH) and alternariol monomethyl ether (AME) are the main mycotoxins produced by *Alternaria alternata*. Both mycotoxins are able to induce DNA strand breaks and gene mutations *in vitro*, and to inhibit topoisomerase I and IIa. AOH and AME are common contaminants of various fruits, vegetables, and cereal grains. For example, more than 70% of the analyzed grain-based foods in a Canadian study contained AOH and AME. *Alternaria* toxins can be partially metabolized in plants as response of the plant detoxification system. The formation of "modified mycotoxins" is of particular concern because they potentially release their precursors after human consumption, thus contributing to overall toxicity. However, conjugated mycotoxins are often not analyzed by routine analytical methods. For this reason, mycotoxin contamination of food and feed, and potential health risks caused by mycotoxins may be underestimated.

Tobacco BY-2 cell suspension culture was used as model system to investigate the conjugation of AOH and AME in plants and to isolate conjugates as standard compounds. BY-2 cell suspension culture was incubated with AOH and AME, and their metabolites were identified by mass spectrometry and nuclear magnetic resonance spectroscopy. For AOH, two glucosides with glucose being attached in AOH 3- or 9-position and their 6′-malonyl derivatives were identified. In addition, one diglucoside of AOH (modification in AOH 9-position) was confirmed. AME conjugation in BY-2 cell suspension culture resulted in the formation of two glucosides (in AME 3- or 7-position), as well as 6′- and 4′-malonyl derivatives of AME-3 glucoside. The formation of AOH and AME glucosides and their malonyl derivatives was confirmed in wheat cell suspension culture, emphasizing the potential relevance of the formation of modified mycotoxins in monocotyledonous plants. AOH and AME conjugates were further tested in the Caco-2 cell system. Caco-2 cells have many features in common with human intestinal epithelial cells and are an accepted *in vitro* model system to study intestinal absorption and metabolism of xenobiotic compounds. Incubation of differentiated Caco-2 cells with AOH and AME glucosides resulted in partial hydrolysis of the conjugates. Further studies are needed to confirm the occurrence of AOH and AME conjugates in field plants to better evaluate their impact on food and feed safety.

Effect of low carbohydrate bread containing beta-glucan enriched barley on postprandial glucose response and its second-meal effect
Y. NAKATSUKA (1), I. Kanamoto (2)
(1) The Low Carbohydrate Bread Society of Japan, Tsukuba-city, Ibaraki-pref., Japan; (2) Laboratory of Drug Safety Management, Faculty of Pharmaceutical Sciences, Josai University, Sakado-city, Saitama-pref., Japan

The consumption of low-carbohydrate meal is known to suppress postprandial glucose response. On the other hand, the health benefits of high molecular weight (1-3),(1-4)-beta-glucan are highly interesting and there is an approved health claim from the European Food Safety Authority (EFSA). It has been shown that the suppression effect on postprandial glucose response for low carbohydrate breads with/without containing (1-3),(1-4)-beta-glucan enriched barley. We have evaluated two types of low carbohydrate (LC) breads compared with refined wheat flour bread. Both LC breads are made of natural powdered materials (soybean, almond, walnuts, barley, wheat bran, wheat gluten etc.), without containing wheat-flour and industrial fiber-enriched materials (e.g. indigestible dextrin). The first LC bread without containing barley was named “Super LC bread” with a carbohydrate content of 4.2 g per 100 g in edible portion, 257 kcal of energy, and 0% (1-3),(1-4)-beta-glucan. The second LC bread containing barley was named as “Mild LC bread” with a carbohydrate content of 9.5 g per 100 g in edible portion, 235 kcal of energy, and 0.9% (1-3),(1-4)-beta-glucan content in bread. The refined wheat flour bread was used as comparison (control) bread, with a carbohydrate content of 48.8 g per 100 g in edible portion, 270 kcal of energy, and 0% (1-3),(1-4)-beta-glucan. Each subject sampled the three types of breads containing the same amount (280 kcal/meal) of energy. The blood glucose levels were measured before the first meal and at 15, 30, 45, 60, 90, 120, 180 min after starting the meal. In the first results, both the LC breads yielded lower postprandial maximum blood glucose concentrations (delta Cmax) than the refined wheat flour bread (comparison of delta Cmax (mg/dL); 120/super LC bread, 123/mild LC bread, 220/flour bread). In the second results, the incremental area under the curve (IAUC, 0-120 min) for both the LC breads were shown to be significantly lower than flour bread (comparison of IAUC (mg min/dL); 1,352/super LC bread, 1,646/mild LC...
The mild LC bread containing beta-glucan enriched barley was only shown that suppression effect persisted to postprandial glucose response after next meal (second-meal effect). The present study suggested that the mild LC bread containing beta-glucan enriched barley had an advantageous potential for diabetes care.

**Bioactivity of amylase trypsin inhibitors affecting the healthiness of grain based products: Do we see the right picture?**

P. L. WEEGELS (1)

(1) Wageningen University Food Chemistry Laboratory, Wageningen, Netherlands

It has been indicated that amylase/trypsin inhibitors (ATIs) are important factors in symptom generation in non-celiac wheat sensitivity (NCWS) and irritable bowel syndrome (IBS). ATIs form a protein family of circa 20 isoforms that are important for the wheat plant to counteract biotic stress by inhibiting a variety of mammalian, pathogen and insect digestive enzymes. They are also known to play a role in human immunogenic reactions (contact allergy, bakers asthma, and likely also gastro-intestinal immune reactions). ATI proteins are relatively stable to heat treatment (baking, cooking) and can pass the stomach and remain active in the small intestine. When their biochemical effects are studied in vivo and in vitro their purity and biochemical state are of crucial importance. Next to these aspects, their anomalous extraction behaviour makes quantitation difficult. In this review the pitfalls of the methodological approaches and the impact on outcomes in investigations on the negative effect of ATIs on health aspects will be discussed. As an example fractions that seem to be pure by SDS PAGE and Coomassie blue staining and HPLC techniques, appear to be impure using silver staining and advanced proteomic techniques. On the other hand sera from patients with wheat allergies, show a high diversity between patients in immunogenic reactivity against wheat proteins. This makes a clear diagnosis and treatment of the illness difficult. In this overview more of these gaps in the scientific knowledge on the negative health effects of ATI will be discussed. The impact of these gaps on treatment of NCWS and IBS and proper consumer information will be highlighted.

**Replacement of added sucrose in burger buns: Are commercially available polyols suitable?**

A. W. SAHIN (1), C. Axel (1), E. Zannini (1), E. K. Arendt (1,2)

(1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland; (2) APC Microbiome Institute, Cork, Ireland

The addition of sucrose in concentrations between 7 and 10% is necessary to ensure the desired texture and taste of burger buns. Due to increasing consumer demand for low-sugar products and recommendations of the UK government to decrease sugar in bakery products by 20% by 2020, replacement of this functional ingredient is urgently needed, but simultaneously challenging. Compared to sucrose, sugar alcohols are lower in calories, do not contribute to tooth decay and are lower in glycaemic response. Thus, the potential of three different available polyols—xylitol, maltitol and mannitol—as sugar replacers in burger buns was investigated. Added sucrose was partially (30% and 50%) or totally replaced by these sugar alcohols, and the effect on dough properties and product quality was analysed. Wheat starch, a non-sweet bulking agent, was use as a control. The investigation of effects on dough properties showed a reduction of up to 86% in CO₂ production when polyols were used to replace sucrose in the formulation. Furthermore, total replacement of sugar by sugar alcohols weakened the gluten network, decreasing its extensibility. The addition of polyols as potential sugar replacers influenced the product quality significantly. Burger buns with polyols showed a 30–50% volume reduction compared to their controls, depending on the amount and type of sugar alcohol tested. Due to a lower specific volume, crumb hardness increased up to 6-fold compared to the controls. Moreover, burger buns containing 100% polyol substitution showed a significantly paler crust, whereas a 50% replacement resulted in the same L*-value as the full-sugar control. The incorporation of sugar alcohols caused a decrease of water activity and a significantly longer shelf life. In conclusion, up to 50% replacement of added sucrose by polyols is feasible, with mannitol being the most suitable among the ones tested.

**Proteins involved in starch granule initiation in wheat endosperm**

D. SEUNG (1)

(1) John Innes Centre, Norwich, U.K.

Starch, the major storage carbohydrate in plants, is vitally important to humankind as food and an industrial raw material. It is synthesised in plastids as semi-crystalline, insoluble granules that are composed of the glucose polymers, amylopectin and amylose. Although the biochemical reactions involved in the synthesis of these polymers are relatively well understood, little is known about the mechanisms that initiate the synthesis of the starch granule, as well as the factors controlling the number of granules per plastid, granule shape and size. In recent years, progress has been made in understanding granule initiation in Arabidopsis leaf chloroplasts, with the discovery of a suite of “initiation proteins” specifically involved in the process, including STARCH SYNTHASE 4, members of the PROTEIN TARGETING TO STARCH (PTST) family, and others. These
initiation proteins are conserved among higher plants, including cereal crops such as wheat. During wheat grain development, starch granules are initiated in two temporally-separate waves during grain filling—the initial wave forming large A-type granules, and the later wave forming smaller B-type granules. We identified the orthologous genes that encode the initiation proteins in wheat and found that they are expressed in the endosperm during grain filling. To investigate their function, we isolated wheat TILLING mutants defective in one or more homeologs of each gene. The altered starch granule size distribution in the endosperm of these mutants allowed us to assess whether each initiation protein is important in the initiation of A-type granules, B-type granules, or both. This research has important future implications for improving the quality of wheat by modifying starch properties.

The efficacy of high-pressure processing treatments on the reduction of Escherichia coli in sugar-cookie dough and its impact on baking performance
L. Sabillón Galeas (1), D. Rose (1), J. Stratton (1), A. BIANCHINI (1)
(1) University of Nebraska – Lincoln, Lincoln, NE, U.S.A.

Refrigerated dough products, such as cookie dough, have the potential to be a safety hazard to consumer health because they could be consumed raw or undercooked. This study investigated the efficacy of high-pressure processing to reduce E. coli inoculated into sugar-cookie dough and its impact on dough functionality and baking performance. Commercially formulated sugar-cookie dough was prepared at 2 different water activity levels (aw: 0.80 and 0.87), inoculated with a non-pathogenic E. coli strain (ATCC 25922) at 7.5 log CFU/g, vacuum-packaged and high-pressure processed (HPP) at 300 and 600 MPa for 3 and 6 min. The experiment followed a split-plot design, with aw as the main plot factor, combined with a completely randomized design for pressure and time variables. Surviving E. coli populations were spread plated for enumeration on Tryptic Soy Agar (TSA) plates and incubated at 37°C for 3 h to allow the recovery of stress/injured cells. TSA plates were then overlaid with Sorbitol MacConkey Agar and incubated at 37°C for 24 h. Non-inoculated dough was used to assess the impact of the processing on functionality and baking performance. The population of E. coli was significantly reduced by all HPP treatments (p < 0.05). Treating the dough at 600 MPa for 6 min significantly reduced E. coli counts by an average of 1.9 log CFU/g. Increasing the water activity of cookie dough did not play a significant role in the reduction of E. coli (p > 0.05); however, it yielded a softer and thicker cookie when baked. Dough stickiness did not differ significantly among HPP-treated and control doughs with the same aw (p > 0.05).

Moreover, no significant differences were observed in the width, thickness, hardness, and fracturability of baked cookies obtained from HPP-treated and control doughs with the same aw (p > 0.05). These results suggest that HPP could be an effective, post-packaging intervention to reduce the risk of E. coli contamination in cookie dough with a minimal impact on product quality parameters.

Influence of pulse seed size and flour/fiber granulation size on the detection of gluten
N. RAMACHANDRAN (1), T. Heal (1), L. Malcolmson (1)
(1) Best Cooking Pulses, Avena Foods Ltd., Portage la Prairie, MB, Canada

Pulses (peas, chickpeas, beans and lentils) are consumed worldwide and are considered safe for individuals that must adhere to a strict gluten-free diet. Supplying gluten-free pulse ingredients can pose a challenge due to the possible risk of contamination or comingling with gluten containing grains during various stages of processing. Initially, pulses undergo a cleaning step to remove any foreign seeds or grains. The cleaned seeds can then undergo dehulling to remove the outer seed coat (hull). Pulse flours and grits are obtained by grinding whole or dehulled seeds resulting in products of varying granulation size. Similarly, pea hulls are ground to obtain pea fiber of varying mesh sizes. Testing pulse ingredients for the presence of gluten to meet regulatory standards is crucial to ensure safe products to end-users and to meet gluten-free claims. Inconsistent gluten test results can sometimes occur even though all of the products tested were processed from the same input material. For example, whole pulses could test positive for the presence of gluten at levels exceeding the permissible limit but when these same pulses are milled to different particle sizes, coarser granulations are found to be within the acceptable limit of gluten whereas for finer flour, the presence of gluten can exceed the acceptable limit. This finding suggests that the grinding step can cause the non-homogeneous gluten source to become a homogenous final product. In addition, lentils which are smaller in size than other pulses, have a higher risk of gluten contamination due to greater challenges in the cleaning operation. Visually, the lentils show no gluten containing grains yet test positive for gluten indicating that the mechanical or visual separation step is not sufficient to adequately remove any gluten contaminant. To better understand this, controlled studies were conducted whereby samples of pulses were spiked with varying levels of wheat kernels and tested for gluten before grinding and after grinding to both a coarse material (grits) and a fine flour. Pea hulls were also tested after spiking with wheat kernels before grinding and after milling to different mesh sizes. Results were tested for their coefficient of variation to determine the influence of particle size on gluten detection. Possible contamination by wheat dust was also examined by spiking a sample of lentils with wheat flour to determine if this posed a threat for a positive gluten test.
Creation of a milling performance index (MPI) based on the behavior of wheat during laboratory milling
A. DUBAT (1)
(1) CHOPIN Technologies, Villeneuve la Garenne, France

For most of the laboratory technicians, test milling is just a mandatory step aiming to transform grain into flour. Their objective is to produce a flour, representative from the grain that will be therefore analyzed in order to determine its quality. In the best case, the laboratory milling process will be characterized in terms of extraction rate and eventually flour ash content. A consortium grouping different actors of the wheat chain (researchers, breeders, farmers, millers, bakers...) worked during 6 years to better understand how wheat behaves during the industrial milling process. A new laboratory mill was designed. Its diagram was studied to mimic as close as possible the different actions that occur during industrial milling. Although reducing the complexity of industrial mill into a “2 Breaks, 1 sizing, 3 Reductions” diagram is a real challenge, the results obtained from the mill are very promising. We tested 150 wheat collected across 14 countries worldwide and exhibiting very different behaviors. Product repartition within the diagram is greatly dependent of wheat performance during fractionation. Our work led to the development of a 3 digit milling performance index (MPI). The first Digit represents the wheat resistance to crushing at first break, the second digit represents the easiness of dissociation related to the capacity to produce fine middling instead of coarse middling, and the third digit represents the easiness of reduction of the fine middling into flour. Data analysis clearly showed that wheats with the same extraction can have very different MPI meaning that they will behave completely differently during the process, creating variability. On the contrary, wheat with the same MPI exhibit very similar and constant product repartition throughout the diagram. Our first results relating our results to Surgères pilot mill on 30 wheat show that the LabMill gives a very good prediction of industrial break flour ($r^2 = 0.80$), a good prediction of sizing flour ($r^2 = 0.66$) and a very good prediction of reduction flour ($r^2 = 0.77$). The MPI is introducing a new way to consider laboratory wheat milling. This new approach offers a real possibility of improving the communication between the lab and the production plant by sharing information about the wheat milling performance. Of course, the flour obtained from this test mill is, as always, representative of the wheat quality in terms of ash content (0.55% db average) and rheological properties.

Whole grain consumption benefits human health: Why is the movement in social media counterproductive?
F. F. BROUNS (1)
(1) Maastricht University, Maastricht, Netherlands

In the world of consumers there is a lot of confusion on what “whole grain” stands for. Consumers generally are not aware that grains belong to the family of grasses and that also rice and corn are grains. Thus also popcorn or puffed rice can be seen as whole grain. Another problem is that “whole grain” is a category name for a number of individual grains that vary significantly in nutrient and plant bio-actives composition. This may lead to significant differences in dietary fiber and nutrient supply, thus impact on nutritional status, metabolism and health. Most observational research has pooled data of intake of various grains and foods in relation to health and disease. The question then arises about which grain has the most potent or the least effect within this pool. Depending on the region and the local eating culture, the answers to this question may differ much. To make it even more complex, the definition of what whole grain foods are, mostly used as a basis for calculating consumption in observational studies differs widely. In some countries whole grain foods are defined to contain only whole grain whereas in other countries products that contain only 30% whole grain may be listed as such. These definitions and related legal space for using the label “whole grain” on the product packaging differ in addition also between certain product categories such as bread or cookies and crackers. See the strong effects of social; media and accessibility of consumers to it, it is a must to create transparency about definitions that can be adopted globally. The same is the case for “dietary fiber” which is the most significant contributor of whole grain foods on health.

Near-infrared hyperspectral imaging for animal feed safety and quality applications – A review
P. T. G. DANTES (1), C. R. Hurburgh (1), D. E. Maier (1)
(1) Iowa State University, Ames, IA, U.S.A.

Recently, there is a growing public concern on the quality and safety of animal-derived food products due to problems such as contamination and outbreaks of food-borne infections that inadvertently pose health risk to humans. These problems have prompted the food and feed industry to closely consider all aspects of the food and feed supply chain. Regulations and protocols are also being implemented towards prevention and control. So, it is not enough to have technologies developed to ensure safe and quality feed. Accurate and reliable methods are also needed to evaluate feed safety and quality parameters at the right time and in a faster way to prevent further risks and problems. Near-infrared hyperspectral imaging (NIR HSI) is a recent analytical technique that integrates machine vision and near infrared spectroscopy. It provides both spectral (composition) and spatial (location) information of the product. It can be applied for in-, at- or on-line quality and safety monitoring. It is faster, easier to implement and less costly than traditional laboratory methods. Many studies on the application
of NIR HSI on food and agricultural products have already been published and some are applied commercially. It has a lot of potential in the feed industry, but it has not been much explored in this area with less available studies that focus on its application to animal feed safety and quality. This review gives a brief overview of the principle of NIR HSI. This also highlights research progress with respect to applications of NIR HSI for safety and quality evaluation of animal feed, specifically in screening illegal adulteration and contamination of feed materials, detecting mycotoxin contamination, measuring constituent concentrations and other quality properties, and evaluating feed processing parameters. NIR HSI is not yet considered a standard analytical tool due to its limitations and disadvantages, such as large data size, instrument cost, data redundancy, inability to detect contamination at very low levels, and low model prediction accuracy. Therefore, there is a need to explore and maximize the potential of this technology in various applications, especially in the postharvest management and processing practices in the feed mill and livestock industries, to ensure safe and quality feed. Suggested future research areas are on instrument development, chemometric methods, and image analysis across various feed products and processing operations. With its potential uses and applications on animal feed, NIR HSI is indeed a promising breakthrough in the feed industry.

WheatData: A data-driven approach to gain a deeper insight into the driving factors influencing end-product quality

S. LANDSCHOOT (1), T. Lefeber (2), S. Stroo (2), S. Maenhout (3), B. De Baets (4), G. Haesaert (1)
(1) Department of Plants and Crops, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium; (2) Flanders’ Foods, Brussels, Belgium; (3) Progeno; (4) KERMIT, Department of Data Analysis and Mathematical Modelling, Ghent University, Ghent, Belgium

The baking industry is currently facing a number of challenges, i.e. yearly fluctuations in wheat composition and origin and more stringent requirements with respect to baking performance. In addition, they are more and more confronted with unexpected flour behavior and thus a reduced baking performance. To guarantee a tasty and standardized end-product, knowledge on the importance of the factors influencing meal and flour characteristics is a prerequisite. The goal of the "WheatData" project is to come to a shared database with data from various partners involved in the wheat value chain and to gain a deeper insight into the driving factors influencing end-product quality. These insights should lead to a model able to predict end-product characteristics based on relevant input data. This project will provide the industry with a more efficient and accurate tool to assess wheat functionality and end-product quality and will thus lead to a reduced number of laborious baking trials. A wealth of information and data are available at different companies involved in the wheat value chain, from farmers, traders, millers until bakeries. However, to extract knowledge from these data, they should be integrated, organized and analyzed in a proper way, which is a first goal of this project. In the first step, data collection, the available data, from different sources, will be brought together. Before the data can be fed into a central database, data cleaning is essential since data may contain errors, missing values, noisy or inconsistent data. If all data are cleaned up and put in compatible formats they can be put into a database. In a next step, data mining techniques will be applied in order to gain insight into the data and to discover interesting patterns. Data visualization, correlation studies, clustering and association analyses are among the many different techniques that will be used in the data mining step. After data mining, machine learning techniques will be applied to predict end-product quality characteristics based on flour/meal properties. The final step is model validation and translation of the model output into practical guidelines in order to improve efficiency and profit in the wheat value chain.

Roller vs hammer milling of yellow split pea (Pisum sativum L.)

A. KAISER (1), C. A. Hall III (1)
(1) North Dakota State University, Fargo, ND, U.S.A.

Pulse milling continues to be a research focus as consumer interest in cereal-based, pulse-containing convenience foods grows. While roller milling is the standard method for wheat flour production, no standard method exists for producing pulse flour. A hammer mill is a relatively simple and cost-effective method of size reduction that may be available to more food processors than the traditional roller milling system. We evaluated yellow split pea milled to a similar particle size via hammer and roller milling systems to determine how hammer-milled pea flour compares to roller-milled pea flour. Yellow split pea at 11% moisture was hammer-milled at 102 m/s through a 0.84 mm screen and roller-milled using a two-pass setup with an intermediate sieving process. Flours from both processes underwent a final sieving through a 150 μm screen. Flour moisture content was lower after hammer milling (10.6% moisture) than roller milling (11.0% flour moisture). Peak, breakdown, and final viscosities were higher for roller-milled flour (2,688, 385, and 5,436 cP, respectively) than for hammer-milled flour (2,478, 340, and 4,806 cP, respectively). Foaming capacity (111% vs 72%), damaged starch content (3.5% vs 2.0%), and median particle size (39 μm vs 31 μm) were also higher in roller-milled flour than in hammer-milled flour. No significant differences were observed between the two treatments for any of the other compositional or functional parameters evaluated.
The lamellar structural differences in wheat and potato starch define their retrogradation behavior
X. LAN (1), J. Wu (1), Z. Wang (1)
(1) Shanghai Jiaotong University, Shanghai, China

Regulating retrogradation properties of starchy foods has significant role in the deep processing of starch in the frozen dough. Of note, this property of starch suspension majorly lies on its inner structure, such as lamellar structure or side chain distribution. In this study, the wheat and potato starches were freezing/thawing treated for five cycles, and the retrogradation and structural differences of the two starches were compared by the aid of small-angle X-ray scattering (SAXS) and dynamic viscoelastic analysis. The results showed that potato starch has higher rate of retrogradation than that of wheat starch, and the surface roughness of the two gels increased during the retrogradation process. In addition, other gel network related traits between the two starches was significantly different. Firstly, the swelling power (SP) of starch from wheat (9.18 g/g) was found to be significantly lower than that from potato (47.58 g/g). Secondly, the storage modulus (G’) and loss tangent (tan δ) of wheat starch was much lower than that of potato starch. The observed higher G’ and SP in potato starch could be due to its less compact structure. The SAXS analysis revealed that the starch from wheat has a lower volume crystallinity (0.71) than potato (0.89), further indicates that a less compact structure in potato starch. Besides, wheat starch has a lower value of repeat distance (d = 8.06 nm) than potato starch (d = 9.40 nm), and repeat number also (n = 9 vs 17), demonstrating a more compact structure in wheat starch. The correlation analysis reveals that less compact structure from the viewpoint of long-range ordering, corresponds to a higher retrogradation tendency under the condition of repeated freezing/thawing. Due to a less compact structure, potato starch molecules has a higher level of mobility, thus are easy to be destroyed and restored, finally accelerate the retrogradation. This study first investigates the mechanism underlying the gel network property differences, and these finding are likely to aid the advancement of frozen dough with wheat or potato.

Why do consumers choose to avoid gluten without a medical diagnosis? A study of the psychological reasons using a large Australian sample
A. J. SALIBA (1), K. Hester (1), E. McIntyre (2)
(1) Charles Sturt University, Graham Centre, ARC ITTC for Functional Grains, Wagga Wagga, Australia;
(2) University of Technology Sydney, Australian Research Centre in Complimentary & Integrative Medicine, Broadway, Australia

Human consumption of grains is a longstanding practice across many cultures. Historically, humans chose to consume based principally on availability, whereas modern dietary choices are more complex and include avoidance behaviours. A relatively modern type of avoidance is gluten avoidance. Grains that contain gluten, and even some that do not, are avoided due to a perception that gluten consumption causes negative symptomology. Coeliac disease is a serious disorder that requires complete abstinence from gluten; the objective of this study was to determine why some individuals without a medical diagnosis or advice to avoid still choose to avoid gluten. Of those non-coeliac individuals, we comprehensively assessed a range of psychological and demographic variables via face to face interviews and online survey, to see whether those who avoid gluten differ from those who choose to consume gluten. The hypothesis was that there is a psychological explanation for non-coeliac gluten avoidance. We sampled 1,521 Australian adults; 500 gluten consumers (control group) and 1,021 gluten avoiders. The sample was derived using purposeful sampling and matched known population characteristics for key demographics such as sex, age and location. Such a robust sample allowed detailed characterisation of those who choose to avoid gluten, as well as cross-tabulated prevalence rates. In terms of psychological variables, there was homogeneity found within the gluten avoidance group compared to the control. Gluten avoiders experienced higher rates of somatisation along with higher levels of autonomic arousability, which suggests that gluten avoiders may pay greater attention to symptoms and ruminate (repeatedly consider) on those symptoms, more so than controls. Rates of non-prescribed gluten avoidance are occurring at a rate of 20%. Typically, non-prescribed gluten avoiders in Australia are more likely to be female and aged between 18 and 35 years. The results are used to predict long-term trends for gluten avoidance, including the likely market size of full-gluten, low-gluten and gluten-free products.

Impact of stabilisation methods on the fatty acid, phenolic composition and antioxidant activity of rice bran
N. SAJI (1,2), A. B. Santhakumar (1,2), L. Schwarz (2), A. Durand (3), C. L. Blanchard (1,2)
(1) School of Biomedical Science, Wagga Wagga, Australia; (2) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (3) SunRice, Sydney, Australia

Rice bran (RB) is a by-product of the rice milling process and has been identified as a valuable source of bioactive phytochemicals that may act as protective agents against cellular and biomolecular damage. However, due to its limited shelf-life and development of rancidity after milling, it is currently discarded or used as animal feed. Various stabilisation processes are currently applied to RB in order to inhibit the rancidification process and thus improve RB shelf-life. However, the application of such treatments has been observed to alter the fatty acids, chemical profile and antioxidant activity. The aim of this study was to evaluate the influence of stabilisation
methods on the fatty acid profile, phenolic composition and antioxidant activity of RB. The samples under investigation were freshly milled non-stabilised RB (NS-RB) and RB that had undergone either extrusion (ES-RB), microwave (MS-RB) or oven stabilisation (OS-RB) processes. Bench-top assays such as Folin-Ciocalteu total phenolic content (TPC), 1,1-diphenyl-2-picrylhydrazyl (DPPH), and 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assays were employed to determine the antioxidant capacity of the various samples. Subsequently, gas chromatography mass spectroscopy for fatty acid profiling and ultra high performance liquid chromatography (UHPLC) with diode array detection coupled to an online ABTS system for the chemical profiling of phenolic compounds present in the samples. Results obtained displayed no significant differences in the fatty acid profile among the different stabilization treatments. RB was observed to be abundant in palmitic acid (16.84%), stearic acid (1.36%), oleic acid (42.38%), linoleic acid (35.64%) and linolenic acid (1.52%). However, TPC, DPPH and ABTS bench-top assays demonstrated ES-RB to contain significantly \( p < 0.001 \) higher total phenolic content as well as higher antioxidant activity in comparison to MS-RB, OS-RB and NS-RB. Similarly, UHPLC and online ABTS analyses also demonstrated a clear distinction between the various stabilisation treatments. ES-RB was again found to have a significantly \( p < 0.001 \) higher number of phenolic compounds with corresponding antioxidant activity compared to MS-RB, OS-RB and NS-RB. In conclusion, although there was no significant differences found in the fatty acid profile, a clear distinction was found between the bioactive components present in RB that has undergone different stabilisation treatments. ES-RB had the highest total phenolic content which correlated well with the increased antioxidant activity observed within this sample compared to the other RB samples. This study has demonstrated that ES-RB may be a crucial technique that can be applied to RB to ensure essential phenolic compounds with antioxidant activity remain intact.

Point/counterpoint debate on glycemic index/glycemic load: Is it helpful?
J. M. JONES (1)
(1) St. Catherine University, St. Paul, MN, U.S.A.

Glycemic index (GI) and glycemic load (GL) were proposed in 1980 as a way to determine carbohydrate quality. Despite much research, there is inconsistency of findings in published literature with respect to most health outcomes. Published values for GI in tables and on packages may not characterize the glycemic response of the food as eaten, especially when it is part of a meal. Further the values do not consider variability introduced by any number of factors such as variety, ripeness, degree and mode of cooking or processing, presence of other foods or ingredients, temperature of eating, the amount eaten and the like. The use GI as a touchstone in food selection and diet planning diet planning and other applications is concerning due to wide variability and limited precision and accuracy. With standard deviations that are equal to class boundaries for medium GI foods, designation of foods as high, medium or low GI is error prone. This discussion identifies some of the limitations around the measure and its use and outlines the weak evidence for many health outcomes. Further it questions the assignment of GI values to food intake data collected in dietary surveys by food frequency and other vehicles. It is unclear whether these measures help consumers determine carbohydrate quality and can guide them to food choices that reduce their risk of chronic disease. While a group of noted scientists met and published a consensus on carbohydrate quality, their findings are not aligned with those of other recognized health promotion organizations such as the American Diabetes Association or the Academy of Nutrition and Dietetics Evidence Analysis Library. Thus, their conclusion that GI and GL are measures of carbohydrate quality is not substantiated by the state of the research as this point in time, thus making the publication of a consensus on the subject premature.

Inhibitory effects of gellan gum, tea polyphenols and glycerol monostearate on starch retrogradation in buckwheat flour gels
Z. Chen (1), Z. Li (1), G. A. ANNOR (2)
(1) China Agricultural University, Beijing, China; (2) University of Minnesota, St. Paul, MN, U.S.A.

Gelatinization and retrogradation are two important physical phenomena that occur in starch-based foods. Even though retrogradation is desirable in some foods, it can also lead to significant reduction in consumer acceptance. To investigate the effects of gellan gum, tea polyphenols (TPLs) and glycerol monostearate (GMS) on inhibiting starch retrogradation in the buckwheat flour gels, the pasting profile and thermal properties of BF and texture profile analysis of resulting gels were determined. Resistant starch content and syneresis of the gels were also determined. Based on weight, the prepared gels had a water to BF ratio of 4:1. The additives were added at the following ratios: BF/ gellan gum; 10/0.1, 10/0.3, 10/0.5: BF/ TPLs; 10/0.1, 10/0.2, 10/0.3: BF/ GMS; 10/0.05, 10/0.1, 10/0.15. Gels with 1% gellan gum, 2% TPLs and 0.5% GMS were selected as levels exhibiting the best anti- retrogradation effect. These levels also resulted in the least starch setback, lower hardness and chewiness after 7 days of storage at 4°C. Increasing levels of additives resulted in decreasing gelatinization enthalpy, especially for gels with 5% gellan gum and 3% TPLs. Resistant starch content was observed to increase rapidly in gels in the first 7 days of storage but remained unchanged when stored up to 28 days at 4°C. Insignificant differences in resistant starch content was observed in gels with 2% TPLs during storage. Extent of syneresis increased but was...
not significant during storage. In the texture analysis, 2% tea polyphenol and 0.5% GMS seemed to have better effect on slowing down the long-term retrogradation. The additives used in this study can potentially be used to inhibit retrogradation in BF-based gel products. Tea polyphenol and GMS were the most effective in inhibiting starch retrogradation in the BF gels.

The influence of a high population of B-type wheat starch granules in the reduction of falling number

Y. Shao (1), M. H. Tsai (1), A. H. M. LIN (2)
(1) Bi-State School of Food Science, University of Idaho and Washington State University, Moscow, ID, U.S.A.;
(2) Bi-state School of Food Science, University of Idaho, Moscow, ID, U.S.A.

The low falling number (FN) issue continued to threaten the wheat industry, especially in the Pacific Northwest Region of the U.S. Our previous research discovered that some low FN wheat contained a higher population of B-type (23%, w/w) starch granules compared to the normal FN wheat (13%). We hypothesized that the increase of B-type granule population is associated with the reduction of FN as B-type starch has a relatively low paste viscosity and high susceptibility to α-amylase (AMY). In this study, we separated A- and B-type granules from the commercial wheat starch (Aytex P®). The viscosity of A-, B-type granules, and reconstituted starch with different proportions of A- and B-type granules were examined using a viscometer—Rapid Visco Analyzer. We also examined the starch paste viscosity with the presence of wheat AMYs extracted from sprouted (AMY-S) and non-sprouted (AMY-NS) mature wheat. It is known the main isoform in AMY-NS is AMY-2, and AMY-S contains AMY-2 and a high amount of AMY-1. We further assessed the susceptibility of A- and B-type starch to AMY by quantifying the increase of reducing power during amylolysis. It is known that B-type granules had a lower viscosity than A-type granules. In our study, the reconstitute starch, with 13 and 23% (w/w) B-type granules, had peak viscosity of 5,042 and 4,748 cP, respectively; with the presence of wheat AMY, the peak viscosity dropped to 3,242 and 2,915 cP, respectively. Moreover, the decrease of viscosity differed upon the source of AMY. With the presence of AMY-S, the peak viscosity decreased from 4,790 to 2,245 cP, whereas the peak viscosity decreased from 4,790 to 4,471 cP with the presence of AMY-NS. The hydrolysis data showed that B-type starch granules have a higher susceptibility to AMY than A-type starch granules; after gelatinization, A-type starch molecules have higher susceptibility to AMY than B-type starch. Both A- and B-type granules had a higher susceptibility to AMY-S than AMY-NS. Our findings support the hypothesis that the increase of B-type granule population impacts on FN due to the interaction between starch and enzymes. Our research also, for the first time, demonstrate that wheat starch granules have different susceptibilities to wheat AMYs and their interaction with various AMY isoforms is different. Promoting wheat variety without B-type granules (e.g., super soft white wheat) is a potential strategy of preventing the low FN issue, and the characters and hydrolytic capacity of AMY at different stage needs to be considered.

Effect of xanthan gum and sodium alginate on dough properties, gluten structure, and bread qualities made from whole wheat flour

L. Tebben (1), Y. LI (1)
(1) Kansas State University, Manhattan, KS, U.S.A.

Whole wheat bread presents technical and sensory challenges related to dough rheology and bread properties including dark color, small loaf volume, and hard crumb texture. Hydrocolloids can help to overcome some of these issues. The objective of this research was to determine effects of two hydrocolloids, xanthan gum (XG) and sodium alginate (SA), on whole wheat dough and bread, with a focus on rheological properties of the dough, gluten microstructures, loaf volume, and bread texture and staling. Bread was prepared from whole wheat flour following AACC Approved Method 10-10.03. Hydrocolloids were added into flour at five concentrations ranging from 0.1 to 1.0% (flour basis). Dough mixing properties were determined using a mixograph. Uniaxial extensibility and resistance to extension, stickiness, and elongational viscosity were tested using a texture analyzer. Gluten secondary structure was analyzed using FT-IR spectroscopy. Raman spectroscopy was used to determine other modifications to the molecular and polymeric structure of the dough. Changes to glutenin and gliadin conformation and extractability was measured by RP-HPLC. Fresh bread was evaluated by measuring specific volume, crust color, width/height ratio, moisture content, texture profile analysis (TPA), and crumb structure. Moisture content and TPA were measured again after 48 h of storage at room temperature to determine changes associated with staling. Effect on starch retrogradation was quantified by DSC after 1 day and 7 days of storage at 4°C. Hydrocolloids increased the water absorption and mixing time for whole wheat dough. Specific loaf volume increased upon addition of 0.2% XG or higher or 0.6% SA. The greatest reduction in initial hardness was obtained for 1.0% XG supplementation. Hardness at 48h was also lowered, but the hydrocolloids did not reduce the rate of hardness increase. Moisture loss over 48h decreased for 0.6 and 1.0% addition of XG or SA. Width/height ratio was improved. Regarding crumb structure, XG increased number of cells increased. SA increased the cell diameter and cell wall thickness. XG and SA decreased amylose-lipid complexation. This study demonstrated that xanthan gum and sodium alginate can help to increase loaf volume and decrease crumb hardness, which may help improve the sensory appeal of whole wheat bread and ultimately increase whole grain consumption.
Porous starches as natural probiotic carriers
Y. BENAVENT-GIL (1), D. Rodrigo (1), C. M. Rosell (1)
(1) Institute of Agrochemistry and Food Technology (IATA-CSIC), Paterna, Valencia, Spain

The market for functional foods is dominated by those that contain probiotics in their formulation. However, probiotics incorporated in processed foods must overcome certain technological aspects, such as temperature, which compromises the viability of probiotic cells. Enzymatically modified starches lead to porous molecules with an expandable space that could be used as a protective microenvironment for probiotic encapsulation. The objective of this study was to identify the potential of controlled pore size starches from different botanical sources as carriers of probiotics. Particularly, to investigate the encapsulation of Lactobacillus plantarum, as probiotic microorganism, on porous starches obtained from glucoamylase (AMG) and α-amylase (AM) treatment on corn (C) and rice (R) starch. For that purpose, a novel system based on porous starches to stabilize probiotic bacteria was developed. To determine the retention capacity of the different starch samples, several factors were taking into account: origin of the starch (corn, rice), enzymatic treatment (AMG, AM), hydration or non-hydration of the sample and the absorption time (30, 60, 90, 120, 150, and 180 minutes). Scanning electron microscopy indicated the different entrapment undergone by the microorganism depending on the type of starch, being adsorbed on the surface of corn starch but entrapped within the rice granules aggregates. The porosity of the porous starches ranged between 4.47 to 0.43% and contributed to increase the encapsulation yield, particularly in the case of rice starch. The encapsulation without previous hydration reached a greater absorption of microorganisms independently of the samples. As regards the encapsulation times applied, a significant effect on the absorption of microorganisms was observed, clearly dependent on the enzyme and the starch source. The samples R-AMG and C-AM presented a higher absorption of microorganisms at 90 minutes of the test, while the samples R-AM and C-AMG showed a slight increase in absorption at 120 minutes. The thermal stability of L. plantarum microcapsules was tested at 55°C, which was set for running stability studies. The cell stability was significantly ($P < 0.01$) affected by starch source and the enzyme applied to obtain porous starches. Viable cells were detected after heating microencapsulates adsorbed in native rice starch, but not in native corn starch. Encapsulation with porous starches, independently of origin and enzymatic treatment, conferred stability to the cells even after 35 min at 55°C. Therefore, microcapsules produced with porous starches can be incorporated in probiotic food formulation to maintain the integrity of the cells.

A rapid in vitro digestibility assay for predicting rice glycaemic index
W. ZOU (1), J. Luo (2), V. Butardo (3), A. Farahnaky (4), C. L. Blanchard (5)
(1) ARC ITTC for Functional Grains, School of Biomedical Science, Wagga Wagga, Australia; (2) Yanco Agricultural Institute, NSW Department of Primary Industries, Yanco, Australia; (3) Department of Chemistry and Biotechnology, Swinburne University of Technology, VIC, Australia; (4) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (5) ARC ITTC for Functional Grains, Wagga wagga, Australia

Rice, commonly perceived as being a high glycaemic index (GI) cereal, displays wide variation in GI with some cultivars falling below the threshold GI of 55 required for the designation of “low GI” rice. There is rising demand for low GI food and with rice being no exception, therefore there is an impetus to breed new low GI rice cultivars. Breeding programs require high throughput phenotyping assays which have the capacity to screen hundreds, if not thousands, of rice lines within tight timeframes. In vivo GI measurement is extremely low throughput and expensive and therefore does not meet these requirements. The aim of this study was to develop an in vitro rice starch digestibility assay for rapidly predicting the GI of rice cultivars and breeding lines. The milled rice grain of seven rice cultivars (Waxy, Reiziq, Topaz, Koshihikari, Opus, Sherpa and Doongara) which differ by GI were subjected to in vitro enzymatic digestion by a mixture of pancreatic α-amylase and amyloglucosidase (Aspergillus niger) and the glucose released was measured by the G0POD assay. Digestion curves were generated by plotting starch digestion percentages vs. time and the kinetics of starch digestion obtained through the combined techniques of logarithm-of-slope analysis and non-linear least-squares fitting method which allow for an accurate determination of critical parameters including predicted GI, areas under curves and/or digestion rate coefficients. Following this approach, this assay allowed rapid prediction of the GI of these rice cultivars that meets the high throughput needs of rice breeding programs and has the potential to assist in the delivery of new low GI rice cultivars.

FODMAPs and functional gut symptoms
K. WHELAN (1)
(1) King’s College London, London, U.K.

There is an intensifying interest in the interaction between diet and the functional gastrointestinal symptoms experienced in irritable bowel syndrome (IBS). Recent studies have used magnetic resonance imaging to demonstrate that short-chain fermentable carbohydrates increase small intestinal water volume and colonic gas
production that, in those with visceral hypersensitivity, induces functional gastrointestinal symptoms. Dietary regulations will be shown.

...grains. Moreover, the occurrence in Europe and worldwide (including developing countries) will be discussed. Mycotoxins, what are they, which organisms produce them, in what foods are they found and their relevance to...
Effects of the amylose content and molecular structure of rice starches from different Korean rice varieties on amylose-lipid complex formation
S. JEON (1), Y. E. Hong (1), Y. Moon (1), Y. Zhao (1), M. Kweon (1)
(1) Pusan National University, Busan, South Korea

Amylose-lipid complex is considered as type 5 resistant starch (RS) because of its resistance to enzyme hydrolysis and health benefits. The present study was to investigate the effects of the amylose content and molecular structure of rice starches on amylose-lipid complex formation. Rice starches with varying amylose content (1.7–35.0%) were isolated from seven Korean rice varieties (4 high amylose, 2 intermediate amylose, and 1 waxy cultivar). Amylose-lipid complex in the starches during heating were analyzed by differential scanning calorimetry (DSC). For molecular structure of the starches, distribution of amylopectin chain lengths of them were analyzed by high performance anion exchange chromatography-pulsed amperometric detection (HPAEC-PAD) and molecular weights of amylose and amylopectin of them by high performance size exclusion chromatography-multi-angle laser light scattering-refractive index detection (HPSEC-MALLS-RI). For demonstrated increasing formation of amylose-lipid complex, pasting characteristics of the starches with sodium stearoyl lactylate (SSL) and palmitic acid were assessed by rapid viscoanalyzer (RVA). DSC data showed the largest melting enthalpy of amylose-lipid complex for the cultivar Hanareum with intermediate amylose content (17.9%). HPAEC-PAD results showed significantly lower percentage in shorter chain length (DP 6-11) and longer average chain length (DP 15.3) of amylopectin for the cultivar Dodamssal with the highest amylose content (35.0%) than other cultivars (p < 0.05). HPSEC-MALLS results showed similar molecular weight (MW) of amylopectin for all cultivars, but much larger molecular weight of amylose for the cultivar Hanareum. Addition of SSL to the starches resulted in a noticeable increase in pasting temperature and viscosities, but the addition of palmitic acid gave a negligible effect. Among the starch samples, the cultivar Hanareum showed the most significant change in pasting characteristics by addition of SSL, which could link to its favorable tendency of amylose-lipid complex formation because of larger MW of amylose. Overall data confirmed amylose molecular structure would contribute more effectively to formation of amylose-lipid complex, compared with amylose content and amylopectin molecular structure. In addition, it could be suggested the potential utilization of the cultivar Hanareum for producing rice products enriched type 5 RS by increasing amylose-lipid complex formation.

Co-passengers of oat β-glucan play a role in starch hydrolysis
Y. WANG (1), L. Yang (1), T. S. Sontag-Strohm (1)
(1) University of Helsinki, Helsinki, Finland

Cereal β-glucan is a non-starch polysaccharide that is partially water-soluble. Many studies have shown the effect of β-glucan on reduction of blood glucose and insulin responses, and suggested that the main mechanisms are the reduction of the enzymatic hydrolysis of starch and the delay of intestinal absorption of glucose by the viscosity of β-glucan. However, most of the studies used impure β-glucans without identifying other associated substances that may affect the starch hydrolysis and the absorption. Our previous studies have shown that oat β-glucan contained a significant amount of phytate which protected the β-glucan from oxidative degradation. Phytate, as such, has been reported to reduce starch digestion and lower the glycemic response. The suggested mechanisms include binding of phytic acid to starch or to α-amylase, or chelation of calcium (Ca2+) which is needed for activation of α-amylase. Therefore, we questioned: whether the phytate in cereal β-glucan contributes to the reduction of starch digestion and furthermore the glycemic response. The aim of this research was to study the role of phytate in oat β-glucan extract in starch hydrolysis with an in-vitro method. Oat β-glucan extract (OBG) was prepared from oat bran concentrate (14% β-glucan). OBG contained 4.8% residual phytic acid and 0.2% Ca (dw basis), which were removed by ion-exchange and dialysis to produce the phytate-removed OBG (OBG-PR, phytic acid 0.8%, Ca 0.04%). Starch was hydrolyzed by α-amylase from porcine pancreatin and the hydrolysis extent was measured by reducing sugar content after hydrolysis for 20 and 120 min. At physiological pH (6.9), pre-incubation of phytic acid (4.8%) with α-amylase slightly reduced the starch hydrolysis. OBG and OBG-PR enhanced the starch hydrolysis due to the intrinsic Ca which enhanced the activity of α-amylase. OBG which contained more Ca showed more increase of starch hydrolysis. The role of β-glucan viscosity in starch hydrolysis was studied by using lichenase to degrade the β-glucan in OBG and OBG-PR. When the β-glucan was degraded in OBG and OBG-PR, starch hydrolysis was increased, which indicated that the viscosity of β-glucan played a role in controlling the starch hydrolysis. Adding phytase to OBG and OBG-PR degraded the phytate, caused viscosity loss of the sample, and increased the starch hydrolysis due to the release of Ca. In conclusion, this study demonstrated that, in addition to the viscosity of β-glucan, the phytic acid and calcium associated in the β-glucan sample largely influenced the starch hydrolysis.
Identification of the phenolic compounds responsible for antioxidant capacity of finger millet samples
J. Xiang (1,2), F. B. Apea-Bah (2), T. BETA (2)
(1) Henan University of Science & Technology, Luoyang, Henan, China; (2) University of Manitoba, Winnipeg, MB, Canada

Millets rank as the sixth most important cereal in the world. Being rich source of nutrients, millets offer unique health benefits as ingredients in multigrain and gluten-free cereal products. Finger millet (*Eleusine coracana L.*) ranks third in importance among millets in the world after pearl millet (*Pennisetum glaucum*) and foxtail millet (*Setaria italica*). However, there is limited information on their polyphenol composition. The profiles of phenolic compounds and antioxidant capacities of four finger millet varieties harvested in northern Malawi were investigated. The contents of total phenolics, flavonoids and condensed tannins in the free fractions ranged from 114.43 to 179.19 mg ferulic acid equivalent (FAE)/100 g, 90.24 to 202.94 mg catechin equivalent (CE)/100 g and 31.76 to 83.59 mg CE/100 g, respectively. Total phenolic contents of the bound fractions ranged from 58.27 to 123.23 mg FAE/100 g. Twenty phenolic compounds were identified in the free fractions including 18 flavonoids, with catechin and epicatechin being the predominant flavonoids. Seventeen phenolic compounds were identified in the bound fractions, with ferulic acid being the predominant one. Ten of the identified polyphenols are being reported for the first time in finger millet. Flavonoids present in the free fractions of finger millet included catechin, epicatechin, quercetin and apigenin derivatives. Catechin and epicatechin were the predominant flavones present in free fractions, while phenolic acids are present only in minute amounts. Phenolic compounds present in the bound fractions included ferulic acid, p-coumaric acid, caffeic acid and protocatechuic acid, with ferulic acid being the predominant phenolic acid. Five ferulic acid dihydrodimers including 8-8′-aryltetralin-DFA, 5-5′-DFA, 8-5′-DFA, 8-5′-DFA benzofuran and 8-O-4′-DFA, were identified in finger millet only in bound forms. Finger millet varieties with colored (brown, reddish or red) pericarp, had higher levels of phenolic compounds both in the free and bound forms than and consequently, higher antioxidant activities than white-pericarp varieties. Dark colored finger millet varieties can serve as a viable functional food ingredient providing a diverse source of natural phenolic antioxidants.

Sensory driven shelf life of whole wheat flour
R. POUDEL (1), D. Rose (1)
(1) University of Nebraska – Lincoln, Lincoln, NE, U.S.A.

Lipolytic degradation, catalyzed by lipase enzymes, is one of the main reasons for declining functionality of whole wheat flour during storage. Lipase, which is active in dry flour, hydrolyzes triacylglycerols to free fatty acids (FFAs), which contribute to rancid flavor in flour, hence, declines the shelf life of whole wheat flour. Although several studies have shown hydrolytic and oxidative lipid degradation of whole wheat flour and how these relate to baking properties, no studies have shown the time where the product is unacceptable to consumers. Therefore, the objectives of this study were (1) to determine the shelf life of whole wheat flour using sensory-guided procedures, and (2) to quantify changes in chemical properties of the flour over time and relate these changes to sensory properties. Whole wheat flour of two particle sizes (0.6 and 1.6 mm) obtained from four cultivars (Anton, Freeman, Overland, and Wesley) was stored at two temperatures (room and 35°C) for 12 months in a completely randomized design split-plot in time. Sensory data were collected and analyzed following Weibull Hazard analysis to predict the shelf life of whole wheat flour. Sensory results showed that the estimated shelf life of whole wheat flour is cultivar and storage temperature dependent. The estimated shelf life of whole wheat flour stored at room temperature was more than 12 months, whereas at 35°C the estimated shelf life was found to be 9 to 10 months. Significant interactions of cultivar × temperature (p = 0.02), cultivar × particle size (p = 0.01), temperature × time (p = 0.0008), and cultivar × time (p = 0.03) were observed for lipase activity. Similarly, cultivar × time (p < 0.0001), particle size × time (p = 0.0015), temperature × time (p < 0.0001), and cultivar × particle size (p < 0.0001) interactions were observed for FFAs. The sensory acceptability and FFAs were negatively correlated for Anton (r = -0.80, p = 0.0015) and Freeman (r = -0.68, p = 0.01), whereas no such correlation were observed for Overland (r = -0.54, p = 0.06) and Wesley (r = -0.49, p = 0.10). Data on the accumulation of oxygenated fatty acids, volatile compounds, and gluten properties are being collected. In conclusion, the shelf life of whole wheat flour was not only dependent on the storage temperature, but also on the cultivar. Particle size and temperature also have significant effects on the chemical stability of whole wheat flour during storage. The findings from this study will provide information on chemical stability and estimation of the shelf life of whole wheat flour from sensory perspectives.
Celiac disease (CD) is a chronic autoimmune enteropathy triggered, in genetically predisposed individuals, by exposure to peptides deriving from incomplete digestion of gluten. The amount of these peptides after digestion depends on several factors, mainly wheat genotype and cultivation region. Gluten peptides generated by digestion can be quantified by UPLC/ESI-MS in different wheat varieties, or in the same varieties cultivated in different regions. Together with CD, wheat is also responsible for IgE-mediated allergic reactions, and allergens are found among gluten, albumins, and globulins. CM3, one of the wheat alpha-amylase inhibitor subunits, is one of the major wheat allergens, being implicated in atopic dermatitis, baker’s asthma and intestinal inflammation. CM3 content is also not constant in wheat, but mostly depends on cultivation region. Indeed, also in this case a method for its quantification in different wheat samples, based on enzymatic treatment and subsequent UPLC/ESI-MS analysis using an isotopically labelled internal standard, has been developed by our group. To prevent the onset of CD, and to reduce allergic reactions, it would be of interest to select wheat with a low content of CM3 and/or a low content, after digestion, of gluten-related CD peptides. Possible strategies for mitigation include: a) selection of varieties; b) selection of cultivation area; c) germination. Durum wheat collection made of 6 genotypes (Duilio, Dylan, Claudio, Iride, Simeto, and Svevo) cultivated in 4 Italian regions (Emilia Romagna, Marche, Apulia, and Sicily), were investigated for their content of CD-related peptides, after in vitro gastrointestinal digestion. In this way, the best combination variety/cultivation region was identified to have wheat samples producing the lowest possible amount of CD-related gluten peptides after digestion. In a different approach, one of this variety was germinated in a lab incubator at 25°C, lyophilized, digested and analysed by UPLC/ESI-MS to assess the effect of 6 days of germination on the amount of CD-related gluten peptides after ingestion. Germination, actually, induced a very important reduction, after simulated gastrointestinal digestion, in the generation of CD-related gluten peptides. Likewise, CM3 content was found to be markedly reduced by germination. In concordance, food processing significantly influenced the content of peptides. In conclusion, appropriate selection of varieties and cultivation area as well as appropriate technologies, such germination, might indeed reduce the impact of wheat in the onset of CD and in the appearance of wheat allergies, possibly exerting a preventive effect able to contain adverse reactions to wheat.

Alteration of the structure of rice proteins by their interaction with soy protein isolates to design novel protein composites

Z. CHEN (1,2), T. Wang (1,2), R. Wang (1,2), J. He (1,2)  
(1) School of Food Science and Technology, Jiangnan University, Wuxi, China; (2) The State Key Laboratory of Food Science and Technology, Jiangnan University, Wuxi, China

Rice proteins (RPs) are plant proteins with high nutritional value, but they attract little industrial interest because they are poorly soluble (<2%, w/v), with poor solubility-related functionalities. To improve the solubility of RPs while retaining their intact structural and nutritional attributes is therefore imperative and challenging. We report that by mixing RPs and soy protein isolates (SPIs) in RP/SPI ratios of 1:0.1–1:2 at pH 12, and then neutralizing the solution to pH 7 at ambient temperature, the solubility of RPs can be boosted to over 80% without damage to the subunits of either protein. Structural and morphological characterization showed that the RPs and SPIs interacted at pH 12 and formed complexed structures that underwent dramatic conformational changes during neutralization, folding together into nanoscale spheres with high surface charges (zeta potential > 30 mV). With their enhanced solubility and retained hydrophobicity, the protein composites displayed excellent interfacial affinities. The emulsifying and foaming capacities and stabilities of the protein composites were almost doubled or even tripled at pH 7 relative to those of RPs. Furthermore, the protein composites maintained the balanced amino acid compositions of both the RPs and SPIs. Our results demonstrate that inducing protein interactions by modulating the pH is a robust technique for the functional and nutritional modification of food proteins.

Grain-blame: Is there solid evidence behind pet foods angst over starches?

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

The pet food industry continues to grow globally with conservative estimates at 4% yearly on a nearly $US 100 billion base. The market has grown in large part through innovation in food form and ingredient selection. In these new products grains are often discounted as inferior or unhealthy in favor of legumes, tubers, and animal-based proteins. This has given way to a significant volume in so called grain free, and limited ingredient diets. The general perception of consumers which are exploited by marketing firms is that grains like corn and wheat are cheap commodity fillers, contain toxins (e.g. aflatoxin), are poorly digested, and lead to adverse food reactions which manifest as digestive upset (vomiting, diarrhea), dermatitis (alopecia, pruritis,
Effect of salt, sugar and xanthan gum on behavior of hairless canary seed starch slurries

E. ABDELAAL (1), I. Rabalski (1), M. Hernandez (2), L. L'Hocine (3), C. A. Patterson (4), P. J. Hucl (5)
(1) Agriculture and Agri-Food Canada, Guelph, ON, Canada; (2) Guelph Research and Development Centre, AAFC, Guelph, ON, Canada; (3) Saint-Hyacinthe Research and Development Centre, AAFC, Saint-Hyacinthe, QC, Canada; (4) The Pathfinders Research & Management Ltd., Saskatoon, SK, Canada; (5) Crop Development Centre, Saskatoon, SK, Canada

Hairless canary seed was recently granted regulatory approvals as a novel food from Health Canada and GRAS status from US-FDA. This would open up new markets for canary seed in addition to its current single bird feed market. In the current study, the behavior of starch obtained from 2 hairless canary seed varieties developed by the University of Saskatchewan, Canada for food use was studied in the presence of salt, sugar and xanthan gum using Rapid Visco Analyzer in comparison with wheat starch as a reference material. The starches were tested at 3 concentrations of salt and sugar (0.3, 0.5 and 1%) and 4 concentrations of xanthan gum (0.1, 0.3, 0.5 and 1%).

In previous studies canary seed starch was characterized in terms of compositional, pasting, thermal and rheological properties. Starch was separated from hairless canary seed using a wet milling fractionation process at yield of 51–53 g/100 g with a purity of more than 95% total starch. The presence of salt, sugar and gum resulted in minor or major changes in the behavior of canary seed starch slurries during heating and cooling cycles subject to their concentration. Slight changes were observed among the 3 salt concentrations studied. The addition of salt was found to lower canary seed starch peak viscosity. Sugar at low concentration had slight effects on peak viscosity but the addition of 1% sugar resulted in an increase in the peak viscosity of canary seed starch. The addition of 0.1, 0.3 or 0.5% xanthan gum powder to canary seed starch slurries formed viscosity which was not significantly higher than the control samples probably because xanthan gum was not fully hydrated to interact with canary seed starch under the test conditions. Hydration of xanthan gum overnight resulted in higher viscosity compared to the control starch samples indicating interactions with canary seed starch. The addition of 1% xanthan gum produced non-uniform starch slurries due to the formation of visible aggregates. Canary seed starch slurries behaved differently compared to wheat starch exhibiting higher stability during heating subject to additive type and concentration. Overall the results suggest strong molecular interactions between canary seed starch and xanthan gum and show changes in starch behavior with the addition of salt and sugar. This information would be beneficial in canary seed starch-based food applications.

Near infrared calibration development for wheat flour quality parameters: Solvent retention capacity, farinograph, falling number, alveograph, and mixolab

N. BURKE (1), Y. Jin (1)
(1) Kellogg Company, Battle Creek, MI, U.S.A.

Near infrared (NIR) spectroscopy in conjunction with partial least squares (PLS) regression has been used extensively for the rapid prediction of wheat flour constituents, particularly moisture, protein, and ash. The work described here demonstrates an extension of our previous work to now include solvent retention capacity (SRC), farinograph, falling number, alveograph, and Mixolab. Previously, NIR spectra were acquired for the development of calibrations for protein, moisture, and ash for 850 wheat flour samples that underwent routine analysis within our cereal science laboratory. NIR spectra were acquired on a Unity Scientific SpectraStar 2400 (wavelength range 1,200–2,400 nm) or a Unity Scientific SpectraStar XT (wavelength range 680–2,600 nm). These samples span the 2015–2017 crop years and encompass a wide variety of wheat flours relevant to commercial cookie and cracker production, including hard and soft wheats, as well as white and red wheats. A database was generated and primary reference values were assembled from historical data stored in an internal laboratory information management system. The database includes the following samples: 803 samples for solvent retention capacity (lactic acid, sodium carbonate, sucrose, water), 471 samples for farinograph (water absorption, degree of softening, stability, and development time), 698 samples for falling number, 355 samples for alveograph (P, L, W(40), P/L, Ie), and 198 samples for Mixolab (water absorption, torque, time to reach C1, stability, dough temperature). Calibrations for SRC, farinograph, and falling number show linear correlations between the NIR spectra and the primary reference values. R-squared and RMSECV (root mean squared error of cross validation) values are consistent with the standard error of each respective primary method. The R-squared and RMSECV for the falling number calibration are 0.718 and 23.89, respectively. For the farinograph calibration, the R-squared values are 0.960, 0.957, 0.920, and 0.805 and the RMSECV values are 0.665, 1.070, 10.456, and 0.151 for water absorption, stability, degree of softening, and development time, respectively. For the SRC calibrations, the R-squared values are 0.839, 0.790, 0.933, and 0.832 and the RMSECV values are 8.023, 5.513, 2.174, and 5.040 for
lactic acid, sucrose, water, and sodium carbonate, respectively. The development of calibrations for alveograph and Mixolab are on-going. The full numerical performance of each calibration model as well as additional factors, such as the effect of wavelength range (680–2,600 nm vs. 1,200–2,400 nm) and the effect of SRC measurement type (manual vs. CHOPIN instrument), will be discussed.

**Preparation and characterization of starch-β-carotene nanoparticles by homogenization–evaporation method**

N. Ji (1), Y. Hong (1), Z. Gu (1), L. Cheng (1), Z. Li (1), C. Li (1)

(1) Jiangnan University, Wuxi, China

β-Carotene, a lipid-soluble carotenoid, has a number of potential health benefits for human. However, their use in food industry is currently limited mostly because of its poor water-solubility. The biodegradable polymeric nanoparticles from natural polymers have attracted considerable attention as potential delivery vehicles to improve the stability and water-dispersibility of β-carotene. Starch, as a naturally renewable and biodegradable biopolymer, is one of the most abundant biopolymers which is a low-cost, renewable, non-toxic with widespread use in food and industrial applications. This work presents a study of the formulation of β-carotene loaded nanoparticles using corn starch as carrier materials with a homogenization-evaporation method. Upon such encapsulation, these starch-β-carotene nanoparticles were water-soluble. Transmission electron microscopy micrograph of starch-β-carotene nanoparticles revealed a much smaller (200 nm) and a well-defined spherical morphology without any aggregation or cluster formation. The X-ray diffraction pattern of starch-β-carotene nanoparticles showed that β-carotene molecules was converted to an amorphous state after being entrapped in starch polymeric matrix. The cell culture demonstrated that the nanoparticles showed no detectable cytotoxicity with relative cell viability all above 85%. Therefore, the starch based nanoparticles are promising polymeric carriers for developing protection and delivery systems for β-carotene. In addition, the technology for preparation of starch-β-carotene nanoparticles could be utilized as a model for encapsulating other hydrophobic compounds to improve their stability and dispersibility.

**Study on the water state and distribution of Chinese dried noodles during the drying process**

X. Yu (1), W. Zhenhua (1), Y. Zhang (1), W. Syed Abdul (1), Y. Wei (1)

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

The drying process of Chinese dried noodles (CDN) is very challenging because it has a limited strength to resist the internal stress caused by rapid drying. Many techniques have been developed so far to measure the moisture content of noodles and all of them are time taking and do not demonstrate water distribution inside the noodles. In this study, the water state and distribution of Chinese dried noodles during drying process (Temperature 40°C, relative humidity 75%, duration 300 min) was investigated by low-field nuclear magnetic resonance (LF-NMR). Transverse relaxation times (T2) were achieved by LF-NMR coupled with a 0.5 T permanent magnet equivalent to a proton resonance frequency of 21 MHz at 32°C. Three types of water in different status can be distinguished: strongly bound water (T21, 0.04–0.40 ms; A21, 0.25–19.08%), weakly bound water (T22, 0.96–5.34 ms; A22, 80.81–98.44%), and free water (T23, 74.50–266.47 ms; A23, 0.11–1.61%). During the drying process, the transverse relaxation time of all water states showed a decreasing trend. Initially, the moisture content decreased faster from the noodle edges; however, moisture migrated rapidly from the central part during 90–180 min. The moisture gradient disappeared after drying for 240 min. Besides, a special method "Oil immersion method" was introduced to address poor signal to noise ratio in samples when moisture content was low during the drying process. High signal to noise ratio was successfully obtained using this method.

**Influence of particle size on the flour and baking properties of pulse flours**

L. Bourre (1), P. Frohlich (1), G. Young (1), K. McMillin (1), Y. Borsuk (1), E. SOPIWNYK (1), A. Dyck (2), L. Malcolmson (2)

(1) Canadian International Grains Institute, Winnipeg, MB, Canada; (2) Warburtons, Winnipeg, MB, Canada

The use of pulse flours in food formulations has increased as food processors look at ways to improve the nutritional quality of their products. Pulse flours can be used to increase fiber and protein content and to provide natural sources of folate and minerals. Research has shown that pulse flours have good functionality in a range of food products but there is limited knowledge as to how particle size affects flour and baking properties of pulse flours. In this study, dehulled and split yellow peas, whole navy beans and decorticated red lentils were milled into flour using a Ferkar multipurpose knife mill. A pre-break step was performed using a 3.0 mm screen prior to flour production. Four different screens (1.27, 1.0, 0.79, 0.5 mm) were used to produce flours with different particle size distributions. Flours were assessed for compositional (protein, starch) and functional properties (particle size, RVA pasting properties, starch damage, water absorption capacity (WAC)), blended with wheat flour (20% pulse flour/80% wheat flour), baked into bread and analyzed for processing quality (dough handling, bread volume, bread scoring, C-Cell properties, crumb firmness, sensory parameters). Starch damage was greater for flours milled using the finer screens. Lower WAC values and higher peak and final viscosities were also found.
for the finer flours. In most cases, pasting time was also lower for the finer flours. Some differences were observed in baking absorption, mixing time and proof time depending on particle size and/or pulse flour type. Higher bread scores for colour and texture were found for the breads made with finer flours. All of the breads made with pulse flours scored higher than the wheat control for resilience. Bread volume was not affected by flour particle size but higher values for crumb firmness and C-Cell properties were found for breads made using the finer flours. Sensory parameters (appearance, aroma, pulse flavour, sweetness, bitterness, aftertaste, overall acceptability) of breads were not affected by flour particle size with the exception of appearance of the bread made with yellow pea flour. Overall, the results from this study showed that particle size influenced the functional and bread baking properties of pulse flours, with the exception of bread volume.

Optimization of process variables for the microwave assisted extraction of phenolic compounds from barley malt rootlets – A low value by-product from brewing industry

S. BUDARAJU (1), K. Mallikarjunan (1), G. A. Annor (2), T. C. Schoenfuss (2), R. Ruan (3)
(1) University of Minnesota, Falcon Heights, MN, U.S.A.; (2) University of Minnesota, St. Paul, MN, U.S.A.; (3) Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN, U.S.A.

Barley malt rootlets (BMR) are spent grains obtained from malting process of barley which are currently used as animal feed. The rootlets are potential source of antioxidants and extraction of such compounds economically is of interest to the industry. Application of microwave assisted extraction (MAE) has increased in the recent years due to its advantages (reduction in extraction time and solvent volume) over traditional extraction methods. The current study evaluated the efficiency of MAE for the extraction of polyphenols from barley malt rootlets. A central composite face centered design (CCFCD) was used to optimize the extraction parameters time (5, 10, 15 min), temperature (20, 40, 60°C) and solvent concentration (20, 50, 80%). The optimum conditions were based on the total phenolic content and DPPH (2,2-diphenyl-1-picrylhydrazyl) activity of barley malt rootlet extracts. The optimum values obtained from MAE were compared to that of the conventional solid-liquid extraction results. Total free phenolics were extracted by placing appropriately 2 g of sample in a microwave extraction system with 15 ml of acetone and subjecting to the respective time, temperature and % solvent combinations at 400 W microwave power. The residues obtained from free phenolic extraction were dried and subjected to alkaline hydrolysis for extracting bound phenolic content. The results showed that the optimal conditions were 5.4 min, 42.1°C and 79.1% of solvent concentration for free phenolics and 14.9 min, 36.5°C and 63.7% of solvent concentration for bound phenolics. Under these conditions, the total free phenolic content was 4.82 (mg g⁻¹ dw of BMR) and the total bound phenolic content was 2.80 (mg g⁻¹ dw of BMR) which was 37% and 51.2% higher than that obtained with conventional solid-liquid extraction technique (60°C, 90 min and 1:15 solute solvent ratio). On the other hand, the optimum antioxidant activity for DPPH assay was obtained at the operating conditions of 13.9 min, 45.7°C and 20.1% of solvent concentration for free phenolics and 7.7 min, 34.4°C and 23.0% of solvent concentration for bound phenolics. For the optimum conditions for antioxidant activity, more water soluble phenolic compounds with high antioxidant capabilities were extracted. In addition, not all the released total phenolics exhibited antioxidant activities resulting in lower activities for optimum conditions aimed for increased yields. The developed method could be used to reduce the extraction time, energy and solvent consumption during extraction, thus providing a commercially feasible and economically viable method for the proper use of by-products by brewing industries.

The waxy trait improves sorghum flour and malt quality

A. G. Mezgebe (1), J. R. N. TAYLOR (1), M. Salaheldin Mustafa (2)
(1) University of Pretoria, Hatfield, South Africa; (2) University of Pretoria, Pretoria, South Africa

Sorghum is probably the most hardy major cereal crop as it tolerates high temperatures, low rainfall and can even withstand periods of drought. Sorghum grain is also classified as gluten-free. However, the inert nature of sorghum flour is a significant factor limiting its broader application in foods and beverages. Sorghum flour is inert because the kafirin prolamin proteins are uniquely hydrophobic and its starch has a particularly high gelatinization temperature. Novel sorghum lines have been developed that possess the high protein digestibility (HD) trait, resulting from suppressed synthesis of particular kafirin subclasses, and also have the waxy (high amyllopectin) trait. The objective of this work was to determine whether the waxy and HD traits significantly improve sorghum’s dough-based food and malt beverage quality, with a specific focus on the needs of countries in semi-arid Africa, like Ethiopia. The endosperm of sorghum lines exhibiting both the waxy and HD traits is soft. Their flours have higher paste viscosity and formed much softer and less sticky pastes than the flour from regular non-waxy, normal protein digestibility sorghum lines. Furthermore, their flours had much higher solubility. In fact, at 30°C flour solubility of waxy-HD sorghum lines was similar to commercial wheat bread flour. Descriptive sensory evaluation and instrumental textural analysis, showed that injera (fermented flatbread) produced from the waxy sorghum lines was very close in texture (softness, flexibility, sponginess, rollability, chewiness and breakability) to the standard injera produced from teff, which is far more expensive than sorghum. However, injera made from combined waxy-HD lines was too sticky and that from regular sorghum lines was dry and gritty. When malted, the waxy sorghum lines generally had improved endosperm modification (partial
hydrolysis) and starch granule degradation, as revealed by scanning electron microscopy. The HD trait, however, did not show a clear effect on endosperm modification and protein body degradation. Malts from the waxy lines had improved hot water extract (starch solubilization and hydrolysis) and free amino nitrogen, more similar to the barley malt standard than malt from normal sorghum lines. The improved dough and malt quality of the waxy sorghum lines is probably primarily due to the better starch granule swelling property of amylopectin. It is concluded that waxy-type sorghums have great potential as partial wheat and barley substitutes in tropical regions where these cereals cannot be economically cultivated and for use in gluten-free products.

WheatData: Is a digitalized wheat value chain feasible?
T. LEFEBER (1), S. Stroo (1), S. Gilis (2), S. Landschoot (3), S. Maenhout (4), B. De Baets (5), G. Haesaert (3) (1) Flanders’ FOOD, Brussels, Belgium; (2) IP[ask]IT, Brussels, Belgium; (3) Department of Plants and Crops, Faculty of Bioscience Engineering, Ghent University, Brussels, Belgium; (4) Progeno; (5) KERMIT, Department of Data Analysis and Mathematical Modelling, Ghent University, Brussels, Belgium

The baking industry is currently facing a number of challenges, i.e. yearly fluctuations in wheat composition and origin and more stringent requirements with respect to baking performance. In addition, they are more and more confronted with unexpected flour behavior and thus a reduced baking performance. To guarantee a tasty and standardized end-product, knowledge on the importance of the factors influencing meal and flour characteristics is a prerequisite. The goal of the “WheatData” project is to come to a shared database with data from various partners involved in the wheat value chain and to gain a deeper insight into the driving factors influencing end-product quality. These insights should, in time, lead to a predictive model able to predict end-product characteristics based on relevant input data. This project will provide the industry with a more efficient and accurate tool to assess wheat functionality and end-product quality and will thus lead to a reduced number of laborious baking trials. Different companies involved in the wheat value chain, from farmers, traders, millers until (industrial) bakeries own data. If these companies want to share data they need to trust any partner. Therefore after thorough discussions they will settle a necessary legal agreement which describes the ownership, background, foreground, intellectual property rights, access rights and other terms and conditions for both the execution of the research and/or further exploitation. Moreover any partner needs to have the same basic level of knowledge, knowhow and understanding to make this abovementioned digital transformation. So that they will be able to make the decisions to maintain and use their shared database in an effective and efficient manner. In parallel data will be collected, cleaned and mined in order to gain insight into the data and to discover interesting patterns. If so, the end-product quality characteristics might be predicted based on flour/meal properties and subsequently this model will be validated. So in conclusion a digitalized value chain is feasible if the project partners can trust each other (equal partnership) and the value chain can profit from the output of the future model.

Investigation of technological, nutritional and sensorial characteristics of wheat bread influenced by different strains of *Saccharomyces cerevisiae*

M. HEITMANN (1), E. Zannini (1), C. Axel (1), E. K. Arendt (1) (1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland

Yeast induced fermentation of dough is an important process in bread making and one of the oldest biochemical processes in the world. Surprisingly, knowledge about dough fermentation in correlation to product quality parameters is scarce and still not completely understood. While yeast selection is an established part of the production process in the beverage industry, less attention was drawn on dough fermentation. This study investigates the suitability of various *Saccharomyces cerevisiae* strains originating from the beverage industry in dough leavening to enhance bread quality characteristics compared to commercial baker’s yeast. The results revealed that various yeast strains showed large differences in technological bread quality parameters like specific volume, hardness and shelf life. In the case of bread, starch being the main carbohydrate source, glycaemic control is of great interest. Therefore, the predicted glycaemic index (pGI) was measured using an in vitro enzymatic model system in relation to the metabolic patterns of the different yeast strains and the compositional analysis of the breads in comparison to baker’s yeast bread (100). pGI values were significantly lower for *S. cerevisiae* s-23 (71.6), wb-06 (63.0) and Blanc (77.9). PCA confirmed that the breads were different in terms of their technological properties, chemical composition and pGI. Furthermore, aroma is an important quality parameter for wheat bread and most of the aroma compounds in yeast-fermented bread result from the fermentative action of yeast. For this reason, the impact of yeast strains on sensory characteristics, flavour and aroma profile was investigated by gas chromatography mass spectrometry after thermal desorption (GC-MS TD) and descriptive sensory analysis. In addition, yeast strain dependent production of aroma compounds was shown, leading to a change in consumer acceptance. The increasing fundamental knowledge about dough fermentation generates new opportunities for their use in the baking industry. Therefore, yeast can be used to replace or reduce the amount of expensive additives and dough improvers. This study also opens alternatives to better satisfy the high demand of consumers for an increasing variety of bread products by only changing the yeast culture.
Impact of electron-beam irradiation pretreatment on elongation modification of waxy corn starch with amylosucrase from Neisseria polysaccharea

J. HE (1,2), Z. Chen (1,2), R. Wang (1,2), T. Wang (1,2)
(1) School of Food Science and Technology, Jiangnan University, Wuxi, China; (2) The State Key Laboratory of Food Science and Technology, Jiangnan University, Wuxi, China

Recombinant amylosucrase (AS) from Neisseria polysaccharea had been widely utilized to prepare modified starch with high resistant starch (RS) content because of its unique transglycosylation property. However, it was found that the starch concentration higher than 3% could not be used because the high viscosity of gelatinized starch made the enzymatic reaction difficult to handle. In this study, waxy corn starch was pretreated by electron-beam irradiation to decrease its viscosity, and then the enzymatic modification was carried out with a starch concentration of 3%. The reaction process was recorded, the relationship between the molecular structure and physicochemical properties of modified starches were clarified, and the effect of electron beam irradiation treatment on digestibility of modified starches was investigated. Irradiated starch showed much lower gelatinization viscosity but exhibited similar reaction rate compared with that of native starch. When the modification lasted for 5 h, both the native and irradiated starch solution turned into gelatinous. Proportions of long (degree of polymerization, DP > 33) and intermediate chains (DP 13–33) was extremely enhanced after modification. Moreover, modified irradiated starches showed lower proportions of long chains (DP > 33) and higher proportions of intermediate chains (DP 13–33). X-ray diffraction showed the crystalline structure altered from A-type to B-type. With the increase of reaction time, the melting peak temperatures of the modified starches gradually increased, whereas the endothermic enthalpy decreased. The content of RS increased till the gelation occurred for both forms of modified starches, and then approximately remain constant. After modification, electron-beam irradiated starches showed slight lower content of RS than did the native starch, due to its lower proportions of long chains. Besides, modified starches after the gelation displayed better thermostability. In general, this pretreatment has great potential on improving the feasibility of high-concentration starch modification reaction, but it will not have a negative effect on the RS content of AS-modified starch.

Quantitation of amylase/trypsin-inhibitors in various wheat species

S. GEISSLITZ (1), K. Scherf (1), P. Koehler (2)
(1) Leibniz-Institute for Food Systems Biology at the TUM, Freising, Germany; (2) Biotask AG, Esslingen am Neckar, Germany

The “ancient” wheat species einkorn, emmer and spelt are cultivated in very low amounts in comparison to “modern” species like common and durum wheat. In the last years, ancient wheat species have gained more attention because of sensory and possible health benefits. To date, it is not known if ancient wheat species contain lower contents of α-amylase/trypsin-inhibitors (ATI), which have been associated with intestinal inflammation and symptoms typical of non-celiac gluten sensitivity (NCGS). Therefore, the aim of this study was to develop a method to quantitate ATI in ancient and modern wheat species. ATI were extracted from whole grain flour with salt solution, reduced, alkylated and digested with trypsin. Peptides were analyzed by liquid chromatography-tandem mass spectrometry (LC-MS/MS) and five ATI-types (0.19, 0.28, CM2, CM3 and CM16) were quantitated by stable isotope dilution assays (SIDA). Precision (<8%), recovery (80–120%) and limits of detection (<5 mg/kg) showed the good performance of the method. For the validation of trueness/accuracy, the results of SIDA were compared with an independent LC-MS/MS system and data evaluation by intensity based absolute quantitation algorithm (iBAQ). Both approaches yielded comparable results. Eight whole grain flours of common wheat, durum wheat, spelt, emmer and einkorn, respectively, were analyzed by SIDA for their ATI contents. In contrast to the other wheat species, only three of eight einkorn cultivars contained ATI in very low concentrations (0.2 ± 0.1 mg/g). On average, all spelt (4.7 ± 0.5 mg/g) and emmer cultivars (5.0 ± 0.5 mg/g) had higher ATI contents than common wheat (3.7 ± 0.3 mg/g) and durum wheat (4.2 ± 0.9 mg/g). Except for einkorn, this disproved the assumption that ancient wheats contain less ATI than modern ones.

Food neophobia predicts new product uptake – Using sorghum as a model grain

A. J. SALIBA (1), D. Metcalf (2)
(1) Charles Sturt University, Graham Centre, ARC ITTC for Functional Grains, Wagga Wagga, Australia; (2) Charles Sturt University, ARC ITTC for Functional Grains, Wagga Wagga, Australia

This presentation describes a new method for assessing market readiness for new food products based on a grain with low awareness, using sorghum as the model. Worldwide sorghum demand is increasing, both from established products such as Baijiu and from new and emerging food products. Demand from new food products is based somewhat on increases in population and affluence, but in particular, the sought-after health characteristics of sorghum. Across several studies, we have traced an increase in consumer interest in health; sorghum’s macro nutritional properties along with good antioxidant properties provides an opportunity for
product developers to utilise sorghum to meet this demand for health. Food choices are complex such that assuring good taste, availability and value are not sufficient for new product success. For existing and well-established food products, small changes can be made with little negative impact on uptake. However, for a new product, based on a grain with low awareness such as sorghum, adoption considerations are more complex. We propose using "food neophobia" as a global measure of propensity to adopt "new" products and have validated this measure in multiple countries. Where food neophobia is high, new products can still be developed using sorghum; in this case we propose that familiarity can be leveraged from other aspects of the product to decrease perception of “newness”.

**Inhibition of *Saccharomyces cerevisiae* strains by wheat flour proteins during bread making**

E. VAN DER MAELEN (1), N. Struyf (1), C. M. Courtin (1)

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

Yeast is essential in the production of tasty leavened bread. The consumption of fermentable sugars results in the production of CO₂ and ethanol. Also secondary metabolites are produced that affect dough rheology and bread quality and flavor, such as glycerol and organic acids. To make use of the possibilities in bread making offered by the existence of a wide variety of existing yeast strains, both wild isolates and industrial strains, the question arises as to how they would influence bread quality parameters. To that end, the fermentation capacity of about 35 different *S. cerevisiae* strains with different industrial applications was examined. Bakery strains appeared not to be the best CO₂ producers. More remarkable, not all strains were able to ferment in wheat flour dough at all. Certain brewery strains and distillery strains had a fermentation capacity up to resp. 90% and 50% lower than bakery strains. Testing those bad fermenting strains in a model dough system of gluten and starch, showed that they did have the capacity to ferment in the solid-state matrix. This led to the assumption that the water extractable fraction of wheat flour contains a yeast inhibiting component, which was confirmed by the lack of fermentation capacity of the bad fermenting strains in a liquid extract-based fermentation medium. Treatment of a crude wheat flour extract with a non-specific protease made inhibition disappear, presuming that the inhibitor is a protein. Cation exchange chromatography and reversed phase high performance liquid chromatography were subsequently used for purification of the crude wheat flour extract. The resulting inhibiting fraction was separated on SDS-PAGE gel showing two distinct bands. LC-MS/MS and Edman degradation showed that one of the bands contained a pathogenesis-related *thaumatin-like* protein. This protein was pointed out as the yeast inhibiting protein. Knowing the identity of the inhibitor allows to specifically search for its mode of action. These data in turn can be used to screen for inhibition resistant yeast strains based on genetic information. These insights can be of importance for the selection of existing or the development of new yeast strains for bread applications.

**Gluten microstructure – Definition of network types and the link to dough rheology**

I. LUCAS (1), M. Jekle (1), T. Becker (1)

(1) Technical University of Munich, Freising, Germany

The quantification and interpretation of the gluten network in wheat dough systems is challenging due to its complex structure. However, quantitative data would enable the development of structure-function relationships. Thus, the aim of the study was to define gluten network specifications in general and to relate them to dough rheology. For this purpose, network formation was altered by specific (glutathione, ascorbic acid, potassium bromate, glucose oxidase, transglutaminase, bromelain) as well as unspecific gluten-modifying agents (reduction and increase of hydration level, addition of rapeseed oil and shortening) in order to achieve a high variety of gluten arrangements. The microstructure of the gluten proteins was visualized by confocal laser scanning microscopy and quantified by protein network analysis (PNA). Rheological behavior was determined by oscillatory and creep-recovery tests. With regard to specific gluten-modified samples, the structural network attributes branching rate, end-point rate, protein width and average protein length correlated linearly among each other (Pearson correlation coefficients between r = 0.65 and r = 0.84). This revealed the general assertion: the higher the branching rate, the thinner the protein threads and the larger the interconnected protein aggregate. Considering specific as well as unspecific gluten-modified samples, a quantitative specification of different gluten arrangements was established by means of the morphological attribute lacunarity. In this regard, six different network types were proposed and confirmed by principle component analysis of microstructural and rheological attributes. The following network types, associated to their rheological characteristics, were defined: a cleaved (low viscous), rigid (highly viscous), spread (viscoelastic), strengthened (viscoelastic), particulate, dense (highly viscous) and a particulate, loose (low viscous) network. In addition, statistical models by partial least square (PLS) were performed to predict rheological values by microstructural attributes. This study improves a detailed understanding of structural interactions of gluten polymers and enables a rheological interpretation of wheat doughs by microstructural investigations.
Formulating gluten-free bakery products using pulse ingredients
L. MALCOLMSON (1), M. Hughes (1)
(1) Best Cooking Pulses, Avena Foods Ltd., Portage la Prairie, MB, Canada

The global gluten-free retail market has grown from $1.7 billion in 2011, to $3.5 billion in 2016, and is forecast to
grow to $4.7 billion in 2020. With increased demand for gluten-free products, there is a need to formulate gluten-
free products that deliver improved end-product quality with enhanced nutritional properties. Pulse flours are
ideal for developing healthier gluten-free baked goods since they are high in protein, fiber, vitamins and minerals
and low in fat. Pulse flours also exhibit functional advantages including greater water absorption and foaming
properties compared to other gluten-free ingredients. Outer pea hull fiber can be added to gluten-free
formulations to boost fiber levels and to provide enhanced functionality. Pulse flours and pea hull fiber
were used to formulate a number of gluten-free bakery products including muffins, cookies, pizza crusts, and
flat breads. In all cases, the nutritional properties and end-product quality was improved compared to products
made with traditional gluten-free flours and starches.

Effects of pentosanase and glucose oxidase on the composition, rheology and microstructure of
whole wheat dough
S. ZHOU (1), L. Wang (2), L. Liu (2), L. Tong (1), N. Sun (2), X. Zhou (2)
(1) China Academy of Agricultural Science, Beijing, China; (2) Institute of Food Science and Technology,
Chinese Academy of Agricultural Sciences, Beijing, China

To understand the modification mechanism of whole wheat buns with pentosanase (Pn) and glucose oxidase
(GOX), their effects on the dough were investigated in terms of the composition, rheology and microstructure.
In the presence of Pn, the dough exhibited a higher content of water extractable arabinoxylan and a stronger
solubility in protein. Besides, a higher extensibility was observed in Pn-treated dough, the gluten matrix was
more open and the starch granules were more visible. On the other hand, the addition of GOX decreased the
number of free sulphydryl and increased the content of glutenin macropolymer (GMP), indicating the formation
of disulfide bonds. Reducing SDS-PAGE of albumin and globulin suggested the generation of large protein
aggregates and the conjugation of protein-polysaccharide by non-disulfide covalent bonds. The GOX-treated
dough was significantly strengthened and became more tenacious, generating a more continuous and highly
dense gluten network. Both Pn and GOX, at appropriate dosages, were able to improve the capability of dough
fermentation. Although the effects of Pn and GOX on the dough were considerably different, both of them
significantly changed the rheology and microstructure of the dough, likely due to their impacts on the dough
composition, such as the solubilization of water un-extractable arabinoxylan, the increase of GMP and the
formation of protein-polysaccharide conjugates. The present results may lead to a better understanding of the
different effects of Pn and GOX on whole wheat dough at the molecular level.

Effects of moisture content, die dimension and addition of corn starch on quality of extruded
soy protein isolate
G. H. RYU (1), B. Y. Gu (2), S. Samard (2), S. Y. Cho (2)
(1) Kongju National University, Choongnam, South Korea; (2) Kongju National University, Yesan, South Korea

The objective of this study was to determine the effects of moisture content and die dimension, temperature
profiles and addition of corn starch on the quality of extruded soy protein isolate(SPI). Extrusion conditions
adjusted were moisture contents (40, 60%), barrel temperature before die exit (130, 140, 150°C), and corn starch
content (0, 10%). Two kinds of die dimensions, 10.0×4.5×50 mm and 80 mm were used. Screw speed and feed
rate were fixed to 250 rpm and 100 g/min, respectively. Extruded SPI at 40% moisture content had higher water
absorption index, texture and color difference than those of extruded SPI at other moisture content (60%). But
the extruded SPI at 40% moisture content had lower integrity index and cutting strength than those of extruded
SPI at 60% moisture content. The extruded SPI at 10% corn starch and 150°C barrel temperature had higher
water absorption capacity, elastic force and cohesiveness than those of extruded SPI at 130 and 140°C. However,
the extruded SPI at 0% corn starch content and barrel temperature 130°C had a lower integrity index, elastic
force, and cohesiveness than those of extruded SPI at barrel temperature (140, 150°C). In conclusion, the tested
physical properties of extruded SPI were more affected by moisture content, die dimension, and corn starch
content than barrel temperature and optimum extrusion conditions of texturization were 60% moisture, 80 mm
die length, 150°C die temperature, and 10% starch addition. Cooling die session required for preventing air-cell
formation and increasing texturization of plant protein.
Enhanced biogas production from bakery waste
T. Kaartinen (1), T. Mäkelä (1), E. NORDLUND (1)
(1) VTT Technical Research Centre of Finland Ltd., Espoo, Finland

Biogas production from bakery wastes offers an attractive alternative to produce locally the energy needed for the ovens at the bakery. At the same time biogas production is a waste treatment process for reducing the content of organic matter to be disposed of. In the present study enhancement of biogas production from bakery waste was assessed in laboratory scale in order to produce design parameters from the upcoming pilot runs at the bakery. Feed for the biogas process was solid bakery residues (flour, dough, bread etc.) mixed with COD-rich effluent from bakery’s washing machines. Batch methane production tests in mesophilic temperature (37°C) were conducted in the preliminary stage to study the effects of two types of pre-treatment—ultrasound and enzymatic hydrolysis—on methane production volumes and kinetics. In the preliminary batch tests the mixture of bakery waste and effluent produced 300 to 330 L of methane per kilogram of volatile solids. Pre-treatment did not seem to increase the amount of methane produced, but the gas production kinetics seemed somewhat faster with the enzymatic hydrolysis as the pre-treatment. The results from the preliminary tests suggested, that the retention time in the biogas process could be shortened by around 30% with the enzymatic hydrolysis. Two parallel semi-continuous 5 L reactor tests were set up in mesophilic temperature (37°C) to assess the biogas process closer to real life conditions. The reactors were fed daily with the substrate, and corresponding amount of digestate was removed from the reactors. Preliminary findings from the on-going experiments show, that without any pre-treatment, the mixture of bakery waste and effluent needs around 30 days retention time in the biogas process. However, even with the enzyme addition, retention time of 25 days led to severe instability of the process. The accumulation of volatile fatty acids was observed at the same time with decreased gas production and share of methane in the biogas. These challenges were successfully tackled later by mixing the substrate mixture for 24 hours in the temperature of 60°C to 1) hydrolyse the feed and 2) make sure that the remaining yeast did not disturb the biogas process. Currently the amount of methane produced in the reactors is similar to what was observed in the preliminary batch tests. In addition to the already available results, also results from thermophilic biogas process will be presented.

Diverse mechanisms of nutritional action of cereal dietary fibres
M. GIDLEY (1)
(1) University of Queensland, St. Lucia, Australia

Dietary fibres play a pivotal role in the digestion of a healthy diet, mostly as the defining structural characteristic of whole grains, fruits, nuts, and vegetables. From epidemiology, associations exist between dietary fibre intake, particularly from cereals, and reduction in risk factors for the major non-communicable diseases. Credible hypotheses can be constructed to link the properties of (cereal) dietary fibre to biomarkers associated with reduced risk of diabetes, cardiovascular disease, obesity and colon cancer. The physical properties of cereal dietary fibre components relevant to digestive tract functionality can be grouped into (i) bulk structuring, (ii) transport barriers, and (iii) molecular binding. Examples of each type of functionality from both in vitro and in vivo studies will be presented. Subsequent health properties are likely to result from the integration of the biological effects of many separate physico-chemical properties. Cereal dietary fibres have particularly marked effects in (a) controlling satiety, most probably through gastric residence time extension, (b) management of starch and triglyceride hydrolysis in the small intestine, and (c) influencing the nature of residual digesta that is available for the large intestinal microflora to ferment. In a number of cases, the behaviour of (charged) fruit and vegetable fibres is different from those of cereals (neutral), suggesting that charge effects may underlie differences in nutritional outcomes for cereal fibre compared with other fibres. The conventional sub-division of dietary fibre into soluble and insoluble types disguises the reality that the physical form of plant cell walls in digesta is typically intermediate between the extremes of dissolved polymers and non-swollen solid particles, which are often used to exemplify soluble and insoluble fibre fractions. An alternative method of categorising (cereal) dietary fibres is proposed based on a combination of particle/molecule size and effective density.

Valorization of mulberry leaves in bakery products
S. WANG (1), F. Zhu (2), M. Ranaudo (1), N. Knapp-Blezius (1)
(1) Canadian Food & Wine Institute, Niagara College, Niagara-on-the-Lake, ON, Canada; (2) University of Auckland, Auckland, New Zealand

Mulberry leaf has unique phyto-pharmacological and nutritional profile. Valorization of mulberry leaves was achieved in the formulation of three wheat flour bakery products (Cookies, bread and Chinese steamed breads). The influences of mulberry leaf addition (0.5, 2.5, 5, 10, 20 and 30%) on certain physicochemical properties (volumetric property, pH, color, water activity, moisture and texture) were product-type sensitive. Mulberry leaf additions (more than 2.5%) resulted in the lower staling rates (stored for 7 days) and the greater total phenolic contents of products than the control products. As to the sensory properties, cookies, bread and Chinese steamed bread with the maximum substitution of wheat flour with 5, 2.5 and 0.5% mulberry leaves, respectively, were...
acceptance. These findings could provide some insights for industrial research and development using mulberry leaf as an anti-stalling agent and a phenolic content enhancer for novel bakery products.

Considerations for sampling grains for mycotoxin analysis
G. A. MORANTES (1)
(1) Bühler, U.S.A., Minneapolis, MN, U.S.A.

The food and feed supply chain represents one of the significant risks for mold and mycotoxin contamination. The technologies that have been developed in response to this challenge since the 1960s when the first major effects of mycotoxin contamination upon human health were public news, and the lack of a single effective solution, continues to create opportunities for innovation in this area, considering the potential impact on both human and animal health. The sampling process is large variability associated with both farm (across and within fields), and grain variability within a plant, all the way down to individual ears, even before getting to the drying and conditioning process, creates a huge challenge when trying to understand the food safety risk involved across the different lots being marketed throughout the worldwide supply chains. Sampling plans are designed to help overcome the variability, in order to ensure availability of a representative sample of a specific lot for testing purposes. The inherent total variance of the sampling process, is so large, that care needs to be taken, to design and carry out a relevant sampling plan, that achieves a significant probability level of succeeding in identifying the risk. We will attempt to illustrate with real industry examples, what it takes to achieve this objective, while highlighting common pitfalls when implementing these sampling plans in commercial supply chains.

Development of best practices in this area, represents a challenge for both large and small companies, due to the complexity of the development and implementation of a good sampling plan, that minimizes the costs involved while helping minimize the risk of mycotoxin contamination. Global food safety regulations require both farmers and food and feed manufacturing industries to know whether or not their grains meet the food safety standards for human and animal food consumption, including molds and mycotoxins. This is especially important when grain supply chains are getting ready to harvest, around the globe.

Extrusion of banana starch: Impact of specific mechanical energy on starch molecular weight, functionality and digestibility
L. ROMAN (1), M. Gomez Pallares (1), O. H. Campanella (2), M. M. Martinez (3)
(1) University of Valladolid, Palencia, Spain; (2) The Ohio State University, Columbus, OH, U.S.A.; (3) University of Guelph, Guelph, ON, Canada

Retrogradation has been reported as one of the reasons for bread staling, although it is also known to result in a reduction of the rate and extension of starch digestion, depending on the main constituent involved. Amylose double helices conformation is known to be enzymatically resistant and yield resistant starch (RS), whereas retrograded amylopectin has been associated with the formation of slowly digestible starch (SDS) depending on its fine structure. Therefore, understanding of structure-function-digestion relationships of novel starches is crucial for successful emerging applications. One-fifth of harvested bananas are disposed of, usually improperly, and their pulp, is an abundant starch source. This work aims to optimize extrusion processing to obtain an extruded banana starch with tailored functionality and digestibility. The effect of 18 different extrusion conditions, varying in feed moisture content (22, 27 and 32%), screw speed (120, 200 and 280 rpm) and last barrel temperature (130 and 180°C), with specific mechanical energy (SME) ranging from 124 to 392 kJ/kg, on pasting properties, molecular size (HPSEC-RI) and molecular weight (HPSEC-MALS-RI) of amylopectin molecules present in banana starch were investigated. Furthermore, the treated starches propensity to form molecular interactions by retrogradation was determined by DSC and rheological methods as well as their slowly digestible structures, which were determined by in vitro tests. In all cases, extrusion resulted in full starch gelatinization/melting (as measured by DSC) and an increase of the cold-viscosity in RVA testing. Cold-viscosity of the extruded starch was highly depending on the initial extrusion feed moisture (decreasing with decreasing feed moisture content), while screw speed had a lower effect. As expected, molecular size (r = –0.90) and molecular weight (r = –0.88) of amylopectin molecules were negatively correlated with SME. Likewise, molecular size (r = –0.91) and molecular weight (r = –0.93) of amylopectin molecules were negatively correlated with the measured enthalpy (onset temperature from 39.1 to 42.1°C) of retrograded amylopectin. Extruded starch also displayed higher propensity to form inter-molecular interactions and a gel structure involving more amylopectin molecules than the native counterpart, as determined by viscoelastic tests. Despite the higher propensity to retrograde, gel development ability (G’ increase from day 1 to day 7) of banana extrudates decreased.

Furthermore, this study shows a molecular size reduction as a strategy to manufacture select starch ingredients that result in structurally-driven SDS. Although this work novel understanding on structure-function-digestion relationships, further studies are needed with the extrusion of raw materials with multiple ingredients.
Efficacy of patented peracetic acid-based sanitizer against shiga-toxin producing *Escherichia coli* (STEC) during wheat tempering and use of *Enterococcus faecium* ATCC 8459 as STEC surrogate

F. DAGHER (1), A. F. Sanchez-Maldonado (1), R. K. Hylton (1), C. G. Leon-Velarde (2), A. Hamidi (1)

(1) Agri-Neo Inc., Toronto, ON, Canada; (2) Agriculture and Food Laboratory, Laboratory Services Division, University of Guelph, Guelph, ON, Canada

**Introduction.** Wheat flour contamination with shiga-toxin producing *Escherichia coli* (STEC) in recent years has created a need for novel pathogen control intervention methods for wheat flour. Having an intervention step before milling, such as during the tempering of wheat, minimizes cross contamination of product and equipment during further processing. **Objectives.** Determine the efficacy of a patented peracetic acid (PAA) based sanitizer on STEC applied during the tempering of wheat. Identify a suitable surrogate for STEC for pilot plant studies. Investigate impact of the PAA based sanitizer on STEC surrogates during wheat tempering. **Methods.** For all experiments: Irradiated wheat was inoculated with 2% of TSB culture, followed by 24 h acclimatization in a biohood. Plate counts were done on TSA. **Pathogen challenge:** Samples (100 g, n = 3) were inoculated with a seven strain cocktail of STEC serotypes O157:H7, O26:H11, O103:H2, O111:NM, O121:H19, O145:NM and O45:H2. The 100 g samples were sprayed with 23 or 70 L/tonne (to mimic tempering) of water solutions with various concentrations of PAA sanitizer: 8.7% (A), 2.9% (B), 13% (C), 4.3% (D). *E. coli* was enumerated after 16 h. **Surrogate compatibility:** Wheat samples (100 g, n = 3) were inoculated with either the STEC cocktail, a cocktail of non-pathogenic *E. coli* (NPEC): ATCC BAA-1427, ATCC BAA-1428, ATCC BAA-1429, ATCC BAA-1430, ATCC BAA-1431, or *Enterococcus faecium* ATCC 8459. Samples were sprayed with solution D, and enumerated after 8 h. One-way ANOVA (alpha = 0.05) was used for the statistical analysis. **Surrogate challenge:** Samples of wheat (1 kg, n = 3) were inoculated with *E. faecium* ATCC 8459, sprayed with solution D (70 mL/kg), and enumerated after 8, 16, or 24 h. **Results.** After 16 h, solutions A, B, C and D reduced STEC counts by 2.96, 2.97, 2.61 and 3.38 log CFU/g, respectively. After 8 h, solution D reduced STEC, NPEC and *E. faecium* counts by 2.09, 1.96 and 2.49 log CFU/g, respectively, with no statistically significant difference (P = 0.05). Solution D reduced the STEC surrogate, *E. faecium* by 2.79, 3.95 and 4.23 log CFU/g after 8, 16, and 24 h, respectively. **Conclusions.** Solution D applied during the tempering of wheat was effective against *E. coli*, producing >3 log reduction with higher reduction achieved with longer tempering. Both the NPEC strain cocktail and *E. faecium* ATCC 8459 were suitable STEC surrogates for industrial-scale studies.

Sorghum and cowpea – Climate-smart African grains with important health-promoting properties

K. DUODU (1)

(1) University of Pretoria, Hatfield, Pretoria, South Africa

There is growing awareness about climate change and its potential effects on food security. Sorghum and cowpea are important grain crops indigenous to Africa and are known to be drought-tolerant. Given the fact that severe and extended periods of drought is one of the features of climate change, the drought tolerant nature of sorghum and cowpeas make them suitable candidates for classification as climate-smart. They are produced extensively in sub-Saharan Africa (e.g. Nigeria is the largest producer of sorghum and cowpeas in sub-Saharan Africa) where they are important food sources. They are also generating interest world-wide due to their nutritional value and sustainability. In much of sub-Saharan Africa, rapid urbanization accompanied by poor dietary choices are contributing to growing incidence of diet-related non-communicable diseases such as cancer, cardiovascular disease and diabetes. Sorghum and cowpeas are important sources of bioactive compounds which may contribute health-promoting properties. This paper will discuss the potential of these relatively underutilized sorghum and cowpea grains as strategically important food crops by highlighting their health-promoting properties. Specifically, our research has shown that sorghum and cowpeas are important sources of bioactive phenolic compounds—phenolic acids, flavonoid-type compounds and proanthocyanidins. Concerning flavonoids, sorghum tends to contain flavones while cowpea is a good source of flavonols. This creates opportunities for potential synergism in regard to their health-promoting properties when the two grains are combined in foods. Our research has also shown that extracts from sorghum and cowpea and their foods display various bioactive properties such as radical scavenging, inhibition of LDL oxidation and DNA damage, prevention of erythrocyte hemolysis, inhibition of starch-hydrolyzing enzymes and exertion of cellular antioxidant activity which points to their potential health-promoting properties. Taking these findings, the looming crisis of the adverse effect of climate change on food security and the growing epidemic of chronic non-communicable diseases into consideration, these underutilized grains could be expected to play a pivotal role in combating food insecurity in Africa and combating the scourge of diet-related non-communicable diseases.
Phil Williams Applied Research Award – Increasing industrial use of corn and evolving corn processing technology

V. SINGH (1)
(1) University of Illinois Urbana-Champaign, Urbana, IL, U.S.A.

Industrial biotechnology markets, which include biofuels, renewable chemicals and biopolymers, is projected to grow from $203 billion to $487 billion by 2024. Growth in industrial biotechnology is predominantly driven by one major unit operation and that is fermentation. Large amounts of renewable carbon in form of fermentable sugars are needed to drive the industrial biotech engine and enable plant-based biorefineries. The biorefinery concept has been broadly defined to represent an extensive portfolio of products analogous to that of oil refineries. Corn production is expected to grow with more bushels of corn produced per acre of land. There is no or little growth in traditional corn starch products such as high fructose corn syrup or ethanol. However, the potential for growth in new biopolymers, renewable chemicals, food products, rare sugars and other food ingredients from corn starch is staggering. For next few years, sugars from corn will be the most abundant carbon source available in the US to drive production of biobased industrial and food products. In this presentation the changing US corn processing technologies and growth in industrial biotech based on corn sugars will be discussed.

Changes of lipoxygenase activity and lipid oxidation during grain and flour storage

Y. JIN (1), R. Spitzley (1), Y. Liu (1)
(1) Kellogg Company, Battle Creek, MI, U.S.A.

The objectives of this study were to understand the changes in lipoxygenase activity during storage of processed grains and wheat flour, and its impact on development of oxidation indicators and rancidity. Lipoxygenase activity decreased by 57–67% after 60 days of storage at 5°C, 21°C and 35°C for a multigrain mixture. Similar trends were observed for other samples including white and whole grain wheat flour. Levels of lipid oxidation products such as free fatty acids, peroxide value, and hexanal, increased over the storage time with a strong correlation to temperature. It was demonstrated that the hexanal levels correlated very well to the scores of organoleptic evaluation (r² ranging from 0.62 to 0.88 for individual materials examined).

Macromolecular characteristics and fine structure of amylomaltase-treated cassava starch

S. BOONNA (1)
(1) School of Food Technology, Suranaree University of Technology, Nakhon Ratchasima, Thailand

Amylomaltase (AM, EC 2.4.1.25) has been used to modify the starch structure for producing thermoreversible starch gels and cycloamylose. With the diversity of the enzymatic reactions, the resulting products from the action of AM are various and heterogeneous. Fine structure of AM modified amylopectin is of interest for more understanding the action modes of AM on the alteration of starch structure. The modification of cassava starch using AM from *Thermus thermophilus* at the reaction times of 5 min to 24 h was investigated. Their structural properties were also analyzed to elucidate the effect of AM reaction time and starch constituents on the AM action modes. All AM-treated starches showed lower amylase content and lower wavelength at maximum absorption (λ_max) of the iodine complexes compared to their parental starch. Long chain proportions with DP 25-80 increased with reaction time up to 4 h and then slightly decreased at 24 h as determined by HPAEC-PAD. The macromolecular and fine structure of AM-treated starches for 5 min (AM5min) and 4 h (AM4h) were characterized more deeply by using HPSEC-MALLS and H¹ NMR combined with beta-amylolysis and MALDI-TOF-MS. Molar mass and dispersity of both AM-treated starches were lower than their parental starch but their beta-amylolysis were higher. The AM5min had longer external chains, higher β-amylolysis, and lower branching degree whereas the AM4h exhibited a larger and denser macromolecular core. A cyclo-structure with DP 8 was found in both AM-treated starches; however, AM4h contained cyclo-structures with various sizes (DP 8–32). This results demonstrate that AM treatment could be an alternative approach to modify the starch structure in order to generate starch with extended-chains and products with cyclo-structures by controlling reaction time and substrate constituents which affect the AM action modes.

Global animal agriculture (things you may not know but should)

K. B. KOCH (1)
(1) Northern Crops Institute, Fargo, ND, U.S.A.

Every day global economic progress delivers to increasing numbers of people the ability to change their dietary circumstances; transitioning from little choice beyond base necessities to options providing greater access to protein in the form of meat, milk and eggs. This dietary advancement is not voluntarily reversible and as demand for meat, milk and eggs grows so also does the demand for animal food to produce those items. Global production of meat (all classes) in 2017 was about 306 million metric tons (MMT), with 177 MMT in developing markets and 129 MMT in mature markets. Reported global production of animal food was 1,070 MMT; 66% for meat production, 13% for egg production, 11% for dairy and 10% other. If projections hold true by 2030 we will
Ancient whole grain gluten-free quinoa, high protein, vegetable flatbreads
T. S. KAHLON (1), R. J. Avena-Bustillos (1), M.-C. M. Chiu (1)
(1) Western Regional Research Center, USDA-ARS, Albany, CA, U.S.A.

The objective was to evaluate four kinds of ancient whole grain gluten-free quinoa, high protein vegetable health promoting flatbreads. The flatbreads were quinoa peanut meal kale (QPK), QPK-Onion, QPK-Garlic and QPK-Cilantro. Quinoa contains all the essential amino acids. Peanut meal was utilized to achieve 25% protein flatbreads and to add value to this low value farm byproduct. Fresh green leafy vegetable kale was used with health promoting potential as it binds bile acids. Onion, garlic and cilantro contain healthful phytonutrients. The level of fresh onion, garlic and cilantro were determined by consensus of the laboratory personnel. Flatbread dough was prepared using 50–67 ml water per 100 g as is ingredients. The ingredients were equal amounts of quinoa flour and peanut meal and 50% as much fresh kale. Onion, garlic and cilantro flatbreads contained 28%, 7% and 28% of the respective ingredients. 50 g flatbread dough was pressed between parchment paper in Sol Luna tortilla press to about 8-inch circle. Flatbreads were cooked in flatbread cooker for 2-minutes. Seventy-one in-house volunteers evaluated Color/Appearance of the all flatbreads to be similar. Odor/Aroma of QPK-Onion and QPK-Garlic flatbreads was similar and significantly (P ≤ 0.05) higher than QPK and QPK-Cilantro. texture/mouth feel of the QPK-Garlic flatbreads was judged significantly higher than QPK and QPK-Cilantro. taste/flavor and acceptance of QPK-Onion flatbread was significantly better than QPK and QPK-Cilantro. The acceptance of the flatbreads tested was QPK-Onion 92%, QPK-Garlic 89%, QPK 77% and QPK-Cilantro 73%. These flatbreads used only 3–4 ingredients and could be made in any house kitchen or commercial production. These high protein gluten-free vegetable flatbreads offer tasty and healthy choice to all and those sensitive to gluten.

Comparative analysis of high protein ingredients and their impact on quality of high protein bread
A. HOEHNEL (1), C. Axel (2), E. Zannini (2), E. K. Arendt (2)
(1) University College Cork, Cork City, Ireland; (2) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland

Corresponding to a growing world population combined with the increasing awareness of environmental sustainability, the global demand for high quality protein-rich (PR) food is substantial. The carbon footprint of products taken into consideration, there is a need to lower animal-based protein consumption and accelerate the transition to plant-based protein. In order to achieve this goal, research is needed to develop plant protein-rich products, which meet consumers’ nutritional and dietary requirements as well as sensory and quality expectations. Bread plays an important role in the human diet, which is why this study focuses on the introduction of plant-based high protein ingredients in simple wheat bread recipes in order to investigate their effects on dough properties and bread quality. Therefore, wheat flour was partly replaced by high protein ingredients (soy, carob, potato, pea, zein, lupin, chickpea, quinoa, amaranth, buckwheat, faba bean, lentil) to obtain products “high in protein” according to regulation (EC) No. 1924/2006, referring to at least 20% of the calories provided by proteins. A detailed compositional analysis was performed for all selected high protein ingredients and taken into account to calculate the amount of wheat flour, which had to be replaced. Due to high variations of protein contents amongst the raw materials, a replacement of either 50% (for protein rich flours, <40% protein) or 15% (for protein isolates, >50% protein) was required. Dough properties were evaluated by determination of a wide range of dough quality characteristics such as rheological parameters, pasting behaviour of starch and gluten network development using a high-shear method. In addition, bread quality attributes, for instance volume, texture, staling behaviour and crumb structure, were analysed. The results revealed striking differences regarding dough properties, bread quality and product appearance for the various formulations. Chickpea, quinoa, amaranth and lentil caused a severe decrease in loaf volume and increased crumb hardness. Whereas breads containing carob, pea, potato, zein and faba bean showed similar characteristics compared to the wheat bread control or even improved bread quality. However, for many of the PR ingredients an intense bitter or beany off flavour was observed, except formulations with carob, potato, lupin and faba bean resulting in breads with rather neutral tastes. In conclusion, significant differences were found in both dough and bread characteristics identifying carob, potato, lupin and faba bean as high protein ingredients with the potential and suitability to produce high quality plant protein-rich breads.
Wheat gluten protein showed higher inhibition on α-amylase activity than soy protein isolate using kinetic analysis

X. CHEN (1,2), Q. Huang (2), B. Zhang (2), X. He (2), J. ZHU (1), Y. Liu (1), S. Chen (1)
(1) Dongguan University of Technology, Dongguan, Guangdong, China; (2) South China University of Technology, Guangzhou, Guangdong, China

Both endogenous and exogenous proteins can affect the rate of starch digestibility using classical Englyst method, first-order kinetic analysis and the logarithm of the slope plots. However, there has been neither comparative study concerning the effects of botanical food protein on starch digestion, nor exploration of the underlying mechanism concerning about the inhibition of α-amylase activity. The objective of this study was to investigate the inhibitory activities of different botanical food protein represented by soy protein isolate (SPI) and wheat gluten protein (WGP) against porcine pancreatic α-amylase (PPA) by measuring their half inhibitory concentrations (IC50). The kinetics of inhibition by these proteins were investigated through Dixon, Cornish-Bowden, and Lineweaver-Burk plots. The results showed that both SPI and WGP were mixed-type inhibitors with both competitive and uncompetitive inhibitory characteristics. The competitive inhibition constants (Kic) of WGP and SPI were 4.975 and 38.197 mg/mL respectively, and the uncompetitive inhibition constants (Kiu) were 5.923 and 33.125 mg/mL respectively. Besides, the IC50 of WGP and SPI were 3.080 and 32.246 mg/mL respectively. For WGP, the lower Kc than the uncompetitive inhibition constant for the mixed-type inhibitors suggests that they bind more tightly with free PPA than with the PPA-starch complex. On the contrary, the SPI bind less tightly with free PPA than with the PPA-starch complex. In comparison with SPI, WGP showed stronger inhibitory effect on α-amylase. These results indicated that SPI and WGP delayed the digestion of starchy foods by inhibiting starch hydrolytic enzymes, which may have relevance in vivo during gastrointestinal digestion. It also have an important practical value for the development of protein-based functional foods in food industry.

A new enzyme solution bringing initial softness

E. AGACHE (1)
(1) Puratos NV, Groot Bijgaarden (Brussels), Belgium

Consumers worldwide are no longer satisfied with bread that remains soft during only a few days. Today’s consumers are looking for bread textures that meet their needs during the entire shelf life of the bread, i.e. from 5 days for fresh bread up to 90 days for packaged bread. Many solutions allow improving long term softness, whereas not that many solutions provide initial softness. Initial softness is defined as the extra softness gained during the first days up to 1 week shelf life. Other features obtained at the same moment in bread are a fine white crumb structure, no major volume effect and no off-odors when used with short fatty acids. It is not easy to obtain all this by an enzymatic solution. With the increasing trend towards clean label, a research project has been set up between Novozymes and Puratos with this goal as target. The new enzymatic solution provides initial softness (measured with a texture analyzer), a white crumb (measured with a colorimeter), and no major volume (measured with seeds displacement) variations. It can be used in all kinds of recipes, not causing off-flavours in combination with short chain fatty acids (measured with SPME-chromatography). An overview on different applications and analytics will be presented.

A microbiological survey of equipment and end-products of the wheat-milling operation

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

Microbial contaminants may enter the mill with incoming wheat kernels. Build-up of tempered grain/flour residues in the milling equipment may also serve as a source of contamination during milling. Therefore, the goal of this research was to assess the microbial load associated with (1) the equipment among the different milling operations and with (2) the wheat as it is processed from grain to packaged flour. A total of 160 contact surface samples were collected, in two sampling periods, from equipment used in a pilot-scale flour milling facility (24 mt/day wheat milled). Sampling points were distributed among equipment involved in cleaning, tempering, milling, and final-product handling. To obtain the contact surface samples, 100 cm² were swabbed on the surface of the equipment using a sterile sponge moistened with 10 ml of 0.1% sterile peptone solution. In addition, a total of 24 samples of different soft wheat milled products, from grain to flour, were collected. Samples were analyzed for aerobic plate counts (APC), coliform/E. coli, Enterobacteriaceae (Eb), and molds. The APC, coliform, Eb, and mold counts associated with the cleaning equipment were, on average, 4.8, 1.5, 2.6, and 4.3 log CFU/10 cm², respectively. E. coli was found in 2 instances on cleaning equipment at an average of 0.4 log CFU/10 cm². Coliform and Eb counts in the tempering equipment were, on average, 0.7 and 0.2 log CFU/10 cm² higher than those observed in the cleaning machines. Average aerobic counts were 0.8 log CFU/10 cm² higher in the surface of break rolls compared with reduction rolls. Residues on the inside walls of grinding equipment had considerably higher microbial counts than those observed on the roll surfaces. Flour storage bins showed noticeably higher APC and Eb counts (4.2 and 2.8 log CFU/10 cm²) than those obtained from the tempering bins.
Coliform and Eb counts in the flour streams were higher than the counts found in the incoming dirty wheat by an average of 1.5 and 0.5 log CFU/g, respectively. The microbial load in the flour streams and the milling equipment were very similar. Therefore, the final microbiological safety of wheat flour can be greatly influenced by the microbial load present on the surface of the equipment and by the broken kernels/flour residues harbored in the milling equipment if appropriate sanitary measures are not implemented in the mill.

A comparison of methods for assessing dough properties of CWRS wheat and their relationship to baking quality

B. X. FU (1), K. L. Pizzi (2), B. Dupuis (1), E. Sopiwnyk (2), S. Wagener (1)
(1) Canadian Grain Commission, Winnipeg, MB, Canada; (2) Canadian International Grains Institute, Winnipeg, MB, Canada

Strong yet extensible dough properties and high water absorption characterize flour milled from Canada western red spring (CWRS) wheat. These properties make it ideal for the production of high-volume pan bread. Depending on the country and quality consciousness of the market, different instruments/methods are used to characterize and specify gluten properties. The objectives of this study were to compare the methods commonly used around the world for gluten strength evaluation and to determine which are better in predicting baking quality and dough handling properties and which might be used interchangeably. Twenty-four CWRS varieties and advanced breeder lines with diverse gluten strength were milled with a Bühler laboratory mill to a constant extraction of 74%. The resulting flours were evaluated for dough properties by farinograph, extensograph, Glutopeak, alveograph, Mixolab, National pin mixer (mixograph), and Glutomatic gluten index (GI), and their baking quality were assessed using a lean no time test baking method. The parameters closely related (r > 0.70) to both loaf volume and loaf top ratio (objective indicator for dough handling properties) were extensograph Rmax and area, farinograph stability, mixograph mixing time and energy, alveograph W, Mixolab time C1 (development time), and Glutomatic GI using wholemeal. Rmax, pin mixer mixing time, W, time C1, GlutoPeak strength index and area, and wholemeal GI were all very effective in discriminating gluten strength. Water absorptions obtained by farinograph and Mixolab were strongly correlated (r = 0.93), and the maximum torque of GlutoPeak was highly correlated with both absorptions. It is generally believed that extensograph Rmax extensibility, and area correspond to P, L, and W of alveograph, respectively. Results generated from this study, however, showed little relationship (r = 0.18) between extensograph extensibility and alveograph length. Although extensograph area and alveograph W were strongly correlated (r = 0.93), Rmax had a much stronger relationship with W (r = 0.93) than with P (r = 0.57). Gluten+, a value generated from Mixolab Profiler software during dough mixing and heating, did not show a significant relationship with any parameters commonly used for assessing gluten properties. In addition, there was no relationship between Gluten+ and baking performance of the CWRS samples examined in this study. The Mixolab time C1, which correlates strongly with many parameters generated by other instruments, appears to be more useful than Gluten+ for assessing dough strength and predicting baking performance.

Factors determining the sensory quality of three japonica rice cultivars

J. BAO (1), Y. Xu (1), S. OUYANG (2), H. Sun (2)
(1) Zhejiang University, Hangzhou, China; (2) Academy of State Administration of Grain, Beijing, China

The sensory quality of cooked rice is important to determine the market price and consumer acceptance of the raw rice. In this study, the sensory qualities and physicochemical properties of three japonica rice cultivars (LD18, LD20 and LD30) harvested in two different environments (Hangzhou and Xiangshui) were compared. The comprehensive score of sensory quality of cooked rice was performed in the order of LD20>LD18>LD30, but varied dramatically in two different environments. All the three japonica rice grown at Xiangshui city in northeast China had better sensory quality than that grown at Hangzhou in eastern China. The physicochemical properties, starch pasting viscosities, gel texture, thermal properties and amino acids contents also differed significantly among cultivars and between environments. Correlation analyses suggested that the protein content and gel hardness were significantly correlated with the comprehensive score of the sensory quality (P < 0.05). In addition to the rice cultivars, this study highlights the importance of growing environments to the sensory quality of cooked rice, and improves our understanding of the factors determining the sensory quality of cooked rice.
The associations of whole grain and cereal fibre intake with measures of nutritional status related to cardiovascular disease
E. M. BARRETT (1), M. J. Batterham (1), S. Ray (2,3), E. J. Beck (1)
(1) University of Wollongong, Wollongong, Australia; (2) NNedPro Global Centre for Nutrition and Health, Cambridge, U.K.; (3) University of Cambridge, Cambridge, U.K.

Whole grain intake is inversely associated with cardiovascular disease and related risk factors in observational studies. Precise mechanisms behind these associations are not well established, although high cereal fibre content may be significant. There is difficulty separating the role of different components of the grain as much of the evidence for whole grain is not reflective of the currently accepted definition, but rather includes added bran as a source of whole grain. We aimed to examine how varying intakes of whole grain and cereal fibre, quantified systematically using published whole grain and cereal fibre databases based on the 2011-13 Australian Health Survey (AHS) food composition database and using currently accepted definitions, were separately associated to body mass index (BMI), waist circumference (WC) and blood pressure in a subset of adult participants of the 2011-13 AHS (n = 2963). Participants were categorised into quartiles of energy-adjusted whole grain and cereal fibre intake. The highest and lowest consumers were categorised into further groups, to allow comparison of consumers of high cereal fibre, with and without high whole grain intake (n = 955). Whole grain and cereal fibre intake were both inversely associated with BMI and WC. Compared to participants in the lowest quartile of whole grain intake (Q1), participants in the highest quartile (Q4) had lower BMI (Q1: 27.09 kg/m², Q4: 26.22 kg/m²; P for trend = 0.0142) and smaller WC (Q1: 92.33 cm, Q4: 90.30 cm; P for trend = 0.0082). Similar associations were seen for cereal fibre intake (BMI Q1: 27.26 kg/m², Q4: 26.38 kg/m²; P for trend = 0.01 and WC Q1: 92.38 cm, Q4: 90.63 cm; P for trend = 0.0398). Whole grain was inversely associated with diastolic blood pressure (P for trend = 0.0265), however the effect was attenuated after adjustment for BMI. Neither intake was associated with systolic blood pressure. No significant differences were found between secondary groups of high/low whole grain and cereal fibre intake, after adjustment for diet and lifestyle factors. The similar associations of whole grain and cereal fibre found for anthropometric measures suggest cereal fibre may play a role in this association. This study was unable to determine differences in measures between consumers of high cereal fibre from whole grain and non-whole grain sources. Additional research separating consumers of whole grain from consumers of bran products, or analysing different whole grains with varying compositions separately, may provide further insight into benefits of different grain components.

Exopolysaccharides from food-grade acetic acid bacteria are unique, but hardly applicable hydrocolloids in dough systems
F. JAKOB (1)
(1) TU Munich, Freising, Germany

Acetic acid bacteria (AAB) are traditionally used for the manufacture of foods such as vinegar. Moreover, AAB are the microbial source for the recovery of the exopolysaccharide (EPS) cellulose, while we could show that many AAB produce further, so far non characterized EPSs. Our objective was to identify the structure and biosynthesis of these new EPS-types and to check their function as water-soluble hydrocolloids in dough systems. In this way, we wanted to establish AAB as novel EPS-producing starter cultures for e.g. sourdough fermentations. For the identification of enzymes involved in EPS biosyntheses of selected AAB, we performed DNA, genome and/or protein sequencing. The structure of these EPSs was characterized in terms of sugar compositions and linkage types as well as of size distributions and particle shapes. Selected AAB were applied in aerobic sourdough fermentations to check their competitiveness and metabolite production in cereal systems. Baking experiments were finally performed to correlate the structure of EPSs produced by AAB with their effects in breads. We found that many AAB produce β-2,6-linked, β-(D)-fructose polymers (levans) from sucrose via secreted levansucrases. The molecular weight distributions of these levans vary in dependence of the selected strain, but can be controlled by adjusting the production conditions. Higher molecular weight levans are more effective in terms of increasing the specific volume and delaying the staling of wheat breads than lower molecular weight levans. These results were correlated with the possible microgel character of spherical high molecular weight fructans in aqueous solutions. Some AAB strains further produce unique heteropolysaccharides (HePS) from activated sugar nucleotides, whose biosynthesis and structure are related to those of the commercially used hydrocolloid xanthan (E 415). In contrast to in situ levan production by selected AAB in sourdoughs, production of HePS by AAB in liquid pre-doughs was not possible so far. This again currently limits the applicability of these unique HePS for the manufacture of clean label products. While we verified the positive functional effects of in situ produced levans and acids on the quality of (gluten-free) breads via control experiments, an optimal balance between acidification, sucrose consumption and qualitative levan production by AAB during sourdough fermentations still has to be reached. In conclusion we could show, that AAB are valuable EPS producing starter cultures, while the metabolism of AAB and the not allowed use of isolated EPS from AAB in breads still hinders their general implementation in cereal systems.
Bran characteristics desirable for making whole wheat pancakes and baking powder biscuits

F. Ma (1,2), Y. Lee (1,3), B. K. BAIK (4)

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

Bran particles present in whole wheat meal (WWM) are likely responsible for the inferior quality and sensory acceptance of whole wheat foods compared to refined flour foods, suggesting that bran characteristics should be considered when selecting wheat grain for the production of whole wheat foods. The first step for improving the quality of whole wheat pancakes and baking powder biscuits would be the identification of desirable bran characteristics and the use of wheat grain carrying those bran characteristics. We investigated the influence of bran characteristics on the quality attributes of whole wheat pancakes and baking powder biscuits. Brans of 17 soft red winter (SRW) wheat varieties obtained using a pilot scale mill were passed through an experimental mill with corrugated rolls twice to remove the remnant endosperm, ground using a sample mill fitted with a 0.5 mm screen, and analyzed for composition (including protein, starch, dietary fiber (DF), phytate, phenolics and arabinoxylans). The refined flours of two SRW wheat varieties were blended with 17 brans in the preparation of 34 WWMs. The protein content, soluble DF, insoluble DF, total DF, water retention capacity (WRC) and water extractable arabinoxylan (WEAX) of bran ranged from 14.3–19.1%, 2.6–5.1%, 38.8–46.5%, 43.5–50.3%, 2.02–2.45 g of water/g of bran and 0.69–1.35%, respectively. The diameter of whole wheat pancakes made from the blends of two wheat flours and 17 bran preparations ranged from 106.6 to 116.0 mm. Height and shape factor (SF, ratio of the highest height to the lowest height) of whole wheat biscuits ranged from 28.8 to 34.2 mm and 1.10 to 1.24, respectively. Bran protein content showed positive relationships with pancake diameter and biscuit height (P < 0.05) in both sets of 17 WWMs. WRC, WEAX and total DF contents of bran exhibited significant relationships with pancake diameter and biscuit SF (P < 0.05) in only one set of 17 WWMs. WWMs that produced pancakes of comparable diameter to those of the base flour (grouped based on their pancake diameter using cluster analysis) contained the brans of relatively high protein content. WWMs that produced biscuits with intermediate-to-high height and low-to-intermediate SF (grouped based on their biscuit height and SF using cluster analysis) contained the brans of high protein and soluble DF contents, and low arabinoxylan and insoluble DF contents. This information will help food manufacturers identify wheat grain with bran that is suitable for making desirable quality whole wheat pancakes and biscuits.

Radio-frequency cold plasma effects on protein aggregation kinetics and starch pasting profile of cereal flours

Y. ZHONG (1), S. Swerdlow (1), G. A. Annor (1)

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

Cold plasma (CP) technology has gained increased interest in the food industry as an emerging non-thermal processing technique. Due to its low temperature, CP has the potential to be used for altering desirable food properties without affecting thermally sensitive constituents. Understanding how CP affects protein aggregation and starch pasting characteristics of cereal flours is essential for their use in food applications. It is therefore hypothesized that radio-frequency cold plasma would not significantly affect the protein aggregation and starch pasting characteristic of cereal flour. This study investigated changes in the protein aggregation kinetics and starch pasting profiles of flour from hard red wheat (HRW), soft wheat (SW) and Intermediate wheatgrass (IWG) treated with cold plasma. CP treatment was done for 60 min at 25°C using a combination of carbon dioxide (flow rate: 25 sccm) and argon gas (flow rate:10 sccm). Moisture content, pasting profiles and protein aggregation kinetics were investigated. All plasma treated flours had significantly lower moisture content than the controls. IWG showed significantly higher breakdown after CP treatment. The setback in HRW significantly increased after CP treatment. CP treated samples reached peak maximum time (PMT) significantly later than the untreated samples on the gluten peak tester. HRW had its PMT at 172 s after CP treatment, while PMT was at 126 s before CP treatment. The maximum torque was higher in CP treated samples. The torque maximum for IWG before CP treatment was 24.5 BU, while it significantly increased to 32 BU after CP treatment. The aggregation energy of both IWG and SW also increased significantly after CP treatment. No aggregation was however observed in SW flour after CP treatment. The results revealed that CP treatment has significant effect on protein aggregation and pasting profile of wheat, and IWG flour.

Extending frozen dough shelf-life up to one year utilizing semi-dry yeast

T. Jondiko (1), A. Pena (1), M. Turkur (2), F. OZPINAR (2), T. Kanbur (2), E. Bezirci (2), T. Jondiko (1)

(1) Pak Group LLC, Pasadena, CA, U.S.A.; (2) Pak Group Biotechnology Center, Izmit, Turkey

The demand for consistent quality ingredients has been driven by cutting edge innovative advances in food ingredients and processing technology leading to the expansion of the frozen goods category all over the world. An evolving-robust distribution system and demand for clean label ingredients has enabled bakeries to access...
markets across the globe, as evidenced by an increase in baked products shipped into the USA from Europe; hence, the need for shelf-stable, freeze-thaw stable, and high-quality yeasts that can be used in frozen doughs and can last up to 12 months while still providing superior quality baked breads. The objective of the study was to understand the functional effectiveness of semi-dry yeast in frozen dough baking, in terms of process performance and shelf-stability, after 360 days of storage. The semi-dry yeast was derived from special Non-GMO yeast strains which have been expertly developed to have durable, reliable and consistent performance in frozen dough applications. Breads rolls used in this study were produced in commercial scale bakery using cream yeast (control) and semi-dry yeast; other ingredients included flour, sugar, and dextrose. The dough sticks were prepared, shaped and blast-frozen for storage. For each yeast type, five dough frozen sticks were thawed, proofed and baked over storage intervals (90, 110, 134, 150, 250 and 360 days) resulting in 5 × 2 × 6 experimental units. Proofing time was measured using a template. Bread roll volume, height, depth, shape ratio and specific volume were evaluated using laser topography (AACC Approved Method 10-14.01). The data was standardized and analyzed using SAS. Multivariate normal distribution of the data was determined (Shapiro-Wilk Pr = 0.3067). The first three principal components explained 78% of variance. Semi-dry yeast bread volume, height and specific volume were not significantly different compared to cream yeast (p < 0.05). Overall, the volume decreased steadily by 6% after 90 days for both cream-yeast and semi-dry yeast. Proofing times increase across the storage period for both yeasts. However, after 360 days in frozen storage, doughs baked with semi-dry yeast dough required significantly (p < 0.05) less time to reach the expected proofing height compared to cream yeast. Hence, semi-dry yeast can be used to effectively replace or improve the functionality of cream yeast in frozen dough bread. It also produces comparatively superior quality bread rolls over a 12-month period, providing a 50% increase of shelf-life compared to cream yeast in clean label frozen bread systems.

Gel structure formation of cereal beta-glucan and its potential role in physiological functionality

N. MÄKELÄ (1), N. H. Maina (1), P. Vikgren (1), Y. Chen (1), T. S. Sontag-Strohm (1)

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

The health effects of cereal (1→3)(1→4)-β-D-glucans (β-glucans) are often considered to be linked to their viscosity in the small intestine, and thus studies on gelation of β-glucan at physiological conditions are essential for understanding their health functionality. Gelation of β-glucan has been linked to the molecular weight and ratio of celloctriosyl and celloctaotraosyl units (DP3:DP4 ratio), but previous studies have been done with such high β-glucan concentrations that are not relevant for foods. Oxidation has been considered as a risk for the functionality, since oxidative degradation has been shown to cause loss of viscosity. This study aimed to investigate the gelation of oat and barley β-glucans at low concentrations (1.5% and 1%, respectively) and the effect of oxidation on gelation. The effect of dissolution temperature was studied with native and oxidatively degraded purified barley and oat β-glucans. The oxidation was induced with hydrogen peroxide or ascorbic acid using ferrous sulphate as a catalyst. Gel properties were measured with a rheometer using an oscillatory measurement. The optimal dissolution temperature for gelation of oat and barley β-glucans was shown to differ. At high temperature where proper dissolution occurred, neither of these β-glucans gelled. Barley β-glucan required higher dissolution temperature (57°C) for gelation than oat β-glucan and the gelation occurred only in a narrow dissolution temperature range. However, oat β-glucan gelled in a relatively wide dissolution temperature range (at temperatures from 35°C to 50°C) and the optimal temperature was interestingly near the physiological temperature. The gelation at low concentrations was suggested to require partial dissolution of β-glucan resulting in formation of nucleation sites for gelation. Gelation also occurred in the oxidised samples, although the gel strength was somewhat lower than in the native ones. In OBG dissolved at 37°C, the storage modulus measured at 1 Hz was 32 Pa in the native and 21 Pa in the oxidised sample. For BBG dissolved at 57°C, the respective values were 38 Pa and 4 Pa. A clear difference in the gelation behaviour of oat and barley β-glucans was observed. Oat β-glucan formed gel-like structures when dissolved at physiological temperature, which is a factor that possibly contributes to its physiological functionality. The viscosity loss due to the oxidative degradation of β-glucan during processing and storage may be a threat for the functionality, but these results indicate that gelation may overcome some of these negative effects of oxidative degradation.

Alternative proteins to face future needs: The insects contribution in cereal-based products

C. M. ROSELL (1), A. Martinez (1), D. Rodrigo (1)

(1) Institute of Agrochemistry and Food Technology (IATA-CSIC), Paterna, Valencia, Spain

Cereals and cereals based food have been considered as staple food in many parts of the world. However, the expected growing population for the next decades and the climate change are forcing the search of alternative sources of proteins. Animals and legumes have been commonly considered as proteins’ sources, but future challenges demand for disruptive innovations and insects represent a good alternative. Considering that insects have high food conversion rate, needing less feed and water and releasing less greenhouse gases than conventional livestock, they could contribute to global food security. Feed and producing less greenhouses gases and ammonia than conventional livestock. Edible insects have been part of the human diet in many parts of the world, but in others, they are not well accepted, and their inclusion in the human diet maybe required the design
Mechanical flour modification impacts the kneading of wheat dough
S. HACKENBERG (1), M. Jekle (1), T. Becker (1)
(1) Technical University of Munich, Freising, Germany

Mechanical flour modification has positive effects on the shelf life of wheat bread, but has also a negative influence on the specific bread volume. The reason for this has not been fully understood yet. This work clarifies the effect of mechanical wheat flour modification on the protein network formation during kneading and its influence on the rheological dough properties, such as biaxial dough expansion, as it occurs during fermentation. During this work, wheat flour (ground by a roller mill) with a mechanical starch modification (MSM) level of 4.78 g 100 g⁻¹ flour (standard) was mechanically modified by re-grinding in a ball-mill. The obtained MSM levels were 6.56, 7.46, 7.85 and 8.15 g 100 g⁻¹ flour, determined according to AACC 76-33 (starch damage). The optimum water addition (according to AACC 54.21) of the flours was 58, 63, 73, 78 and 83 g per 100 g flour with increasing MSM level. Dough was kneaded until dough development time (Peaktime), generally defined as the optimum kneading time, which complies with the maximum dough viscosity. At this point, the protein microstructure in dough was visualized with a confocal laser scanning microscope. The quantitative evaluation of the protein network structure was implemented using the protein network analysis (PNA). Biaxial dough expansion, as it occurs during fermentation, was measured with a texture profile analyser, whereas the maximum dough height (Hm) during fermentation was analyzed with a rheofermentometer. Hm is commonly highly correlated with the bread volume and thus it is a good attribute for describing the baking quality. The network attributes protein end-point rate and the lacunarity, obtained by PNA, were increased by 25% and 139%, whereas the protein-branching rate was reduced by 14% compared to the standard. This indicates that the protein network in the dough had a poor connectivity, characterized by network interruptions. These changes of the protein microstructure were strongly correlated with the dough rheological behavior. Statistical correlations have shown that a reduced extensibility and resistance to extension of dough produced with high MSM levels were the reason for low Hm during fermentation. From the findings can be concluded that with an improved development of protein microstructure reached by an adaption of the kneading time, the baking quality might be improved. Mechanically modified wheat flours could then be used to improve the shelf life of bread without a negative influence on the baking volume.

Evaluation of mechanical properties of gluten subjected to heat treatment
P. CHOMPOORAT (1,2), P. Rayas-Duarte (2), S. Mulvaney (3)
(1) Maejo University, Chiang Mai, Thailand; (2) Oklahoma State University, Stillwater, OK, U.S.A.; (3) Cornell University, Ithaca, NY, U.S.A.

During heating in fermentation and baking processes, the gluten network is altered leading to changes in viscoelastic properties which greatly influence the final loaf volume of bread. Understanding gluten structural changes of wheat in relation to viscoelastic properties or gluten functionality during early stages of heating in breadmaking (<90°C) could reveal differences not detected in analysis performed at room temperature. The objective of this study was to investigate the mechanical properties of wheat gluten at different temperature levels using shear stress. Six commercial hard red winter wheat flour samples varying in protein content were studied plus three references representing soft red winter, hard red spring and durum wheat flours. Viscoelastic properties of the isolated wet gluten (moisture content 35%) were measured using a creep and recovery test with different temperature settings 25, 35, 45, 55, and 65°C and a constant shear stress of 100 Pa. The experimental data was fitted into a Burgers model. Overall, two major transitions of gluten viscoelastic behavior were observed at 45°C and 65°C. At 45°C, an increase in creep compliance (flowability, maximum strain up to 36.8% from 25 to 45°C for hard red winter wheat gluten) and a decrease in recovery compliance (elasticity, recoverability up to 10.8% from 25 to 45°C for hard red winter wheat) were observed suggesting that gluten started to denature and became more deformable. At 65°C, the trend of flowability reversed when compared to the behavior at 45°C with a decrease of up to 22.3% of maximum strain from 45 to 65°C of gluten from hard red winter wheat, which suggested that aggregation of gluten polymers predominated at 65°C. The relationships between samples and

of new foods. Insects contain 35–61% proteins, which has prompted the inclusion of insects in food and feed owing their high biological value. Nevertheless, the use of edible insects as human food will require an intensive research from the safety to the technological point of view, as well as, the selection of the most convenient among the about 2,000 species. Insects have an elevated bacterial and fungal count, because of that preservation methods (thermal or non-thermal treatments) are required to ensure the safety of their intake. For instance, high hydrostatic pressure was effective against natural contaminating yeasts and molds of black soldier larvae, but a low reduction of total microbial load was achieved. In spite of their high protein content, composition is greatly dependent on the insect families and also their developmental stage (larvae or adult). A comparison of three different insects (Hermetia illucens, Acheta domestica and Tenebrio molitor) as protein source ingredients for bakery products will be presented, from the chemical composition of the flours to the bakery products quality, including rheological behavior. Results on their performance in bakery and product features will be presented, confirming the usefulness of insects’ flours as nutritional rich ingredient for bakery products.

Mechanical flour modification impacts the kneading of wheat dough
S. HACKENBERG (1), M. Jekle (1), T. Becker (1)
(1) Technical University of Munich, Freising, Germany

Mechanical flour modification has positive effects on the shelf life of wheat bread, but has also a negative influence on the specific bread volume. The reason for this has not been fully understood yet. This work clarifies the effect of mechanical wheat flour modification on the protein network formation during kneading and its influence on the rheological dough properties, such as biaxial dough expansion, as it occurs during fermentation. During this work, wheat flour (ground by a roller mill) with a mechanical starch modification (MSM) level of 4.78 g 100 g⁻¹ flour (standard) was mechanically modified by re-grinding in a ball-mill. The obtained MSM levels were 6.56, 7.46, 7.85 and 8.15 g 100 g⁻¹ flour, determined according to AACC 76-33 (starch damage). The optimum water addition (according to AACC 54.21) of the flours was 58, 63, 73, 78 and 83 g per 100 g flour with increasing MSM level. Dough was kneaded until dough development time (Peaktime), generally defined as the optimum kneading time, which complies with the maximum dough viscosity. At this point, the protein microstructure in dough was visualized with a confocal laser scanning microscope. The quantitative evaluation of the protein network structure was implemented using the protein network analysis (PNA). Biaxial dough expansion, as it occurs during fermentation, was measured with a texture profile analyser, whereas the maximum dough height (Hm) during fermentation was analyzed with a rheofermentometer. Hm is commonly highly correlated with the bread volume and thus it is a good attribute for describing the baking quality. The network attributes protein end-point rate and the lacunarity, obtained by PNA, were increased by 25% and 139%, whereas the protein-branching rate was reduced by 14% compared to the standard. This indicates that the protein network in the dough had a poor connectivity, characterized by network interruptions. These changes of the protein microstructure were strongly correlated with the dough rheological behavior. Statistical correlations have shown that a reduced extensibility and resistance to extension of dough produced with high MSM levels were the reason for low Hm during fermentation. From the findings can be concluded that with an improved development of protein microstructure reached by an adaption of the kneading time, the baking quality might be improved. Mechanically modified wheat flours could then be used to improve the shelf life of bread without a negative influence on the baking volume.

Evaluation of mechanical properties of gluten subjected to heat treatment
P. CHOMPOORAT (1,2), P. Rayas-Duarte (2), S. Mulvaney (3)
(1) Maejo University, Chiang Mai, Thailand; (2) Oklahoma State University, Stillwater, OK, U.S.A.; (3) Cornell University, Ithaca, NY, U.S.A.

During heating in fermentation and baking processes, the gluten network is altered leading to changes in viscoelastic properties which greatly influence the final loaf volume of bread. Understanding gluten structural changes of wheat in relation to viscoelastic properties or gluten functionality during early stages of heating in breadmaking (<90°C) could reveal differences not detected in analysis performed at room temperature. The objective of this study was to investigate the mechanical properties of wheat gluten at different temperature levels using shear stress. Six commercial hard red winter wheat flour samples varying in protein content were studied plus three references representing soft red winter, hard red spring and durum wheat flours. Viscoelastic properties of the isolated wet gluten (moisture content 35%) were measured using a creep and recovery test with different temperature settings 25, 35, 45, 55, and 65°C and a constant shear stress of 100 Pa. The experimental data was fitted into a Burgers model. Overall, two major transitions of gluten viscoelastic behavior were observed at 45°C and 65°C. At 45°C, an increase in creep compliance (flowability, maximum strain up to 36.8% from 25 to 45°C for hard red winter wheat gluten) and a decrease in recovery compliance (elasticity, recoverability up to 10.8% from 25 to 45°C for hard red winter wheat) were observed suggesting that gluten started to denature and became more deformable. At 65°C, the trend of flowability reversed when compared to the behavior at 45°C with a decrease of up to 22.3% of maximum strain from 45 to 65°C of gluten from hard red winter wheat, which suggested that aggregation of gluten polymers predominated at 65°C. The relationships between samples and
parameters were also tested using principal component analysis (PCA). This multivariate study showed that gluten from hard red winter wheat samples was easily separated into two groups according to their with strength/elasticity and deformation/flowability properties. In summary, our results proved that parameters from the mathematical modeling were useful to discriminate viscoelastic behavior of gluten subjected to heating.

Formation of gliadin-chitosan pH-induced complex coacervate: Relationship to encapsulation and controlled release properties
Y. YUAN (1)
(1) Guangzhou University, Guangzhou, China

This paper investigated the formation of complex coacervate between gliadin and chitosan as well as its relationship with the encapsulation and controlled release properties as a function of pH. Turbidimetric analysis, isothermal titration calorimetry (ITC), Fourier transform infrared spectroscopy (FT-IR), dynamic light scattering and scanning electron microscopy (SEM) were used to study the dynamic formation of gliadin-chitosan complex/coacervate particles (GCCPs). The results suggested that the soluble complexes were formed at pHs between 4.0 and 5.0 while coacervates were formed at pHs around 7.0, showing a mean particle size increased from 561.6 nm to 5358 nm. The spherical GCCPs with well-homogeneity were found at pH 4.5, while the aggregation of GCCPs were observed by SEM at pH 7.0. Particularly, gliadin-chitosan nanocomplexes was formed at pH 4.5 and showed smaller particle size (570.4 nm), lowest PDI (0.191), higher ζ-potential (+19.2 mV) and higher encapsulation efficiency (85.1%) of curcumin. The ζ-potential, ITC and FT-IR indicated that the interaction between the pH-induced GCCPs were mainly electrostatic dependent. ITC showed that the interaction was spontaneous exothermic at pH 4.5 (ΔH = –6.14 kcal/mol and ΔG = –3.56 kcal/mol). Controlled release profile in vitro indicated that gliadin-chitosan interaction decreased the released rate of curcumin in both peptic and tryptic digestion. In conclusion, the encapsulation and controlled released properties of GCCPs could be controlled by formation of protein/polysaccharide soluble complexes and coacervates via pH-induced. The study can be an available reference for the utilization of chitosan in cereal protein-based food.

The trend of “less” (sodium, sugar, and fat), and what it means for grain-based foods
L. DORNBLASER (1)
(1) Mintel International Group, Chicago, IL, U.S.A.

Those three villains—sodium, sugar, and fat—continue to come under fire across regions and across categories. Adoption of products reduced in sodium, sugar, and fat has been mixed, however. We will take a look at what’s happening in the marketplace and what consumers have to say about these products. Trends and activity across categories will be explored, with an emphasis on grain-based foods.

The impact of heating on the unfolding and polymerization process of frozen-stored gluten
P. WANG (1), Z. Gu (1)
(1) Nanjing Agricultural University, Nanjing, China

Gluten deterioration is the main factor for the degraded quality of frozen dough. Previous studies comprehensively elucidated the degradation mechanism of gluten during frozen storage, however, the subsequent polymerization process of frozen-stored gluten remains largely unelucidated. The current study comparatively investigated the effects of heating on the unfolding and polymerization process of fresh and frozen-stored gluten from molecular weight, subunit composition, non-covalent interactions, secondary structure, surface hydrophobicity and microstructure. The combined results of size-exclusion and reversed-phase high performance liquid chromatography showed that frozen storage degraded the polymerization of gluten during heating by weakening the polymerization ability of both gliadin and glutenin. Glutenin monomers were more sensitive, while the γ-gliadins were less sensitive to polymerize upon heating for frozen gluten. The sensitivities of glutenin polymers and the other gliadin subunits to the heating temperature were marginally affected by frozen storage. Frozen storage could impede the unfolding process at the initial heating stage for frozen gluten: fourier transform infrared spectroscopy analysis suggested that the ordered α-helices in frozen gluten were significantly higher than that of fresh gluten during heat treatment, and the surface hydrophobic groups tracked by the fluorospectrophotometer were more buried than fresh gluten. The scanning electron microscopy analysis suggested that the ruptured frozen gluten network was more sensitive to shrink during the initial heating at 50°C and further formed denser and thicker pore walls when the temperature exceeded 70°C. This study may consummate the deterioration theory of frozen gluten quality from both freezing and heating stages, and thus providing a more comprehensive theoretical basis and technical support for the effective preservation of frozen dough quality.
Detection of chalk in single kernels of long grain milled rice using imaging and visible/near infrared instruments

P. R. ARMSTRONG (1)

(1) USDA ARS, Stored Product and Engineering Research Unit, Manhattan, CO, U.S.A.

The competitiveness of U.S. long grain rice among U.S. and foreign customers can be enhanced by reducing grain chalk. An objective technique for detection of chalk in single seeds of milled rice will provide rice breeders and industry with a critical tool in developing low-chalk varieties or agronomic practices to reduce chalk occurrence. The objective of this research was to evaluate different methods to assess rice chalk. The performance of two commercially-available imaging instruments, WinSEEDLE (Regent Instruments Inc., Quebec, Canada) and S21, (TKD Tecnologia Ltda, Santa Cruz do Rio Pardo, Brazil) was compared with qualitative assessments conducted by the Grain Inspection, Packers & Stockyards Administration (GIPSA) – Federal Grain Inspection Service (FGIS) and 11 commercial mills. The WinSEEDLE was found to measure chalk levels with an overall mean 3.75% and a coefficient of variation of 0.23 compared to the S21 with a mean chalk level 25.24% and coefficient of variation of 0.34. The WinSEEDLE thus predicted chalk at much lower levels than the S21. An evaluation of two other instruments, a single kernel near-infrared (SKNIR) and silicon-based light-emitting diode (SiLED) high speed sorter developed by the United States Department of Agriculture, Manhattan Kansas were used to detect chalk in single seeds. Both showed potential for two-way classification of chalky and non-chalky kernels at varying levels of accuracy depending on chalkiness definition. The three classification definitions evaluated were (a) <50% chalky versus ≥50% non-chalky (GIPSA), (b) ≤10% chalky versus ≥10% non-chalky (USA-Rice) and (c) 100% chalky versus 100% non-chalky (LAB). GIPSA and USA-Rice definitions were based on U.S. industry rice chalk classifications while the LAB definition was created in-house. For the GIPSA chalk definition correct classification rates were 82.4% and 77.6% for the SKNIR and SiLED instruments, respectively. For the USA-Rice definition, rates were 82.5% and 78.0% correct classification for the SKNIR and SiLED respectively and the LAB definition yielded 93.3% and 95.0% correctly classified for the SKNIR and SiLED respectively. SKNIR classifications appear to be based on differences in starch, protein, and water content between chalky and non-chalky rice kernels. The SiLED sorter utilized pre-selected visible and near infrared wavelengths that also detected differences in starch, protein, and water content. Results showed that both SKNIR and SiLED instruments could correctly identify rice chalk. The causes of variability in chalk assessment by different methods, instrumentally or human grading, would be critical in developing repeatable and consistent grading methods.

Responding to change – An industry perspective

N. ANDERSON (1)

(1) PepsiCo, St. Paul, MN, U.S.A.

Change does not come easy. For change to occur, industries must be flexible and agile while still demonstrating strategic leadership and control. In doing so, industry can ensure that they are providing their customers with the highest quality products and experiences. All industries have to consider several factors that either “push or pull” where they choose to innovate and make changes. “Push” factors can come from new advances in technology or changes in the way products are regulated. Pull factors can also arise from altered regulations or new demand from changes in consumer awareness. Food industries have a dual challenge in that they need to identify strategies that provide food for a growing and ever-changing population while also addressing the escalating rates of diseases such as obesity and diabetes. These challenges drive innovations that deliver products that aim to keep people healthier for longer. Several companies have responded to supporting improved consumer health by mounting efforts that reduce nutritionally-challenging add-ins such as sugar, sodium, and trans fats and by reformulating products so that they contain fewer, less-processed ingredients. When products are reformulated, industry needs to ensure that quality is maintained and that properties such as taste and appearance are unaltered. Industries make these decisions in part because consistently delivering the same quality of product is highly valued as a competitive advantage. Often, the closest thing to stability is adequate preparation and how well industries make these types of decisions along with how they address new opportunities determine their success.

Enhancing functionality of pigmented waxy barley by roller milling and pearling

M. S. IZYDORCZYK (1), T. L. McMillan (2), A. Chepurna (2), J. Kletke (2), S. Bazin (2), A. Beattie (3), B. Rossnagel (4)

(1) Canadian Grain Commission, Grain Research Laboratory, Winnipeg, MB, Canada; (2) Canadian Grain Commission, Winnipeg, MB, Canada; (3) Crop Development Centre, University of Saskatchewan, Saskatoon, SK, Canada; (4) University of Saskatchewan, Saskatoon, SK, Canada

Grain pigmentation is considered an important agronomic trait because of its protective functions against biotic and abiotic stresses; however, relatively little is known about the composition or functional properties of pigmented barley. A hull-less, black pigmented barley line has been developed in Canada for human
consumption. The objectives of this study were to understand the nutritional and functional attributes of this new barley line and investigate how fractionation of grain by roller milling and pearling enhances its specific characteristics. The black barley line and the common tan-coloured barley (cv. CDC Rattan) were grown in three locations in western Canada in 2016. Compared to tan-coloured CDC Rattan, the pigmented line had distinguishable black-coloured, bigger and heavier kernels. On average, the concentrations of protein, ash, and dietary fibre in the black barley line were higher than in CDC Rattan. The concentration of β-glucans ranged from 7.1 to 7.2% in CDC Rattan and from 7.4 to 7.9% in black barley. The content of starch was similar in both genotypes; however, the starch gelatinization temperature and pasting properties differed significantly due to the absence of amylase in the black line. Barley was milled using a Bühler MLU 202 laboratory mill and a Bühler MLU 302 Impact Finisher into break flour, shorts and bran fractions. Yields were 48.0–50.3% for the flour fraction, 48.1–50.2% for shorts, and 1.6–2.0% for bran. The β-glucan and arabinoxylan contents of white flour were 1.8–2.0% and 1.0–1.1%, respectively. Shorts and bran fractions contained high concentrations of β-glucans (11.9–12.9% and 14.2–14.4%, respectively) and arabinoxylans (9.3–10.0% and 7.4–9.8%, respectively). For those fractions β-glucan extractability was relatively high (78% and 66%, respectively), whereas arabinoxylan extractability was low (14% and 12%, respectively). The shorts consisted of porous particles and exhibited high thickening properties. Barley was pearled, using a Satake pearler, in 5% (w/w) intervals to produce four pearling-by-products: PBP 0-5, PBP 5-10, PBP 10-15 and PBP 15-20 and the corresponding pearled grain. The concentrations of phenolic acids, catechins, yellow pigments, and tocopherols were highest in PBP-05 and PBP-10. The PBP of black barley had higher contents of β-β, γ-, and δ-tocopherols as a well as β-tocotrienols than CDC Rattan. The concentration of β-glucans increased with increasing degree of pearling, but the concentration of arabinoxylans and tocopherols decreased. The results of this study indicated that pigmented barley possesses some unique characteristics and that the nutritional value can be enhanced and controlled by conventional grain fractionation techniques.

Considerations for analytical methods to determine mycotoxins
F. BERTHILLER (1)
(1) Center for Analytical Chemistry, University of Natural Resources and Life Sciences, Austria, Tulln, Austria

The objective of the presentation is to provide an overview about the state-of-the-art in analytical methods to determine mycotoxins in cereals and grains. A variety of methods are available to stakeholder, which can be grouped into quick immunoanalytical methods, accurate chromatographic methods and emerging spectroscopic methods. These methods vary in their speed, reliability, accuracy, repeatability, detection capability, cost and ultimately applicability. The most important decision criteria for any analytical method, however, should be that the chosen method is fit for purpose. The presentation therefore gives an overview of how to handle cereal samples after proper sampling has been performed. Pros and cons of various extraction, sample preparation, measurement and data evaluation procedures will be given. Practical information how to rate the reliability of analytical results will be provided to the audience. The cereal food and feed industry remains vulnerable to weather conditions which favour the growth of fungi and the formation of mycotoxins. Proper usage of analytical methods is key to both the protection of consumers, to guarantee free trade and to avoid high costs due to rejection of lots or even recalls.

Effects of extrusion conditions on Fuji otebo bean powder intended for cookie production
C. CAPPA (1,2), L. Masseroni (1), E. E. Gailey (2), C. Alamprese (1), P. K. W. Ng (2)
(1) DeFENS, Università degli Studi di Milano, Milan, Italy; (2) Department of Food Science and Human Nutrition, Michigan State University, East Lansing, MI, U.S.A.

Nowadays, the consumption of pulses, the edible seeds of plants belonging to the legume family, is highly recommended. Pulses need to be cooked before consumption. Extrusion processes can provide new technological performances to pulse powders. The objective of this study was to explore the effects of different extrusion conditions on the physical and chemical properties of Fuji otebo bean powder intended for cookie production. To study simultaneously the main and interaction effects of feed moisture (20, 27.5, 35%), barrel temperature (70, 100, 130°C), and feed rate (2, 2.5, 3 kg/h), a 3-factor, 3-level Box Behnken experimental design was applied. According to the response surface methodology elaboration, a highly significant effect of feed moisture was observed for slowly digestible and resistant starch levels, with a minor influence of barrel temperature. As expected, feed moisture and barrel temperature each had effects on bean powder pasting properties, studied by a rapid visco analyzer (RVA), as well as on water and lactic acid retention capacities. Feed rate significantly affected only resistant starch of extruded powders. In comparison with raw bean powder, the extruded samples showed lower RVA-final viscosities (mean value of 609, versus 1,642 cP for the raw sample) indicating that partial gelatinization of starch occurred during extrusion and confirming the cooking effect of this technology. Extruded bean powder samples were then used in the production of gluten-free cookies by blending bean powder (raw or extruded) with corn starch (70:30). Depending on the extrusion conditions applied, different cookie spread ratio values were obtained (from 5.83 to 6.76), while a value of 6.20 was obtained for raw-bean-powder cookies. The texture parameters of cookies containing extruded powders were in the range of the values obtained for raw-
Similarly, cocoa extract containing 8–500 μM dose-dependently reduced IL-15 induced by p31-43 to the level of procyanidin-B2 dose-dependently reduced IFN-γ-induced IL-15 secretion to the level of IL-15 in control cells.

Dietary metabolites for application in CD management will be discussed.

activity of procyanidin-B2 against TG2 or IL-15. The potentials of procyanidin-B2 rich cocoa extracts and other dietary metabolites for application in CD management will be discussed.

Diets containing a high proportion of foods with low glycemic response are associated with reduced risks of metabolic syndrome diseases. However, white bread still remains the consumers’ first choice and its crumb is formed by starch highly susceptible to enzyme digestion due to its gelatinization during hydrothermal processing. Here, we present a successful strategy to slow down the digestion rate of the fully gelatinized starch present in gluten-free bread (usually with higher glycemic index than gluten-containing bread) by the manipulation of the starch molecular structure. Control bread was made from a basic composite of maize starch and rice flour (50:50). This study shows the effect of a 20% replacement of the basic composite by: 1) native banana starch (NB); 2) extruded banana starch (EB) and; 3) a 1:1 native to extruded banana starch composite (MB), in slowing down the starch digestibility of bread crumb and crust. Results showed a slowly digestible starch (SDS, determined in vitro as the digested portion between 20 and 120 min) increase in the fully gelatinized crumb (analyzed through DSC) from 1.09% (control) to 4.2% in NB crumb. DSC and HPSEC data attributed this occurrence to re-associations involving A and B1 chains of banana amylpectin, with an average length of 17.0 glucose units, upon storage, which resulted in structurally driven slowly digestible starch. During extrusion, the molecular weight of banana starch was reduced from 2.75 × 10^6 to 4.48 × 10^6 g/mol (HPSEC-MALS-RI) and, interestingly, the content of SDS increased up to 6.6, and 7.76% in MB and EB crumbs (fully gelatinized), respectively. Results also showed that a 20% replacement with native banana starch brought about the highest RS in the crust (5.66%). The hedonic sensory test showed no differences in overall liking between MB, EB and control, validating feasibility of a 20% replacement with extruded banana starch to attain a fivefold SDS increase in the crumb. This study shows, for the first time, that the propensity of amylpectin molecules to form structurally-driven SDS is further improved by a reduction of their molecular size by means of extrusion (a clean and cost-effective technology). Results of this work are also expected to contribute to the improvement of the sustainability of food systems and increasing local and global food availability. Banana pulp is an untapped food by-product and, in this work, we demonstrate its enormous nutritional potential with a successful application in a baked food.

Banana starch and molecular shear fragmentation: Perhaps the perfect precursors of structurally driven slowly digestible starch in fully gelatinized bread crumb

M. M. MARTINEZ (1), B. R. Hamaker (2), M. Gomez Pallares (3), L. Roman (3)
(1) University of Guelph, Guelph, ON, Canada; (2) Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A.; (3) University of Valladolid, Palencia, Spain

Diets containing a high proportion of foods with low glycemic response are associated with reduced risks of metabolic syndrome diseases. However, white bread still remains the consumers’ first choice and its crumb is formed by starch highly susceptible to enzyme digestion due to its gelatinization during hydrothermal processing. Here, we present a successful strategy to slow down the digestion rate of the fully gelatinized starch present in gluten-free bread (usually with higher glycemic index than gluten-containing bread) by the manipulation of the starch molecular structure. Control bread was made from a basic composite of maize starch and rice flour (50:50). This study shows the effect of a 20% replacement of the basic composite by: 1) native banana starch (NB); 2) extruded banana starch (EB) and; 3) a 1:1 native to extruded banana starch composite (MB), in slowing down the starch digestibility of bread crumb and crust. Results showed a slowly digestible starch (SDS, determined in vitro as the digested portion between 20 and 120 min) increase in the fully gelatinized crumb (analyzed through DSC) from 1.09% (control) to 4.2% in NB crumb. DSC and HPSEC data attributed this occurrence to re-associations involving A and B1 chains of banana amylpectin, with an average length of 17.0 glucose units, upon storage, which resulted in structurally driven slowly digestible starch. During extrusion, the molecular weight of banana starch was reduced from 2.75 × 10^6 to 4.48 × 10^6 g/mol (HPSEC-MALS-RI) and, interestingly, the content of SDS increased up to 6.6, and 7.76% in MB and EB crumbs (fully gelatinized), respectively. Results also showed that a 20% replacement with native banana starch brought about the highest RS in the crust (5.66%). The hedonic sensory test showed no differences in overall liking between MB, EB and control, validating feasibility of a 20% replacement with extruded banana starch to attain a fivefold SDS increase in the crumb. This study shows, for the first time, that the propensity of amylpectin molecules to form structurally-driven SDS is further improved by a reduction of their molecular size by means of extrusion (a clean and cost-effective technology). Results of this work are also expected to contribute to the improvement of the sustainability of food systems and increasing local and global food availability. Banana pulp is an untapped food by-product and, in this work, we demonstrate its enormous nutritional potential with a successful application in a baked food.

Procyanidin-B2 rich cocoa extract inhibits inflammation in Caco-2 cell model of in vitro celiac disease by down-regulating interferon-gamma- or gliadin peptide 31-43-induced transglutaminase-2 and interleukin-15

M. YEBOAH-AWUDZI (1), N. Magazine (1), R. Moreno (1), B. Magazine (1), J. N. Losso (1), K. Kramer (1)
(1) Louisiana State University, Baton Rouge, LA, U.S.A.

Celiac disease (CD) is an immune-mediated systemic disease triggered by the absorption of incompletely digested gliadin-derived glutenamine-rich peptides in the small intestine of susceptible individuals. Transglutaminase 2 (TG2) and interleukin-15 (IL-15) are highly expressed in the small intestinal mucosa in active CD. The objective of this research was to investigate the efficacy of procyanidin B-2 rich cocoa extracts on interferon-gamma (IFN-γ) or gliadin peptide p31-43-induced transglutaminase-2 and interleukin-15 (IL-15) in Caco-2 cell model of in vitro celiac disease. Cysteamine was used as a positive control inhibitor of TG2. The cocoa powder was characterized using ultra high-performance liquid chromatography (UHPLC). Western blot analysis was performed for TG2 and cyclooxygenase-2 COX-2 levels. Enzyme linked immunosorbent assay (ELISA) was used to determine the levels of inflammatory cytokines. One-way analysis of variance (ANOVA) followed with Tukey’s test for multiple comparison were done. Procyanidin-B2-rich extract reduced IFN-γ-induced TG2 activity by up to 77% and p31-43-induced TG2 by 45%. Cocoa extract containing 8–500 μM of procyanidin-B2 dose-dependently reduced IFN-γ-induced IL-15 secretion to the level of IL-15 in control cells. Similarly, cocoa extract containing 8–500 μM dose-dependently reduced IL-15 induced by p31-43 to the level of control. Procyanidin-B2-rich cocoa extract reduced the activities of other inflammatory biomarkers including COX-2, IL-1β, IL-6, and IL-8 in both IFN-γ and p31-43-treated Caco-2 cells. Caffeine or theobromine, at the concentration found in the cocoa extract, did not significantly contribute any synergistic effect on the inhibitory activity of procyanidin-B2 against TG2 or IL-15. The potentials of procyanidin-B2 rich cocoa extracts and other dietary metabolites for application in CD management will be discussed.
Cereal foods provide us with a major source of dietary carbohydrate and protein, and contribute thus to the energy intake. The grains also are a diverse and abundant source of dietary fibre and phytochemicals. Whole grain and bran-rich foods contribute significantly to the intake of dietary fibre and different secondary metabolites. In the past 20 years the knowledge of their role in health maintenance has expanded remarkably: amounts and types in grain raw materials, process-induced changes, human metabolism and effects on health-relevant biomarkers. What further should be investigated to better build on the large health-promoting potential of grains? Dietary fibre is the food of human gut microbiota, which has also been attributed as the “second brain”. Phytochemical bioconversions also take place in the colon by intestinal bacteria, providing a metabolome that reveals a lot about the diet quality and influences many reactions in human cells. Interactions of grain fibre complex with gut microbiota may be one mediator in the protective role of high fibre cereal foods against type 2 diabetes. Signalling between gut microbiota actions and brain is an emerging field of research. Instead of only studying the gut microbiota composition, the research questions are now in the functions. Cereal food fibre induced changes in gut microbiota activity and links to long and short term physiological and psychological outcomes in different subject groups should be more investigated. What does this mean for cereal food manufacture? Firstly there should be more motivation than ever to use the inherent grain fibre and associated compounds in an array of cereal foods. Secondly, more emphasis should be put to knowledge and design of structure and flavour of high-fibre cereal ingredients and foods to make them appealing to consumers. And last but not least, cross-disciplinary attempts should be started to develop cereal food nutrition services offering cereal foods as part of personalized diet, and means to monitor personal responses to the quality of cereal food consumed.

Hard wheat flour properties affecting batter consistency

Y. JIN (1), Y. Liu (1), P. Alvarez (1), S. R. Baker (2), J. Sun (2)
(1) Kellogg Company, Battle Creek, MI, U.S.A.; (2) Ardent Mills, Denver, CO, U.S.A.

While HRW flour has been used in many baked products, it also found applications in batter for waffle production. The objective of this study was to understand the impact of flour physicochemical properties on batter consistency and flowability. Twenty commercial hard red winter wheat samples of known varieties were collected from five sourcing states. In addition to moisture, protein and ash analyses, arabinoxylan, ferulic acid, damaged starch, solvent retention capacity (SRC) and batter consistency by Bostwick were performed on the lab milled flour samples. Rapid visco analyzer was also used for viscosity evaluation of flour in suspension of water (as part of the oxidative gelation testing). It was found that SRC can be applied to the hard wheat flour for evaluation of water absorption capacity. The combination of SRC-sucrose and SRC-sodium carbonate inversely correlated to batter flowability ($r^2 = 0.80$). Arabinoxylan (total or water extractable) and ferulic acid were found not to be directly correlated to batter consistency. Oxidative gelation capacity demonstrated a slightly negative correlation with the batter consistency.

Exploiting neglected and underutilised wheat varieties and species

H. GRAUSGRUBER (1)
(1) University of Natural Resources and Life Sciences, Vienna, Tulln an der Donau, Austria

More than 25 natural and artificial Triticum species were described by wheat taxonomists, but only two species, i.e. hexaploid common wheat (T. aestivum) and tetraploid durum wheat (T. durum), are grown commercially to a large extent, at which common wheat accounts for about 90% of the global wheat production. Small amounts of various ancient and heritage wheat species are grown either because of a renewed interest by processors and consumers, e.g. Khorasan wheat (T. turgidum), einkorn (T. monococcum), emmer (T. dicoccum) or spelt (T. spelta), or as a relic of traditional cultivation in marginal areas, e.g. Zanduri wheat (T. timopheevi), Georgian emmer and spelt (T. paleocolchicum, T. macha), club (T. compactum) or shot wheat (T. sphaerococcum). Neglected wheat varieties and species, and genetic stocks developed during the height of wheat cytogenetics in the 20th century, pose today an important genetic reservoir, which can be exploited manifold in wheat breeding, either with respect to agronomic traits or end-use quality. For example, genes for grain colour (B, blue aleurone; Pp, purple pericarp) and endosperm colour (Psy, phytoene synthase) can be stacked to develop wheat with a specific functional flour quality and high antioxidant activity. Grain size and shape are important attributes that influence milling performance. Khorasan, Polish and shot wheat represent extreme phenotypes in this regard which can be exploited per se for specific whole grain products and/or be used to develop new genotypes by stacking their genetics. The diversity in grain characteristics can be additionally increased by including different phenotypes of grain hardness. To maintain yield and quality in the light of global warming might make it necessary to exploit more neglected wheat species in breeding programmes. Zanduri wheat, for example, was already exploited for disease resistance genes. The pronounced leaf and stem hairiness, however, is assumed to be
Effects of type of starch and fatty acid on complexation and thermal properties of rice starch-fatty acid complex
J. H. LIN (1), Y. H. Chang (2), C. L. Lin (2), C. L. Pan (2)
(1) MingDao University, Changhua, Taiwan; (2) Providence University, Taichung, Taiwan

Starch-lipid complex has been classified as type-V resistant starch. Physicochemical properties of the complex were dependent on type of starch, structure of fatty acid, preparation condition, etc. As yet research on how to adjust the properties of starch-fatty acid complex (SFA) and further widen its application in the food sector is still evolving. In this study, rice starches with different amylose content from varieties of TKW1 (waxy rice), TNu67 (Japonica rice) and TCS17 (Indica rice) were gelatinized and complexed with fatty acids (myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid) at different concentrations (0.03–0.09 mmole/g starch). The obtained SFA was then characterized for its complex index (CI) by iodine spectrophotometry and its thermal properties by calorimetry to investigate the interaction of starch molecules with different types of fatty acids during the SFA formation. Results indicated the CI of SFA was undetectable for TKW1 starch, but were in the range of 45.3–88.0% and 26.7–77.2% for TNu67 and TCS17 starches, respectively. Moreover, with the same type and concentration of fatty acid, the SFA of TNu67 showed a higher CI than that of TCS17, which was particularly evident when the concentration of fatty acid was in the range of 0.03–0.06 mmole/g starch. Calorimetric results showed the enthalpy changes (ΔH) of SFA with the same type of fatty acid increased with the concentration of fatty acid. At the same concentration, it is interesting to observe that the ΔH of SFA was noticeably lower for TNu67 than for TCS17. In connection with the effect of the saturation degree of fatty acid, the onset and conclusion temperatures of SFA prepared by complexing starch with saturated fatty acids were slightly higher than those of unsaturated fatty acids. The findings of this study reinforce the viewpoint which the capability of rice starch to complex with fatty acid is governed predominantly by the existence of amylose. Moreover, for amylose-containing starches, low amylose content may enhance the swelling and consequently the lipid adsorption of the granules as shown by the increased CI. Meanwhile, the low amylose content could also lead to the granules forming less calorimetrically detectable amylose-lipid complexes. Besides, the results of this study could serve as a reference for the use of starches from different origins, especially for those with different amylose content, to complex with lipids in order to tailor the digestibility of starch.

Nutrigenomics implications in rice for translated health benefits of consumers to tackle the double burden of global challenges
N. SREENIVASULU (1)
(1) International Rice Research Institute, Los Banos, Philippines

Diabetes and related non-communicable diseases are becoming epidemic in urban regions of Asia, while children and women face undernutrition challenges in the rural community. Assessing the nutritional profiles of modern varieties of rice did not show enough genetic variability for low glycemic index (GI) and enriched micronutrients. Hence we have employed various phenotyping methods such as slower digestibility techniques and all 12 macro and micronutrient profiling techniques from the gene bank diverse lines. The core panel has been subjected to resequencing and accounted SNP and indel variation has been explored to mine novel alleles for the nutritional traits. These opportunities provide novel opportunities for diet based intervention to counter the growing problems. However, screening for low glycemic index (GI) in rice breeding programs is not possible due to time and cost constraints. In this presentation I will be providing overview about the novel methods such as the feasibility of using in vitro cooked grain amyolysis, starch mobilization patterns during seed germination, and variation in starch structure and composition in the mature seed to differentiate patterns of starch digestibility. Mobilization patterns of total starch, resistant starch, amylose and amylopectin chains, and free sugars during seed germination revealed that the process is analogous to digestion in the human gastrointestinal tract. The combination of these biochemical markers can be used as an alternative measure to predict GI. Studying contrasting low GI lines with transcriptome analysis of stored mRNA transcripts detected differences in starch metabolism and confirmed the importance of seed storage pathways in influencing digestibility. Pathway analyses supported by metabolomics data revealed that resistant starch, cell wall non-starch polysaccharides and flavonoids potentially contribute to slower digestibility. These new insights can guide precision breeding programs to produce low GI rice with acceptable cooking quality to help mitigate the burden of diet-associated lifestyle diseases.
Sourdough as a tool for sugar reduction in burger buns
A. W. SAHIN (1), C. Axel (1), T. Rice (2), E. Zannini (1), E. K. Arendt (1,3)
(1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland; (2) Cork Institute of Technology, Biological Sciences Department, Cork, Ireland; (3) APC Microbiome Institute, Cork, Ireland

The consumption of added sugar in Europe reached in average 50 g per head per day. This represents double the amount of sugar intake advised by the WHO. According to a marketing study, burger buns are a source of added sugar containing up to 8 g per unit. The reduction of added sugar, while maintaining its function, is challenging and demands the incorporation of other functional ingredients and sweetening agents. In this study lactic acid bacteria were isolated from sourdough and screened for their ability to produce mannitol. Since Leuconostoc citreum TR116 produced high amounts of mannitol in-vitro, it was applied in wheat sourdough and its growth behaviour was monitored over 48 h. Leuconostoc citreum TR116 was able to dominate the sourdough system and to produce 9% mannitol after 30 h of fermentation. TR116 sourdough was incorporated in a sugar reduced burger bun system and its effect on the dough properties and burger bun characteristics was investigated. Compared to the sugar reduced control, sourdough increased the viscous part in the dough and delayed, as well as weakened, the gluten network development (+96 s; –15 BU). Furthermore, a decrease in peak viscosity (−188 cP) and breakdown (−70 cP) during starch gelatinization reflected the weakening effect of sourdough on the burger bun system. Regarding burger bun characteristics, sourdough decreased the specific volume and increased crumb hardness (+3.5 N). Interestingly, the addition of sourdough contributed to browning reaction and prolonged microbial shelf life (+2.5 days). No significant difference in product quality was observed between the full-sugar control and the low-sugar TR116 sourdough burger buns. Thus, the application of sourdough fermented by Leuconostoc citreum TR116 has high potential to ensure the quality in sugar reduced bakery products and can be considered as a novel natural approach in sugar reduction.

Production of whole wheat flour treated with enzymes to improve flavor and texture
L. C. HAYNES (1), B. Zhao (1)
(1) Mondelez International Inc., East Hanover, NJ, U.S.A.

A systemic analysis of individual-level nutrition intake and national food balance data found only a small percentage of the global population was meeting the recommended daily consumption of whole grains (≥2.5 (50 g) servings/day) (Micha, 2015). Adolescents, in particular, had low consumption rates which could be improved by greater sensory appeal and choice of whole grain products (Kumar, 2016). This study identified technology to improve the texture and flavor of bran and germ, during the production of whole wheat flour by treating either the whole kernel, or the bran/germ, with pentosanase enzymes. Four enzyme treatments, including heat-tolerant xylanases, were investigated. The extent of enzyme hydrolysis of soluble pentosan in the wheat was confirmed by increased sugars and decreased arabinoxylan (AX) ratio of remaining extractable xylans in whole wheat flour. Enzymes applied through tempering, at 10 units to 30 units per g wheat, remained active in stored flour, and activity was primarily located in the bran fraction. Enzyme treatment was found to reduce solvent retention capacity (SCR) of whole grain flour and increase cookie spread by AACC Approved Method 10-53. High temperature treatment conditions for separated bran, from 70°C up to 93°C for 10 min, were explored to understand enzyme tolerance to heat/moisture conditions and the potential to be applied to a bran “stabilization” process. Sensory scores, for biscuits made with treated whole wheat flour, had improved flavor and texture. We hypothesized the enzyme treatment resulted in partial hydrolysis of pentosans to decrease SRC of whole wheat flour, increase cookie spread and produce oligosaccharides and sugars which, through Maillard reaction during baking, contributed to improved caramelized and baked flavor/aromas in whole grain biscuits. Sensory data from descriptive panel, analyzed with Senpaq (v. 5.0) found improvements: color, nutty, buttery, caramelized flavor and less gritty texture which were significant at p ≤ 0.05. We conclude xylanase/pentosanase treatment of either whole grain kernel, or bran/germ, for use in whole wheat flour, improves flavor and texture of whole grain biscuit products.

Optimization of millet and buckwheat sourdough-breads added with arabinoxylans
D. BENDER (1), E. Zand (1), S. D’Amico (1), R. Nemeth (2), S. Tomoskozi (2), R. Schoenlechner (1)
(1) University of Natural Resources and Life Sciences, Vienna, Austria; (2) Budapest University of Technology & Economics, Budapest, Hungary

Arabinoxylans (AXs) are the most important thickening agents and the key structural components in rye bread-making. Their outstanding chemical and structural properties allow them to crosslink into a stable hemicellulose network under oxidizing conditions. Thus, rye AXs could be very promising for application as baking improvers in gluten-free (GF) bread. The aim of this investigation was to determine the effect of rye AXs in batter rheology and bread properties of two different GF breads (i.e. buckwheat and millet sourdough-breads). Different concentrations of AX (0–6%) were tested in each bread formulation and combined with the oxidizing enzyme pyranose 2-oxidase (POx; 0–2 nkat/g flour) to further promote AX crosslinking. Results showed that AXs and POx significantly influenced the rheological properties of the GF batters. Highest viscoelastic properties were
achieved when POx was added to the batter alone. The functional bread properties were mainly influenced by type of flour and the concentration of AX and POx used. Overall, best results in buckwheat breads were shown when AXs and POx were added in combination, while millet showed better results when the AXs were added alone. Compared to the control, specific volume and firmness could be improved the most at a concentration of 3% AX and 1 nkat POx/g flour, increasing from 1.80 ± 0.18 to 1.93 ± 0.09 cm³/g and from 9.61 ± 1.78 to 4.69 ± 1.49 N, respectively. In contrast, addition of 1% AX in the millet formulation displayed the highest specific volume (1.86 ± 0.07 cm³/g) and softest crumb firmness (8.53 ± 1.06 N). These outcomes indicate that AXs could be applied as natural structure-forming agents to improve GF bread quality.

How bright is NOVA? Does how we classify fibres, cereals and foods change the way we eat?
E. J. BECK (1)
(1) University of Wollongong, Wollongong, Australia

Nutrition sits in a nexus between science and art because unlike traditional medical science, a food or ingredient is never taken in isolation and when consumed, may displace another item in the diet of an individual. Therefore there is always a nuance not easily replicated in a scientifically controlled setting. Nonetheless, as scientists we often work on ingredients or single foods. Sometimes this is driven by industry who will supply funding to test if their ingredient or food will “make a difference” to a marker of disease or a health outcome. Even when we collect large population data we examine intake of each food group and sometimes each food in its minuitae, hoping to find the elusive magic bullet. Over the last two decades, health researchers have tried to move away from such a reductionist approach and move towards a whole of diet description of how we should eat to maximise our quality and quantity of life. Furthermore, systems such as the NOVA classification system (especially descriptions of processed and ultraprocessed foods) attempt to categorise foods into those we should eat, and those better left alone; to further describe how dietary patterns influence health. The reason food classification or food modelling is important is because we wish to develop health messages that might best encourage populations to choose wisely, given the increasing personal and fiscal burden of chronic disease. Significant evidence exists to demonstrate that intake of whole grain cereals (for example), is associated with improved markers of cardiovascular disease. However, similar evidence exists for bran alone and for cereal fibre generally. It might be argued that whole grain breads and high fibre cereals such as brans, encouraged in dietary guidelines of the vast majority of countries, are healthful based on scientific literature, yet some classification systems (e.g. NOVA) would say they are less than ideal based on added ingredients (often added to improve shelf life and therefore the food security of millions of people). This presentation will consider the complexities of how we categorise food and whether this sends the ideal message to the public and even to health educators. A translational approach to cereal science will be discussed and how we cannot consider any part of the food system in isolation—from farm to table and in medicine, from bench to bedside—if we are to maximise health benefits and ensure nutrition communication continues to evolve.

Physicochemical properties changes of soy protein isolate induced by sodium sulfite
X. Su (1), B. Zhang (1), Y. Gong (1), M. Dai (1), F. Li (1), Y. WEI (1)
(1) Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences, Beijing, China

Disulfide bonds were regarded as one of the main interactions for maintaining the structure of protein products, like extruded proteins. Disruption of the disulfide bonds could change the protein aggregation and affect the physicochemical properties of extruded proteins. Soy protein is one of widely used vegetable proteins in food industry and has potential application in gluten-free products. Soy protein isolate (SPI) was used as raw material in this study, and 0.0, 1.5 and 3.0% (w/w) sodium sulfite was added to break disulfide bonds of the protein. The specific mechanical energy (SME) during SPI extrusion, physicochemical properties including thermal decomposition temperature, water absorption capacity (WAC), oil absorption capacity (OAC), free sulfhydryl content, the protein solubility, tryptophan (Trp) residue fluorescence and surface hydrophobicity were measured. The free sulfhydryl content increased significantly from 98.46 to 449.64 μmol·g⁻¹ when the sodium sulfite content, the protein solubility, tryptophan (Trp) residue fluorescence and surface hydrophobicity were measured. In contrast, addition of 1% AX in the millet formulation displayed the highest specific volume (1.86 ± 0.07 cm³/g) and softest crumb firmness (8.53 ± 1.06 N). These outcomes indicate that AXs could be applied as natural structure-forming agents to improve GF bread quality.
Grain-derived arabinoxylans are efficiently hydrolyzed by two esterases and cognate xylanases from human gut bacterium Bacteroides intestinalis

D. WEFERS (1,2), J. J. V. Cavalcante (2), R. Schendel (1), K. Wang (2), R. I. Mackie (2), I. Cann (2)
(1) Karlsruhe Institute of Technology, Karlsruhe, Germany; (2) University of Illinois at Urbana-Champaign, Urbana, IL, U.S.A.

Consumption of whole grains or whole grain products contributes to an increased intake of dietary fiber. This is usually associated with positive health effects which are in part attributed to the microbial fermentation of dietary fiber by microorganisms in the large intestine. The fermentation extent is determined by the structural composition of the polysaccharides as well as the enzymes secreted by the bacteria. In most cereal grains, cellulose and arabinoxylans are the major dietary fiber polysaccharides. Microbial fermentation of arabinoxylans is realized by several carbohydrate-degrading enzymes which cleave the xylan backbone (xylanases, xylosidases) and the arabinose side chains (arabinoxylansidases). However, most grain-derived arabinoxylans contain arabinose side chains with ester-bound ferulic acid which may impede hydrolysis by the corresponding glycoside hydrolases. It has been demonstrated that Bacteroides intestinalis and other common human gut microorganisms are able to produce various arabinoxylan degrading enzymes. However, less is known about esterases which may facilitate arabinoxylan degradation. Therefore, two esterases which were upregulated during the growth of Bacteroides intestinalis on wheat arabinoxylan were cloned, heterologously expressed in E. coli, purified to homogeneity, and characterized by various methodological approaches. Both enzymes were able to hydrolyze the artificial substrates methyl ferulate and p-nitrophenyl acetate. However, specific activities and kinetic properties of the enzymes demonstrated that methyl ferulate and thus ester-bound ferulic acid residues are the preferred substrates. In addition, the pH and temperature profiles suggested that both enzymes are most active at conditions comparable to the human gut environment. To obtain more information on the substrate specificities, naturally occurring, grain-derived substrates were used. Both enzymes were able to de-esterify several purified feruloylated arabinoxylan oligosaccharides with a varying complexity. Furthermore, a mixture of ferulic acid oligosaccharides from wheat bran was completely de-esterified which was demonstrated by using HPLC-DAD and two-dimensional NMR spectroscopy. To investigate the hydrolysis of polymeric substrates, insoluble wheat arabinoxylan was used. Both enzymes liberated significant amounts of ferulic acid from this substrate. In addition, combination of the esterases with backbone and side chain cleaving glycoside hydrolases resulted in an increased release of monomeric sugars from insoluble wheat arabinoxylan. These results suggest that both enzymes most likely play an important role for the fermentation of cereal dietary fiber by Bacteroides intestinalis. The occurrence of proteins with a high degree of identity in other human Bacteroidetes suggests that these organisms are also capable of hydrolyzing complex feruloylated arabinoxylans.

Stabilizing effect of condensed tannins on pectin–3-deoxyanthocyanin solutions and possible mechanisms involved

J. F. BRANTSEN (1), J. M. Awika (1)
(1) Texas A&M University, College Station, TX, U.S.A.

3-Deoxyanthocyanins (3-DXA) are stable natural pigments from sorghum that have good potential as food colorants, but rapidly self-associate and precipitate in aqueous solutions because of reduced hydrophilicity, limiting their usability in beverages. We previously showed that pectin reduce self-association of 3-DXA but the mechanisms remain unclear. This work evaluated the effect of proanthocyanidin (condensed tannins) molecular weight on the stability of pectin–3-DXA solutions. The stabilizing effect of pectins of different degrees of methoxylation (0.5 g/L) on 3DXA extracted from black sorghum (with or without tannins) was evaluated at pH 3 and 5. Catechin (monomeric), grape seed tannins (oligomeric), and sorghum tannins (polymeric) were added to 3-DXA-pectin solutions. Zeta potential and average particle size were measured using a Malvern Zetasizer, and absorbance spectra were recorded with a UV-vis spectrophotometer over 22 weeks. After 22 weeks, at pH 5, pigment retention was higher (100% and 86%) for tannin 3-DXA extracts than for non-tannin extracts (58% and 13%) with moderately methoxylated (MM) and highly methoxylated (HM) pectin, respectively. MM pectin likely primarily stabilized 3-DXAs via electrostatic repulsion as evidenced by increased zeta potential (from ~24 to ~42 mV) and reduced particle size (>2,500 nm to <700 nm) with the addition of pectin. Stability of 3-DXAs with HM pectin was likely due to mainly hydrophobic interactions and steric hindrance as particle size decreased from >1900 nm to <800 nm, while zeta potential was not affected. Molecular weight of proanthocyanidins did not affect zeta potential, but particle size was lowest in solutions with sorghum tannins (<470 nm compared to >530 nm without tannins). This suggests polymeric, higher molecular weight proanthocyanidins contribute to aqueous stability to a greater extent than lower molecular weight proanthocyanidins, likely through hydrophobic interactions with pectin and copigmentation with the 3-DXAs.
Quantitative structural organisation model for wheat endosperm cell walls – A major source of dietary fibre
G. Gartaula (1), S. Dhital (2), G. Netzel (2), B. Flanagan (1), G. Yakubov (3), C. Beahan (4), A. Basic (5), M. GIDLEY (3)
(1) ARC Cntr of Excellence in Plant Cell Walls, Qld All Agr Food Innov, University of Queensland, Brisbane, Australia; (2) University of Queensland, Brisbane, Australia; (3) University of Queensland, St. Lucia, Australia; (4) ARC Cntr of Excellence in Plant Cell Walls, School of BioSciences, University of Melbourne, Melbourne, Australia; (5) La Trobe Institute for Agriculture and Food, Bundooora, Australia

The objective of this work was to define the structure and architecture of wheat endosperm cell walls, a major source of fibre in many diets and of importance in seed structure and germination. Defining an architectural model would provide a rational basis for tailoring the structure of wheat endosperm cell walls either in planta or by postharvest processing to enhance nutritional properties. Literature evidence suggests that wheat endosperm cell walls contain ca 70% arabinoxylan (AX), together with ca 20% (1, 3; 1, 4)-β-glucan (MLG), and unusually low levels (<5%) of cellulose for plant cell walls, but most data is from more than 30 years ago. Previously, wheat endosperm cell walls have been analysed after isolation from milled flour, where even small impurities of much thicker cell walls from aleurone and other tissues can distort structural analyses. In this study, cell walls were isolated from both pure endosperm (isolated by a novel technique described in J Cer Sci, 74, 165-173, 2017) and milled flour. Solid state 13C Nuclear Magnetic Resonance spectroscopy in conjunction with methylation analysis, before and after acetic/nitric acid treatment, showed that, in addition to AX and MLG, wheat endosperm cell walls contain a significant proportion of cellulose (ca 20%) which is tightly bound to xylans and mannans. Atomic force microscopy imaging revealed that wheat endosperm cell walls contain a fibrous acid-resistant core structure laminated by matrix polysaccharides. Detailed analysis of phenolic acid substituents in monomeric and dimeric forms showed that endosperm cell walls had only about 20% of the levels of phenolic acids as milled flour, although the ratio of monomeric to dimeric forms was similar. Taken together, the data allow the first quantitative model for wheat endosperm cell wall structural organisation to be proposed. This is based on a core of cellulose and interacting non-cellulosic polysaccharides which anchors AX (with very occasional diferulic acid cross-linking) that in turn retains MLGs through physical entanglement. This model informs opportunities for enhancing the nutritional value of wheat-derived foods. In particular, opportunities for increasing the amount of soluble fibre are apparent through controlling both the anchoring of AX and MLG to the cellulosic core and the level of diferulic acid cross-linking.

The role of sourdough in the development of gluten-free cereal products
E. K. ARENDT (1)
(1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland

The incidences of celiac disease or other allergic reactions/intolerances to gluten are increasing largely due to improved diagnostic procedures and changes in eating habits. This creates a high demand for high quality gluten-free products. A recent comprehensive market study performed in UCC on gluten-free bread, revealed that the majority of the gluten-free cereal products currently on the market are lacking structure, flavour, very often of poor sensory quality and low nutritional value. This presentation gives an overview of the market study, novel approaches for the development of gluten-free cereal products focusing on the gluten-free bread. The areas covered in the presentation are the detailed characterisation of gluten-free cereals and functional ingredients and the assessment of these in gluten-free breads. The characterisations ranges form a detailed chemical characterisation, to rheological evaluation of the resulting doughs, structural properties of the doughs and breads using advanced microscopical methods as well as pilot-scale baking trials and sensory evaluation. The impact of gluten-free sourdough on the quality of cereal products will be the main focus of the presentation. Selected lactic acid bacteria with properties such as antifungal activity and exopolysaccharides production will be introduced, and the impact of sourdough on the nutritional properties of the GF-bread will also be discussed in detail.

Flow properties of yellow split pea (*Pisum sativum* L.) flour on several surfaces
A. KAISER (1), N. Barber (2), F. A. Manthey (1), C. A. Hall III (1), J. Kallenbach (1)
(1) North Dakota State University, Fargo, ND, U.S.A.; (2) Northern Crops Institute, Fargo, ND, U.S.A.

Incorporating pulse flours into cereal-based foods is of interest due to demand for healthful convenience foods. Knowledge of pulse flour behavior in conveying systems is important in the scale-up of such novel products but is currently limited in the literature. We sought to support the development and scale-up of cereal-based pulse products by investigating the flow properties of hammer-milled yellow split pea. Yellow split pea at 9 and 11% moisture was hammer-milled at two rotor speeds (34 and 102 m/s) and with 9 mill screen aperture sizes (ranging from 0.84 to 9.53 mm). Particle size distribution and flow properties (angle of repose and angle of slide) on 6 surfaces (stainless steel, aluminum, polypropylene, PVC, HDPE, and PVDF) were assessed. Flour particle size distribution was significantly affected by the interaction between mill rotor speed and screen aperture size. Particle size distribution was most like that of commercial wheat flour at a rotor speed of 102 m/s and screen aperture of 0.84 mm. Angle of slide and angle of repose both decreased at larger median particle size, indicating
that pulse flour flows more readily when coarsely milled and may tend to clump at finer particles sizes. Angle of slide was also affected by surface. Flour flowed most readily (low angle of slide) across aluminum and least readily (high angle of slide) across HDPE.

Sourdough – An ancient technique for nowadays bread
M. J. BRANDT (1)
(1) Ernst Boecker GmbH & CO KG, Minden, Germany

Sourdough is, beside wine, one of the most traditional food processing techniques and goes back to ancient times. These fermentations are started spontaneously or there has been traditional techniques developed in order to keep starter cultures for this processes alive. A sourdough is fermented by lactic acid bacteria and yeasts, respectively. Whereas in rye bread production, sourdoughs are commonly used to lower the pH to inhibit the amylase activity of the rye flour, in wheat breads or wheat based baked goods sourdoughs are not commonly used, although sourdough can contribute to a more pronounced bread aroma and taste, as well as a longer bread shelf life. Sourdough fermentation in bakery requires specific knowledge on the effects of process parameters, raw materials and microorganismis in order to obtain a specific, reproducible quality of the resulting baked goods. Sourdough starter cultures supporting these processes are now for about one century on the market. As fermentation is a labour-intensive and time consuming process, a growing demand for convenient products raised early. Based on optimization and modification of the traditional sourdough processes, dried, liquid and pasty sourdoughs with a long shelf life were developed. They allow the convenient, direct production of baked goods with constant quality combined with all advantages of the biological fermentation process, e.g. flavor, reduced staling rate or prolonged microbial shelf life.

Effect of radio frequency cold plasma on the thermal, molecular characteristics, pasting and unit chain profile of waxy starches
A. Y. OKYERE (1), G. A. Annor (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Non-thermal modification of starches, using radio frequency cold plasma is an emerging novel technology, free of chemicals and also eco-friendly. It thus, has the potential to replace the chemical modification of starches. This study investigated the effect of radio frequency cold plasma on the thermal properties, molecular characteristics, pasting and unit chain profile of waxy maize, rice and potato starches. Starches were treated for 60 minutes, at 120 Watts, using carbon dioxide (25 sccm) and argon gas (10 sccm). The unit chain profile, molecular characteristics, thermal properties and pasting profiles of the starches were determined using ion exchange chromatography, gel permeation chromatography (Sepharose CL-2B), differential scanning calorimetry and the micro visco amylograph respectively. The unit chain profile of samples showed decreases in the lengths of the short, long, and average chains after plasma treatment. These decreases were not statistically significant except for the average chain length of waxy potato starch. Plasma treatment also resulted in a decrease in the carbohydrate content that eluted in the amylopectin region on Sepharose CL-2B of all samples. The thermal properties of the starches were significantly affected after plasma treatment. Enthalpy of gelatinization significantly increased from 7.5 to 9.4 J/g, 13.3 to 14.4 J/g, and 8.8 to 12.6 J/g for waxy rice, potato and maize starches respectively when plasma treated. Plasma treatment, also decreased the onset temperature of gelatinization but had no significant differences in peak temperature, except for waxy potato starch. The pasting profiles of all 3 starches were affected after plasma treatment. Significant decreases were observed in the set back and final viscosities of all treated samples. Peak viscosities decreased in waxy maize but increased significantly in waxy rice and potato starches after plasma treatment. In conclusion, the enthalpy of gelatinization, initial gelatinization temperature, set back and final viscosities of all starches were significantly affected after radio frequency cold plasma treatment. There were no significant differences in the unit chain profile after plasma treatment except in the average chain length of waxy potato.

Improving and aligning dough quality analysis
J. M. C. Dang (1), S. Uthayakumaran (1), M. L. BASON (1)
(1) Perten Instruments of Australia Pty. Ltd., Macquarie Park, Australia

Bakers need fit-for-purpose flour with accurate information on its processing requirements. For bread flour this includes information on water and mixing energy requirements, tolerance to overmixing, and relevant measures of the rested dough’s viscoelastic properties. Rationalization of the milling and baking industry has presented a significant challenge (and opportunity) to provide consistent quality products across multiple regions and crop years, to meet increasing consumer expectations for consistently healthy, safe and palatable products. In the milling industry, the problem of managing geographical and seasonal variation in wheat quality is compounded by historical problems aligning traditional test equipment to give the same result on the same flour. Differences due to manufacturing variation, mis-calibration, wear-and-tear, local operating procedures, flour storage and other factors contribute to this variation, and can result in costly rejections and redirections of wheat and flour
shipsments. Large flour producers in particular, have a need for instrumentation, regardless of location, age or wear, which will provide dough quality measurements that are consistent across all production sites. We have devised a method to align results from multiple doughLABs to produce more consistent results across all units, using a bowl correction factor (BCF). Dough quality measurements were determined on several sets of doughLAB/bowls, with and without the application of BCF, on three different flour types and using three different mixing methods that varied in speed and target torque. Variation in the results was significantly reduced after application of the BCF, relative to target mixing torque, regardless of sample. Fit-for-purpose bread flour requires a balance of viscoelastic properties to ensure good dough molding and oven spring. We have prototyped a new dough extension system (DES), consisting of a molding apparatus, proofing chamber and uniaxial extension rig fitted to a TVT texture analyzer. Extension tests of doughs with diverse properties were performed on both the extensograph and DES. DES results showed acceptable correlations to extensograph maximum resistance, extensibility and ratio of resistance to extensibility, with similar or superior within-instrument repeatability. These advances in dough quality testing systems from Perten Instruments provide a solution for millers and bakers to help ensure suitable quality and better consistency in their products.

**Emulsion stabilisation with non-chemically modified starch polymers**

M. Kasprzak (1), W. Macnaughtan (1), S. E. Hill (2,3), S. Harding (1), B. WOLF (1)
(1) The University of Nottingham, School of Biosciences, Loughborough, U.K.; (2) The University of Nottingham, Loughborough, U.K.; (3) Biopolymer Solutions, Loughborough, U.K.

Emulsions are frequently encountered microstructures in foods. They are thermodynamically unstable two-phase liquid systems comprised of droplets dispersed in a continuous phase. Their interfacial area requires kinetic stabilisation through adsorption by surfactants, macromolecular polymers or amphiphilic particles. A large proportion of food emulsions are of the oil droplets-in-water (o/w) type, however oil droplets may contain an additional aqueous phase (w/o/w). This research was developed to encapsulate salt or sugar solution within starch stabilised oil droplets. The concept is that starch will breakdown on contact with the salivary amylase during oral processing, destabilising the emulsion and releasing the encapsulated tantant. While it has been demonstrated that chemically modified starches may be utilised, these are not label friendly. Clean-label starch granules have been shown to act as particulate emulsifiers, but here we demonstrate that gelatinised starches can be used. Waxy rice after gelatinisation stabilised an emulsion in a commercially relevant emulsification process. Oil droplet size ranged between 0.6–100 microns (quantified by small angle laser diffraction) with their distribution remaining unchanged for at least 4 weeks. The emulsions contained 20% sunflower oil and 1–4% starch. Creaming was observed, so stabilisation is not due to increased emulsion viscosity. A control emulsion prepared without starch destabilised immediately. Since sunflower oil naturally contains surface-active lipids, emulsions were also prepared after treating sunflower oil with magnesium silicate to remove these molecules. These emulsions were stable despite the absence of any known interfacially active species. The expectation that the hydrophilic starch polymers would not adsorb at the o/w interface was validated by pendant drop interfacial tension measurements. The value at the purified oil/water interface was 26.5 ± 0.4 mN/m and in presence of 4% starch it was 26.8 ± 1.3 mN/m. Emulsions stained with Fast Green and viewed by confocal laser-scanning microscope revealed a layer of starch around the oil droplets. This layer was extracted with ethanol, following a 4% starch it was 26.8 ± 1.3 mN/m. Emulsion stabilisation with non-chemically modified starch polymers

**Production, nutraceutical and anticancer properties of yeast-leavened breads supplemented with selenized proteins from sprouted legume seeds**

S. O. Serna Saldivar (1)
(1) Escuela de Ingenieria y Ciencias, Tecnológico de Monterrey, Tecnológico, Mexico

Bread is among the three top food items that provide most of the dietary selenium (Se) for the world population who consumes yearly about 50 kg of baked goods. The intrinsic Se present in wheat and extrinsic sources are highly converted by yeast into more bioavailable organic Se forms, chiefly selenomethionine (SeM). However, the selenium content of wheat varies according to the planting region and soil fertility. In addition, the conventional dry-milling process of wheat diminishes Se levels because this trace mineral is mainly present in the aleurone. There are several strategies to increase organic Se in wheat and bread systems. These consist in the partial germination in presence of sodium selenite and/or the supplementation of Se as yeast food. However, these wheat breads still have low protein quality and lack of important phytochemicals that favor health. The aim of this presentation is to summarize recent research related to the enrichment of wheat flour with different sprouted legumes (i.e. soybean, chickpea and yellow peas) with and without the presence of sodium selenite and evaluate
their performance in yeast-leavened pan breads. Breads made with composite flours containing from 5 to 15% sprouted legume flours showed detrimental changes in oven spring, bread volume and density in a dose dependent matter. However, a comparison between control sprouted legume flours and selenized sprouted counterparts indicated that breads had similar features. Good quality breads were produced when the levels of substitution was lower than 10%. The use of germinated-selenized legume flours in yeast-leavened breads dramatically increased Se especially in the SeM form. Additionally breads had better protein quality and overall nutraceutical profiles because these legumes are high in protein and lysine that complement the profile of wheat and phenolics, saponins, phytosterols, folic acid, tocopherols and other phytochemicals that are known to prevent chronic diseases. Studies with immune-suppressed mice xenografted with cancer cells have demonstrated that Se-enriched breads diminish the growth of tumors and increase levels of hepatic glutathione peroxidase, which protects mammalians against oxidative stress. In addition, the germination of legumes in presence of sodium selenite positively changes the phytochemical profile. In conclusion, several research studies demonstrate that is feasible to produce yeast-leavened breads enriched with sprouted legume flours rich in organic selenium. These breads contain better protein quality, higher amounts of antioxidants and especially organic selenium that protects mammalians against oxidative stress and cancer.

Timing of pre-harvest desiccant and its effects on wheat starch properties

M. MALALGODA (1), J. B. Ohm (2), S. Simsek (3)
(1) University of Minnesota, MN, U.S.A.; (2) USDA-ARS, ETSARC, Cereal Crops Research Unit, Hard Spring & Durum Quality Lab, Fargo, ND, U.S.A.; (3) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

During wheat cultivation, some herbicides are used prior to harvest as pre-harvest desiccants or harvest aids. Glyphosate is the most widely used pre-harvest desiccant in the case of wheat. It is a non-selective, broad spectrum, post-emergence herbicide, and therefore controls a wide range of different species. Although glyphosate is effective in its role as a harvest aid, side effects of this herbicide on the crop itself, micro and macro organisms and plant diseases have been reported. In this context, the objective of this study was to determine how the timing of glyphosate application affects wheat starch properties. For this purpose, two wheat cultivars were grown in three locations, and glyphosate was applied at the recommended rate at soft dough stage and ripe stage. Upon harvest, starch properties, such as amylose and amylopectin characteristics, starch pasting properties, granule size distribution and digestibility were determined using HPLC, RVA, mastersizer laser particle size analyzer and Englyst assay, respectively. As for amylose and amylopectin molecular weight, significant \( P \leq 0.05 \) differences were not detected between the different treatments and the control. However, RVA peak viscosity and final viscosity were significantly \( P \leq 0.05 \) higher for samples with glyphosate applied at soft dough stage compared to ripe stage application and the control with no glyphosate application, indicating that glyphosate timing influences starch pasting properties. As for starch granule size, both A type and B type starch granule distribution was affected by glyphosate application timing, where the proportion of B-type granules was lower in the treated samples than in control, and vice versa for A-type granules. The data from the Englyst assay indicated that rapidly digestible starch, slowly digestible starch, total starch, and resistant starch showed significant \( P \leq 0.05 \) differences between treatments. Rapidly digestible starch was highest in the ripe application treatment, and lowest in the control, and vice versa for slowly digestible starch. Total starch was lowest in the control, and resistant starch was higher in the control compared to the treated samples. In this context, glyphosate application time appears to have an influence on starch characteristics of spring wheat, and further studies are needed to examine the chemical changes that occur in starch with regard to different application times.

Ultra-high performance liquid chromatography-size exclusion chromatography (UPLC-SEC) as an efficient tool for the rapid and highly informative characterisation of biopolymers

N. Perez-Moral (1), J. M. Plankeele (2), C. Domoney (3), F. J. WARREN (1)
(1) Quadram Institute Biosciences, Norwich, U.K.; (2) Waters, En Yvelines Cedex, France; (3) John Innes Centre, Norwich, U.K.

We present a rapid, flexible method for biopolymer molecular weight characterisation, particularly applicable to starch chain length distribution, which overcomes many of the technical limitations of previous methods. Starch has a complex molecular structure, with properties dependent on the relative chain lengths and branching structure of its constituent molecules, which may be altered due to variation in starch biosynthetic genes. Here we present the application of ultra-high performance size exclusion chromatography to the separation of starch chains from plant seeds. Several methods have been used to analyse chain length distributions in starch, all with limitations in terms of analysis time, sample preparation and molecular weight range. Here we demonstrate that chain length distributions can be obtained with dramatically reduced analysis time using ultra-high performance size exclusion chromatography. Barley and pea starch samples were debranched using isoamylase prior to analysis. Samples were analysed using a Waters Advanced Polymer Chromatography System fitted with XT-450 Å, XT-125 Å and XT-45 Å columns run in series with a differential refractive index detector. Pullulan
standards were also analysed, and run times were approximately 10 minutes, a significant reduction in analysis time relative to HPLC based methods. The resolution enhancements possible through UPLC allow the separation of amylose and amylopectin as well as the identification of key structural features in the amylopectin chain length distributions, as well as amylose fine structure. We demonstrate the potential of this technique through the analysis of starch fine structure in a series of pea mutant starches with various mutations in the starch branching enzyme, in which we demonstrate relationships between location of the mutation within the branching enzyme and amylose fine structure. Understanding links between starch fine structure and biosynthetic genes will allow bioengineering of starches with tailored properties. This technique may have application to the size separation and resolution of a range of biopolymers of value to the food, drink and pharmaceutical industries. In particular, the high throughput nature of the method lends itself to phenotyping of starches in cereal collections and in breeding programmes. Such high-throughput phenotypic screening of starch structures, using germplasm collections to identify biodiversity, to correlate phenotypes with genomic and genetic data linked to variation in the underlying genes, and to facilitate breeding programmes aimed at specific food and feed uses. The method can also be applied to other biopolymers in applications where rapid determination of molecular weight distribution is beneficial.

Susceptibility of crystalline structures of starches from different origins to repeated heat moisture treatment: A calorimetry study
C. L. Lin (1), J. Lin (2), J. J. Lin (1), Y. H. CHANG (1)
(1) Providence University, Taichung, Taiwan; (2) MingDao University, Changhua, Taiwan

In this study, starches (corn, tapioca and potato) were subjected to heat moisture treatment (HMT) at 100°C for 0–60 mins with up to 6 iterations, then their gelatinization thermal properties were analyzed to investigate the relationship between molecular structure of starch and impact of repeated HMT on its crystalline structure. Results showed the weight-average degrees of polymerization of the short (A and B1) chains and the long (B2 and longer; B2+) chains of amylopectins of the starches were both in the order of corn (17.8, 58.0) ≈ tapioca (17.7, 58.3) < potato (18.8, 64.8). The short/long chain (S/L) ratios were in the order of corn (3.21) > tapioca (2.57) > potato (1.57). Endothermic transition reflecting the melting of crystalline structure primarily formed by amylopectin was observed between 58–77°C for all the native starches, while the dissociation of amylose-lipid complexes was found solely for corn starch. After repeated HMT, the amylose-lipid endotherm remained comparable to the native, while increasing in conclusion temperature and reducing in enthalpy change (ΔH) of amylopectin-related endotherm were observed. The dissociation of crystalline lamellae (ΔHcryst), essentially formed by the short chains of amylopectin, altered marginally for corn starch after HMT. However, its ΔH with respect to the amorphous region (ΔHmono), including the inter-crystalline amorphous lamellae, decreased and the extent depended on the condition employed, which was undetectable after 5 HMT cycles without holding at 100°C and 2 cycles with 30-min or 60-min holding time. For tapioca starch, the ΔHcryst was reduced by 12–22% after HMT, and the ΔHmono was absent only when the variable of holding time was incorporated into HMT (after 5 and 4 cycles for 30-min and 60-min holding, respectively). For potato starch, the ΔHcryst was decreased by 48–67% after HMT, and the absence of ΔHmono was observed only with 60-min holding time. The findings of this study suggest that corn starch is more resistant to the HMT than potato starch. This is probably because corn starch has a high S/L ratio and short B1 chains, thus its crystalline lamellae are well organized and appear to be parted from the amorphous region. Besides, the progressive change in thermal properties of starch due to repeated HMT could potentially affect the pasting profile of starch to a different extent, which would further widen the spectrum of application of starch.

The role of egg white and yolk proteins during pound cake making
L. J. DELEU (1), K. Brijs (1), J. A. Delcour (1)
(1) Laboratory of Food Chemistry and Biochemistry, KU Leuven, Leuven, Belgium

Like any type of cake, pound cake relies on the techno-functional roles of proteins (foaming, emulsifying and gelling) for its final quality. Combining one pound of wheat flour, eggs, sugar and margarine or butter, the recipe of pound cake is rather simple. Nevertheless, the result is a very complex product. The batter consists of a continuous aqueous phase in which sugar and some protein are dissolved, flour particles are suspended and margarine fragments (containing air cells) are emulsified. During baking, things become even more complicated as, among others, fat melts, gas cells expand, starch gelatinizes and a protein network is formed. During the whole process, egg proteins play a key role. Profound understanding of their contribution at the different stages of cake making is crucial when one wants to replace them. This presentation details the formation of the cake quality determining protein network. The latter was studied by monitoring the extractability of 15N-labeled egg proteins during temperature controlled baking in an electrical resistance oven. The hydrodynamic volumes of the protein populations in the extracts were analyzed with size exclusion - high performance liquid chromatography. Also analyzed was the microstructural organization of the egg yolk proteins in the aqueous phase of the batter (obtained by ultracentrifugation). The results on the network formation were combined with protein denaturation temperature and sulfhydryl availability and cake making properties (i.e. oven rise during baking...
and cake quality). While all egg white proteins contribute to this network, ovalbumin plays a key role. The properties of ovalbumin determine the incorporation of many other proteins, among which the wheat flour gliadins. The impact of ovalbumin coincides with the gas cell opening at maximal oven rise and does codeetermine cake crumb springiness and cohesiveness. Egg yolk proteins are very diverse. Those organized as lipoproteins are accessible in batter and combine emulsification, gas cell stabilization and participation in the protein network during the baking process. The final mixed protein network consist of proteins from egg white, egg yolk and wheat flour and is based on disulfide bonds and strengthened by other interactions. The above insights can also to a degree be applied for mixed protein systems (e.g. pasta, other cake types) or egg protein-stabilized baked products (e.g. gluten-free bread).

Characterization of cell wall composition of Miscanthus grass
J. SCHAEFER (1), M. Sattler (1), Y. Iqbal (2), I. Lewandowski (2), M. Bunzel (1)
(1) Karlsruhe Institute of Technology, Karlsruhe, Germany; (2) University of Hohenheim, Hohenheim, Germany

Monocotyledonous plants are important resources for food, forages, and bioenergy production. However, converting food plants such as maize into bioethanol and using farming land to cultivate bioenergy plants compete with food production. For this reason, perennial grasses that are able to grow on marginal land are potential candidates for bioenergy use. Miscanthus is a leading candidate for bioenergy production; however, efficient utilization of its lignocellulosic biomass for the production of liquid biofuels, such as ethanol, is challenging. The recalcitrance of Miscanthus biomass is influenced by individual plant cell wall polymers and their interactions, e.g. reduced lignin contents, and reduced cell wall cross-links are associated with biomass saccharification efficiency. Knowledge about biomass composition is necessary to select appropriate genotypes and pretreatment processes for efficient biomass use. Here, different organs (stems and leaves) of four potential Miscanthus genotypes (Miscanthus sinensis, Miscanthus sacchariflorus, Miscanthus × giganteus, Miscanthus sinensis × Miscanthus sacchariflorus hybrid) were analyzed for their non-starch polysaccharide composition and structures, lignin contents and structures, and hydroxycinnamate profiles (monomers and ferulic acid dehydrodimers). These analyses demonstrate organ and genotype related differences. Polysaccharides of all genotypes were mainly composed of cellulose and low-substituted arabinoxylans. Ratios of hemicelluloses to cellulose were comparable, with the exception of Miscanthus sinensis that showed a higher hemicellulose/cellulose ratio. Lignin contents of Miscanthus stems were higher than those of Miscanthus leaves. Considering the same organs, the four genotypes did not differ in their Klason lignin contents, but Miscanthus × giganteus showed the highest acetyl bromide soluble lignin content. Lignin polymers isolated from stems varied in their syringyl/guaiacyl ratios and linkage type distributions across genotypes. p-Coumaric acid and ferulic acid were the most abundant ester-bound hydroxycinnamate monomers in all samples, with different amounts depending on genotype and organ type. The largest amount of ferulic acid dehydrodimers, which represent cell wall cross-links, was analyzed for Miscanthus sinensis. In all samples, 8-5-coupled diferulic acid was the main monomer, followed by 8-O-4-, and 5-5-diferulic acid.

Particle size distribution and physicochemical properties of dry-milled rice flours from mutant rice varieties, Hangaru and Singil, by N-methyl-N-nitrosourea treatment on fertilized egg cells
M. SHIN (1), J. No (2), E. Ok Choe (3)
(1) Division of Food and Nutrition, Chonnam National University, Gwangju, Korea; (2) Songwon University, Gwangju, South Korea; (3) Inha University, Incheon, South Korea

Background and objectives: New Korean rice varieties, Hangaru and Singil, were developed by treating fertilized egg cells with N-methyl-N-nitrosourea and inbreeding, to obtain dry milled rice flours from rice kernel using an air classification mill without polishing. Hangaru was obtained by inbreeding a japonica type Dealipbyeo1 with large sized kernel and Seolgaeng derived from a high quality japonica type Ilpumbyeo through the MNU treatment, and Singil was derived from an Indica type Hanarum by the MNU treatment. Particle size distribution patterns, apparent amylose and damaged starch contents, water absorption, morphology, crystallinity, and pasting properties were measured. Findings: Particle size distribution patterns of rice flours were free starch granule and cell agglomerate fractions and differed by varieties. Hangaru flour showed a higher free starch granule fraction (2–15 μm) than Singil flour, whereas a large sized cell agglomerate fraction (40–60 μm) showed a reverse trend. The apparent amylose, total starch and damaged starch contents of Hangaru and Singil flours were 15.62 and 24.52%, 88.69% and 86.60%, 12.24% and 9.56%, respectively. Water binding capacities and swelling powers at 80°C were higher in Hangaru flour (137.07% and 8.56 g/g) than in Singil flours (124.83% and 5.86 g/g). Unlike the polygonal shape of general rice starch granule, some starch granules of Hangaru and Singil flours represented a round shape on the side. All flours showed A-type crystallinity. The initial pasting temperature of Singil flour (91.68°C) was higher than that of Hangaru flour (70.98°C), but the pasting viscosities of Singil flour were lower than those of Hangaru flour. Conclusions: From the above results, it was discovered that MNU mutant varieties, Hangaru and Singil, should be milled easily because of softening endosperm of rice kernel. The rice flours could be used as an application for bakery products and a substitute for wheat flour. Significance and novelty: The results of this study are different as the particle...
size distribution patterns of dry milled rice flours obtained from MNU mutant rice varieties were compared with those of general dry milled rice flours.

### The fate of mycotoxins during processing of grains

**S. SCHAARSCHMIDT (1)**

(1) German Federal Institute for Risk Assessment, Berlin, Germany

Cereals can be contaminated with multiple mycotoxins produced in the field and/or during storage by fungi of different genera. In wheat, the *Fusarium* toxin deoxynivalenol is probably the most common mycotoxin and co-occurs to some extent with other *Fusarium* toxins (mainly nivalenol and zearalenone). Besides toxins produced by *Fusarium* species, wheat can also be contaminated with toxins of other fungal genera, such as *Alternaria* and *Penicillium*. Aflatoxin-producing *Aspergillus* species are of particular significance in maize. Common maize-colonizing *Fusarium* species produce relatively high levels of fumonisins, but also other mycotoxins are often present in maize. Processing of cereals is capable to affect the concentration and composition pattern of mycotoxins by redistribution, degradation/detoxification processes, transformation to other toxic forms, or binding to/release from food matrices. Data on the fate of mycotoxins were collected from the literature to estimate processing factors for selected mycotoxins. Processing factors help to identify high-risk products and potential critical steps in processing chains, and can support risk assessment and management. To allow comparison with legal obligations in the European Union, changes in the composition and the moisture content were taken into account when estimating the processing factors. The presentation will give an insight into the fate of selected mycotoxins (mainly deoxynivalenol and fumonisin B1/B2) during steps of primary and secondary processing of wheat and maize. The work was done in preparation for tasks of the MyToolBox project. This project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under Grant Agreement No 678012.

### Modelling of rice flour turbo cooking

**C. CAPPA (1), R. Invernizzi (1,2), A. Marti (1), M. Lucisano (1), C. Alamprese (1)**

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

Pre-cooking is a thermal process to produce food ingredients to be used in a variety of products (e.g. puddings and gluten-free pasta) in which a partial gelatinization of starch is desired. In this context, turbo cooking can be applied. This technology is based on the creation of a thin film of material in high turbulence by means of a turbine rotating inside a static horizontal chamber. After cooking, the material is dried to reduce its moisture content. The objective of this study was to explore the effects of different processing conditions on the physical and chemical properties of rice flour (Carnaroli cv). A 3-factor, 3-level Box Behnken experimental design was applied to study simultaneously the main and interactions effects of cooker temperature (120, 160, 200°C), feed moisture (30, 35, 40%) and dryer temperature (160, 180, 200°C). A fixed residence time of 30 s into the cooker was applied. A commercial flour prepared in a conventional belt cooker was used as reference. According to the response surface methodology elaboration, different significant effects of the experimental factors were observed for moisture and some indices for evaluating starch gelatinization level, including damaged starch (i.e. α-amylase accessibility), pasting properties and viscosity at 30°C. Furthermore, lack of fit of the models was not significant, indicating an adequate fitting of the design space. A higher significance of feed moisture was observed in comparison with the other factors. In particular, the higher the feed moisture, the higher the values of moisture and starch gelatinization as indicated by damaged starch, pasting temperature and viscosity at 30°C of the treated flours. At the same time, high feed moisture lowered the final paste viscosity, indicating once again that partial gelatinization of starch occurred during turbo cooking. As expected, cooker and dryer temperatures directly affected viscosity at 30°C and final paste viscosity. Optimization of the process conditions by the desirability function demonstrated that a cooking and drying temperature of 200°C coupled with 40% of feed moisture must be applied to obtain the maximum level of damaged starch, the highest viscosity at 30°C as well as the lowest peak viscosity. In conclusion, turbo cooking modifies the physical and chemical properties of rice flour, without reaching the same starch gelatinization as in the commercial sample, probably due to the limited residence time into the cooker. This work was supported by Lombardy Region (Linea R&S per Aggregazioni; Project Number 145075).

### Difference in the water mobility and state during boiling of Chinese fresh and dried noodles

**Y. WEI (1), X. Ling (1), B. Zhang (2), M. Li (1), Y. Zhang (1)**

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

In this study, The water mobility and state during boiling of Chinese fresh and dried noodles have been observed to explain the difference of cooking time and texture of fresh and dried noodles. The water mobility and state during boiling of Chinese noodles have been studied by using low-field nuclear magnetic resonance(NMR) and low-field nuclear magnetic imaging (NMI). Fresh and dried noodles were made with same flour that was milled...
by Buehler Miller with a spring wheat variety Yongliang 4. The drying process of Chinese dry noodle (CDN) were in a drying cabinet under condition with temperature 40°C, relative humidity 75% and for 10 hours. The fresh noodles (FN) and Chinese dried noodles (CDN) were boiled with distilled water and samples were collected in every 2 mins for NMR and NMI analysis. The noodle-expansion ratio and water absorption were also measured. The FN and CDN were boiled for 4 minutes and 10 minutes respectively. The NMI message showed that water could transfer just to the middle after 2 min for FN and 8 minutes for CDN during boiling. FN had a 60.0% of bed-expansion and 99.7% of water absorption at 4 min boiling, while CDN has a 120.1% of noodle-expansion and 164.7% of water absorption after boiling for 10 min. This explains why the FN can be easily cooked and chewy; and why the CDN needs longer cooking time and with softer taste than FN. Transverse relaxation times (T2) curves during FN boiling shows the water in the FN was mainly weakly bound water (T22), less strongly bound water (T23) appeared after dough mixing, and then the water binding facility was slightly stronger after cooking. The water in the CDN was mainly free water (T23) during boiling of CDN, and after cooking appears less strongly bound water (T23). This is because during noodle cooking, water is mainly involved in the starch gelatinization. In addition, the physical binding capacity of water increased relatively at the same time, because of starch gelatinization. Fresh noodles can be easily cooked and chewy than dried noodles because of water content, thermal transfer, and starch gelatinization. The technique of LF-NMR and LF-NMI can be used in studying water mobility and status and texture change during the noodle cooking.

Comparative production of short chain fatty acids during in vitro colonic fermentation of sorghum flours and donuts
K. COOK (1), M. Goita (1), M. Moore (1), J. Losso (1), J. W. Finley (1)
(1) Louisiana State University, Baton Rouge, LA, U.S.A.

Sorghum contains dietary fibers and short chain fatty acids (SCFA) which makes it beneficial in the prevention of many diseases. The production of SCFA causes a reduction of the luminal pH, which inhibits pathogenic microorganisms and increases the absorption of some nutrients. Also, SCFA play an important part in the maintenance of the gut barrier function and have been shown to have positive correlation in inhibiting chronic diseases. The sorghum crop comes in numerous colors. The objective of this work was to compare the production of SCFA from black, burgundy, and pearl sorghum flours and donuts, respectively. Sorghum samples were analyzed for fiber content. A model of in vitro colonic fermentation was used to evaluate the formation of SCFA following digestion of the sorghum donuts or sorghum flours by a simulated human gastrointestinal enzyme cocktail. Samples were pulled at 0, 12, and 24 h of fermentation. Gas chromatography-mass spectrometric analysis was done on the model digested samples. The pH changes were observed on all sorghum samples after 12 h of fermentation. Percentage crude fiber showed no significant differences among the black, burgundy, and pearl with 1.79%, 1.60%, and 1.86% respectively. Gas chromatography-mass spectrometric analysis of the digests showed that SCFA levels of sorghum flours and sorghum donuts were comparable. In the 12 h, all three SCFAs showed no significant differences among the flours but in 24 h, SCFA from burgundy increased significantly to 55% for acetic acid. For butyrate, burgundy showed significant increase at the 24 h by 76%. For propionic low amounts were seen in all types of sorghum flours at both 0 and 12 h but increased significantly by the 24 h. Relatively high concentrations of SCFA were seen in donuts made from the flour with no significant differences among them at the different times of fermentation. The in vitro colonic fermentation of sorghum flour and sorghum donuts generates SCFA, hence consumption of sorghum food products could generate SCFA beneficial for humans with chronic inflammatory diseases.

Develop method for monitoring the sprouting process for grains and seeds
D. BIGAGNOLI (1)
(1) University of Milan, Milan, Italy

Despite the enhancement of both nutritional and sensory profile of grains, sprouting can negatively affect the technological characteristics of the obtained products. A controlled process could assess the perfect balance between nutritional advantages and technological performance. In this context, this study aims at developing a methodology for wheat sprouting evaluation directly on kernels by a NIR portable device. Two batches of common wheat were germinated at lab scale (Memmert GmbH Co. KG, Schwabach, Germany). Samples were soaked in water (kernels:water ratio of 1:4 w/v) for 24 h, and germinated until 72 h. Samples were collected after soaking and after 24 h, 36 h, 42 h, 48 h, 60 h, 66 h, and 72 h of sprouting and analyzed as such or after drying at 50°C for 9 h. Unsprouted wheat was used as control (CTRL). Wet and dried samples were analyzed by a MicroNIR-OnSite (VIAVI) in the spectral range of 950–1,650 nm. Conventional methods for evaluating enzymatic activities (i.e. falling number, stirring number and the amount of alpha- and beta-amylases) were also assessed on either whole grain and refined flour. All the data, after the suitable pre-treatments, were analyzed by PCA to assess the behavior of the wheat according to the sprouting progress. PCAs on spectral data, both from wet and dried kernels, assessed a similar effect of sprouting time as observed by technological data analysis: the control and 24 h-sprouted samples are well distinguished from the others, whereas the changes slow down for longer times and cease after 62 hours. Wavelengths responsible of sample distribution are linked to both starch
and protein absorptions. In addition, the scores values obtained by PCA were normalized between 0 and 1 and modelled against time to compare the obtained germination trajectories. 24 h sample differed from CTRL and higher sprouted times. From 24 h on, all the PC2 trajectories described a quick slow down up to 48 h followed by an almost constant behaviour, suggesting that the most interesting changes described by chemical composition and technological features occurred in the first 48 h whereas longer germination times generated no further relevant changes. The sprouting process can be predicted by spectroscopic data collected directly on wet kernels and giving similar information gained by complex analysis on refined flour.

Protein conformations and interactions in dough systems as affected by redox agents
A. Cameron (1), I. J. JOYE (1)
(1) University of Guelph, Guelph, ON, Canada

Redox agents are used to alter the consistency and machinability of dough and to improve the final bread quality. Redox agents are believed to mainly influence the dynamics of thiol-disulfide interchange reactions, which at their turn may also affect structures of and other (non-covalent) interactions between proteins in dough. These structures and non-covalent interactions are much less well-studied due to limitations in terms of sample preparation. However, these non-covalent interactions may play a very important role in dough formation and machinability. In this context, it is important to note that previous research has hinted at a different dominant interaction type driving the formation of dough-like structures of soft and hard wheat (Jazaeri et al., 2014). The aim of this research project was mapping structures and interactions using vibrational spectroscopy, low resolution NMR and microscopy in complex dough structures supplemented with redox agents. Dough was mixed to optimal strength using a mixograph prior to being studied by FTIR and low resolution NMR and being chemically mapped using a Raman microscope. As could be expected based on previous research, reducing agents (cysteine and glutathione) shortened the mixing time, while the oxidizing agents (potassium bromate, potassium iodate and ascorbic acid) slightly increased the mixing time. All redox agents tested only slightly affected the protein secondary structure. For example, cysteine reduced the level of beta-turn structures and increased the average level of beta-sheet structures. However, the secondary protein structural changes induced were generally minimal. Also, low resolution NMR did not reveal differences in water distribution in dough between the different redox agents. These results may have been expected based on the fact that the agents studied affect the disulfide-thiol interactions, but do not necessarily alter non-covalent interactions between proteins. Raman microscopy enabled to chemically map dough structures in a non-invasive way. Future research will focus on other techniques to probe non-covalent interactions and on testing other flour types in order to accept or reject the current findings and hypotheses and dig deeper into the previously noticed differences in gluten network formation between soft and hard wheat flour. References: Jazaeri, S. et al. (2014). Structural modification of gluten proteins in strong and weak wheat dough during mixing. Cereal Chemistry, 92(1): 105-113.

Exploiting heritage and landrace wheats to increase the diversity of modern bread wheat
T. PELLNY (1), A. Plummer (1), A. Lovegrove (1), P. R. Shewry (1), A. Wood (1), S. Orford (2), L. Wingen (2), S. Griffiths (2)
(1) Rothamsted Research, Harpenden, U.K.; (2) John Innes Centre, Norwich, U.K.

Intensive wheat breeding has produced varieties that would not be recognizable to our ancestors. In particular, the tall land races of the 18th and 19th century have been replaced by semi-dwarf types with several-fold increase in yield. However, the development of such varieties, by the introduction of Reduced height (Rht) genes derived from a small number of breeding lines, has caused a bottleneck in diversity, which is exacerbated by the fact that breeders usually prioritise traits of value to producers (yield) and processors (breadmaking quality). The objectives of this study are to identify new diversity in traits that affect the quality of wheat for diet and health in historic wheat varieties and land races. Materials: We are focusing on two sources of variation. Firstly a “heritage” collection of wheat varieties that were grown in the UK with significant acreage over the last 200 years. These varieties are adapted to the local environment and therefore provide an insight into changes in composition associated with modern breeding. Secondly, the Watkins collection of landraces, which were sourced in the 1920s and 1930s from over 30 countries, particularly those in the “British Empire”. This living collection of over a thousand lines is therefore a major source of diversity for exploitation in wheat improvement. Analysis of the genetic structure using molecular markers has allowed the identification of a core collection of 120 lines, many of which have been crossed with elite cultivars to identify and map QTLs and genes for traits of interest. First results show diversity in many traits of interest and the ability of this approach to generate genetic markers for the introgression into modern wheat varieties.
Dynamics of gluten protein polymerization during pasta processing under varying temperature and time conditions
C. Martin (1), M. H. Morel (1), A. Reau (1), B. Cuq (2)
(1) INRA Montpellier – UMR IATE, Montpellier, France; (2) Montpellier SupAgro – UMR IATE, Montpellier, Cedex 1, France

Gluten protein content and quality have a major influence on the final quality of durum wheat pasta. During pasta processing, glutenin polymers successively go through de-polymerization mechanisms during the mechanical processing of pasta and polymerization mechanisms during the drying step. The aim is to study the polymerization kinetics after extrusion under different conditions (temperature and time). The goal is to assess time related recovery of large glutenin polymers and temperature related formation of glutenin cross-linked aggregates. These changes in gluten polymerization are correlated with the cooking quality of pasta and the final quality of pasta. Resting times of 1 and 2 hours at 30°C were applied on fresh pasta prior drying at low temperature (55°C) or high temperature (90°C). Pasta were sample over the resting and drying periods and immediately frozen in liquid nitrogen to hinder the polymerization of proteins. The kinetic of gluten polymerization induced by resting and drying were assessed from the SE-HPLC elution profiles of the SDS-soluble proteins from fresh, rested and dried pasta. Final pastas were characterized for their organoleptic (color, surface roughness) and physical (diameter, cooking time, index of viscoelasticity) properties, before and after cooking. Pasta cooking quality is discussed in relation with the impact of temperature and resting time on the final gluten network structure. There is an impact of temperature and resting time on texture properties of pasta. No influence of these parameters is seen on pasta color.

Investigating the changes in quality of historical and modern Australian wheat varieties
Q. T. A. Riaz (1,2), C. G. Florides (3), A. Farahnavy (1,2), F. Bekes (4), M. Majzoobi (1,5), R. F. Eastwood (6), D. K. Pleming (5), C. L. Blanchard (1,2)
(1) School of Biomedical Sciences, Wagga Wagga, Australia; (2) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (3) Western Australian State Agricultural Biotechnology Centre, Perth, Australia; (4) FBFD PTY LTD, Sydney, Australia; (5) Department of Primary Industries, WWAI and Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (6) Australian Grain Technologies, Wagga Wagga, Australia

Australia is the 5th largest exporter of wheat in the world. Among other breeding aims, maintenance and improvement in grain quality is an important goal of Australian wheat industry. The objective of this study is to investigate the changes in the quality of Australian wheat varieties over the last century. A set of 78 varieties released between 1860 and 2015 were selected and studied in terms of physical grain attributes, milling quality, dough rheology and protein composition. Protein composition (gliadin and glutenin content and composition) was examined using high performance liquid chromatography (HPLC) while dough rheological characteristics were investigated by Mixograph, Micro-doughLAB and extensograph tests. Grain protein contents were observed to be decreased in modern varieties although not when considered as grain protein accumulation per hectare and this is explained by the negative correlation to increase in grain yield. Over the years, significant changes in quality parameters of varieties have been found. Compared to historical varieties, modern cultivars were found to be stronger as observed by Micro-doughLAB and Mixograph results (increase in dough development time, dough stability, peak mixing time, midline peak width and decrease in softening after 5 min of mixing and weakening slope). The improvement in protein quality, compensating the decrease in protein content, is associated with the increase in glutenin to gliadins ratio and un-extractable polymeric proteins (UPP%). The shift in the size distribution of polymeric proteins is derived from the systematic alteration of higher molecular weight (HMW) and lower molecular weight (LMW) glutenin alleles in the modern cultivars. The two most significant examples in this alteration are the increase in the number of cultivars containing the Glu1Dd and Glu1Bal alleles (HMW glutenin subunits 5+10 and overexpressed 7 respectively) and also the consideration of the effects of LMW glutenin alleles determining functional properties. Selection within the diversity of glutenin and gliadin composition of Australian wheat varieties has led the breeders to the development of wheat varieties with improved dough functionality and better product quality in more recent years. The current research provides evidence that by selection, wheat breeders have changed the protein composition of current varieties and this has led to an improvement in grain quality. This selection will need to continue to meet the demands of industrial bread-making processes.

Preparation and characterization of beta-cyclodextrin and wheat bran phenolic acid inclusion complexes
S. Simsek (1)
(1) North Dakota State University Department of Plant Science, Fargo, ND, U.S.A.

Wheat bran, the major by-product of the milling industry, is composed of various layers and very rich in phenolic compounds. The most common phenolic compounds found in whole grains are phenolic acids and flavonoids. Bitterness is an undesirable trait often associated with in whole grain, bran and germ. The bitter or
Inulin-type fructans (ITFs) are plant-derived storage polysaccharides consisting of multiple fructans units. ITFs can be classified as prebiotic dietary fibers because they arrive partially or not digested to the large intestine and are selectively fermented by the beneficial bacteria of the large intestine. That function becomes even more important when microbiota alterations occur, as in the case of celiac individuals. Consequently, the enrichment of gluten-free (GF) foods with ITFs has been proposed as a strategy to improve the health of celiac patients. Nevertheless, processing can drastically affect the level of ITFs, particularly in leavened products like breads. Therefore, the aim of this study was to evaluate the behavior of different ITFs along the breadmaking process, with particular attention to their fermentation using two different bakers’ yeasts. A simple GF formulation based on rice flour containing 10% of different ITFs (varying in their degree of polymerization, DP) was fermented with yeasts having normal (Y1) or reduced (Y2) invertase activity. Fructans content was assessed during the process and fresh breads were also characterized. Results showed that fructans content decreased during breadmaking, and that was significantly dependent on the type of yeast used as a leavening agent and the DP of the fructans. The ITFs loss in GF breads fermented with Y1 reached up to 40% after baking, but that was significantly reduced when using Y2. Furthermore, technological characteristics of GF breads were significantly affected by the yeast used but not by the type of inulin. Higher specific volume and softer crumbs were obtained when doughs were fermented with Y2. Therefore, to reach an effective ITFs enrichment of leavened foods like bread, specific types of ITFs and the yeast must be used.

How to modulate the performance of inulin type fructans in gluten-free breadmaking
F. Morreale (1), C. M. ROSELL (2)
(1) University of Parma, Parma, Italy; (2) Institute of Agrochemistry and Food Technology (IATA-CSIC), Paterna, Valencia, Spain

Inulin-type fructans (ITFs) are plant-derived storage polysaccharides consisting of multiple fructans units. ITFs can be classified as prebiotic dietary fibers because they arrive partially or not digested to the large intestine and are selectively fermented by the beneficial bacteria of the large intestine. That function becomes even more important when microbiota alterations occur, as in the case of celiac individuals. Consequently, the enrichment of gluten-free (GF) foods with ITFs has been proposed as a strategy to improve the health of celiac patients. Nevertheless, processing can drastically affect the level of ITFs, particularly in leavened products like breads. Therefore, the aim of this study was to evaluate the behavior of different ITFs along the breadmaking process, with particular attention to their fermentation using two different bakers’ yeasts. A simple GF formulation based on rice flour containing 10% of different ITFs (varying in their degree of polymerization, DP) was fermented with yeasts having normal (Y1) or reduced (Y2) invertase activity. Fructans content was assessed during the process and fresh breads were also characterized. Results showed that fructans content decreased during breadmaking, and that was significantly dependent on the type of yeast used as a leavening agent and the DP of the fructans. The ITFs loss in GF breads fermented with Y1 reached up to 40% after baking, but that was significantly reduced when using Y2. Furthermore, technological characteristics of GF breads were significantly affected by the yeast used but not by the type of inulin. Higher specific volume and softer crumbs were obtained when doughs were fermented with Y2. Therefore, to reach an effective ITFs enrichment of leavened foods like bread, specific types of ITFs and the yeast must be used.

Wheat quality requirements of Asian noodle markets – Asian Products Technical Committee
L. CATO (1)
(1) 3 Baron Hay court, Perth, Australia

Noodles have been an important for Asian cuisine for many centuries and continue to play a central role in many dishes in Asia but are also becoming very popular and widely consumed all over the world. Often, the quality of Asian noodles is described by noodle appearance (noodle colour) and eating quality (noodle texture). The suitability of wheat for noodles is assessed in terms of product quality but also processing properties. Starch and protein, two major components of wheat flour largely determine both noodle end-product quality as well as processing. Due to a relatively simple formulation (flour, water, salts) and simple processing (mixing, sheeting and slitting) starch and protein and their physiochemical properties possibly play bigger roles in Asian noodles than in many other wheat-based products. The diversity of Asian noodle varieties and regional preferences in processing equipment have meant that no internationally approved standard methods or guidelines have previously been developed and approved for noodle evaluation. However, some countries have developed method for evaluation of their specific products. The Asian Products Technical Committee (APTC) as undertaken significant amount of work in recent years to support and guide researchers with methods and guidelines in the Asian products field (particularly noodles). This presentation will focus on the work of the
Development of barley grain analyses probing malting quality of barley
D. N. Kalinga (1), W. Cao (1), I. J. JOYE (1), D. E. Falk (1)
(1) University of Guelph, Guelph, ON, Canada

The techniques currently used to evaluate the malting quality of barley have limitations, especially when it comes to using these in breeding programs for the rapid screening of new and promising malting varieties. Therefore, this research project aims at developing new and optimizing old methods for the reliable, quick and cost-efficient determination of malting quality in barley. Two wheat (soft and hard) and a dozen barley varieties of different malting quality grown in Canada were used in this study. Wheat and barley kernel hardness indices were measured using a single-kernel characterization system. Next to protein content and extractability, and starch and beta-glucan content measurements, the samples were also analyzed in SRC tests. The kernel hardness indicated a substantially higher hardness index in feed barley than in malting barley. Solvent retention capacity (SRC) tests, initially optimised for soft wheat, clearly pointed to differences between malting and feed barley. Higher SRC values were consistently obtained for barley as compared to wheat due to the higher amounts of beta-glucan in barley. Interestingly, these differences were also apparent when testing the whole grain flour obtained by grinding the hulled barley. Ability to present valid results on samples with minimal processing is an added advantage as this reduces the workload, experiment time and sample size requirement. Based on the obtained results, feed barley can be distinguished from malting barley based on its hardness and SRC values. More research encompassing a broader diversity of barley samples will validate the above findings.

Occurrence of “super soft” wheat kernel texture in hexaploid and tetraploid wheats
(1) USDA-ARS WWQL, Pullman, WA, U.S.A.; (2) Washington State University, Pullman, WA, U.S.A.;
(3) USDA-ARS Food Quality Laboratory, Beltsville, MD, U.S.A.; (4) USDA-ARS, Manhattan, KS, U.S.A.

Wheat kernel texture is a key trait that governs milling performance, flour starch damage, flour particle size, flour hydration properties, and baking quality. Kernel texture is commonly measured using the Perten Single Kernel Characterization System (SKCS). The SKCS returns texture values (hardness index, HI) of ~25 for soft hexaploid wheat (Triticum aestivum), ~55–70 for hard hexaploid wheat, and ~75–90 for durum wheat (T. turgidum subsp. durum). The primary basis for kernel texture is the puroindoline genes at the Hardness locus. When the wild-type puroindoline genes are naturally present in hexaploid wheat or introduced into durum wheat, the texture is soft. However, we have observed SKCS phenotypes considerably softer than those commonly encountered, as low as ~9 (hexaploid) and ~2 (tetraploid) in two genetically defined populations. The hexaploid population was a recombinant inbred line (RIL) set from cv. Alpowa soft white spring by a back-cross-2 (BC2) super soft Alpowa derivative (BC2SS163); the durum population was a RIL set from cv. Creso durum by a Langdon durum translocation line carrying the Hardness locus on ca. 28 Mbp of chromosome 5DS. Genotyping by sequencing (GBS) identified 193 significant single nucleotide polymorphic markers at two quantitative trait loci, the more prominent one was associated with a major locus on chromosome 1B in hexaploid wheat. In durum wheat, significant dominant markers identified loci on 6AS and 3AL. Cylinders of defined geometry were prepared from kernel endosperm and subjected to compression testing. SKCS HI for the tested hexaploid samples ranged from –9 to 25, whereas the tetraploids ranged from 1 to 26; Creso durum was 78. Results indicated that for the hexaploid wheats, SKCS HI was positively correlated with maximum stress (r = 0.72), Young’s modulus (r = 0.68), and work at maximum stress (r = 0.55). For the tetraploids, SKCS HI was positively correlated with maximum stress (r = 0.86), Young’s modulus (r = 0.85), and work at maximum stress (r = 0.74). Among the hexaploid wheat lines, HI was correlated with percentage B-type starch granules (<10 μm) at r = –0.61. Whereas “normal soft” flour had 2.0% damaged starch, the super soft hexaploid wheat flours ranged down to a low of 1.2%. We continue to resolve the genetic basis and commercial value of this “super soft” phenotype.

Managing variance in order to assess the relationship between gluten concentration and visual assessment of gluten-containing grains in oats, oilseeds, and pulses
(1) Canadian Grain Commission, Winnipeg, MB, Canada; (2) Allergen Control Group, representing the Canadian Celiac Association, Milton, ON, Canada; (3) Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, Canada

In order to protect consumers with celiac disease and gluten intolerance, Health Canada established a threshold of 20 mg/kg gluten to indicate food is “gluten-free”. As a tool to assist in developing best practices, the relationship between the visually-assessed contamination of non-gluten containing grains (NGCG; oats, pulses, oilseeds) with gluten containing grains (GCG; wheat, durum, barley, and rye) and gluten concentration was
investigated. Contamination of NGCG occurs due to the presence of GCG kernels, or fragments of kernels. This results in a heterogeneous sample, which is a particular challenge to sample and analyze, particularly when the GCG may be a different size and/or density than the NGCG. In addition, the low limit of 20 mg/kg for “gluten-free” implies that it may take as little as 4–5 kernels of wheat to contaminate a 1 kg sample of NGCG. In this work, the variance in gluten measurements obtained from the analysis of NGCG processed using two sample preparation schemes was evaluated with the aim of minimizing the effects of sample heterogeneity on gluten measurements. The R-Biopharm Ridascreen Gliadin ELISA was used to determine gluten concentrations. The low variability between duplicate aliquots taken from test portions (ranging from 0–30.6% relative standard deviation [RSD], with over three quarters in the 0 to 9% range) demonstrated that the ELISA itself was precise and contributed a low amount to the overall variability of gluten results. The processing of ground samples using rotary sample division and the use of a 1 g test portion for all grains decreased the variability of gluten results for most samples. Using the improved sample preparation scheme, the variability in gluten amongst test portions ranged from 1 to 85% RSD, with more than three quarters in the range of 1–50%. In the original sample preparation scheme, the variability amongst test portions ranged from 1 to 143% RSD, with only slightly over half in the range of 1–50%. The high lipid content hemp seed was a particular challenge to grind, and this was reflected in the higher variability in gluten measurements between test portions (mean RSD = 61%). At concentrations relevant to existing thresholds of gluten contamination, there was no relationship between gluten concentration in NGCG and cereal contamination as determined by visual inspection.

**Digestibility of processed wheat with increased resistant starch**

M. CORRADO (1), A. Cherta Murillo (2), E. Chambers (2), A. Wood (3), A. Plummer (3), A. Lovegrove (3), G. Frost (2), B. Hazard (1,4)


Refined starchy foods are often seen as unhealthy because of their low dietary fibre content and rapid digestibility leading to poor blood glucose control; but not all starchy foods are the same. Complex carbohydrates like resistant starch have been shown to exert clinical benefits by reducing risks factors for chronic diseases such as elevated blood glucose levels, insulin resistance, overweight and obesity. Thanks to modern breeding and new genomics technologies, wheat is an ideal candidate for genetic manipulation and generation of genotypes with increased of resistant starch. Increased resistant starch wheat can boost dietary fibre intake from refined staple foods ultimately providing consumers with healthier dietary choices. In this study, we evaluated starch physicochemical properties of semolina prepared from mutant sbeIIa/b wheat with increased levels of resistant starch (Hazard et al., 2014) during gelatinization and retrogradation. A retrograded wheat test meal (pudding) was developed to deliver 50g of total starch with constant liquid to solid ratio, for both sbeIIa/b and wild-type control semolina. The puddings were used to study the effect of increased resistant starch content on upper gastrointestinal digestion using established in vitro models. The puddings were then used in a randomized cross-over study to determine the effect of resistant starch on glycaemic response. Here, we served sbeIIa/b and the wild-type puddings to 10 healthy volunteers measuring postprandial blood glucose over a 2-hour period. Unprocessed semolina from sbeIIa/b wheat showed a 3–4 fold increase in resistant starch (3.32 g/100 g) compared to the wild-type control (0.76 g/100 g) and 9.9% increase in apparent amylose content. Resistant starch levels decreased after processing in gelatinized (boiled) and retrograded (boiled and cooled) semolina but still showed a ~1.5-fold increase in resistant starch compared to the wild-type control. In vitro digestion models showed significant differences in resistant starch content and digestion rate, possibly due to change in native structure of the starch. While no glycaemic index difference was found between the two genotypes, blood glucose levels decreased over time after ingestion of sbeIIa/b wheat pudding compared to wild-type. The present study highlights the importance of processing in designing functional foods with increased resistant starch. The increase in resistant starch and amylose in the sbeIIa/b semolina and pudding appears to alter the digestion kinetics in vitro and the glucose response in vivo, without affecting the glycaemic index. These results will be used to develop new wheat foods and to inform future human studies using sbeIIa/b mutant wheat.

**Process induced changes in nutritional properties of rye**

K. K. KATINA (1)

(1) University of Helsinki, Helsinki, Finland

Rye is a traditional part of Northern and Eastern European cuisine called the European rye belt. Among the grains, rye is unusual as it is mostly consumed as whole grain. The main rye foods include dark, sour and crisp breads. Also new types of rye breads and rye foods have been developed for the modern consumer. Rye is an important source of dietary fibre in Northern European countries, e.g. almost 40% of dietary fibre intake comes from rye foods in Finland and Denmark. Rye contains both soluble and insoluble fibre and together with several bioactive components, the fibre complex is presumably largely responsible for the health benefits of rye. Epidemiological studies suggest that consumption of whole grain foods is associated with reduced incidence of chronic diseases, e.g. diabetes, cardiovascular disease, and certain cancers. EFSA has accepted a health claim for rye fibre to
improve bowel function. Rye has unique features of rye to regulate bowel functions, enhance beneficial glucose metabolism, help weight management, reduce cholesterol and even reduce risk of certain cancers. Typically, whole grain rye bread is produced with sourdough method, in which rye is fermented with (in house) starter culture overnight at varying temperatures (20–35°C). Sourdough fermentation induces number of changes in rye matrix with both technological and nutritional impact on rye properties. Typically, fermentation creates acidity which either in-activate or actives enzymes present in grain. Rye fermentation has been shown to induce endogenous phytase activity and decrease phytic acid content of rye, which improves bioavailability of minerals of whole grain rye. Rye sourdough fermentation can increase especially folate and other vitamin content of dough depending on the microbial composition of sourdough. Sourdough fermented rye breads have often positive impact on glucose/insulin regulation. Fermentation of rye bran has recently shown to induce completely new benzoazinoid metabolites such DIBOA and DIMBOA with potential health promoting properties. Processing has thus important role in modifying phytochemicals of rye. This presentation highlight impact one of major cereal processing operation, fermentation, in nutritional properties of rye.

**HMW-GS composition and rye translocation of U.S. Eastern soft winter wheat and their associations with gluten strength**

F. Ma (1,2), J. KIM (2,3), E. Cho (3,4), B. K. Baik (5)


The significance of HMW-GS composition and rye translocation, and their association with gluten strength, are well understood for hard wheat in the estimation of bread-baking quality, but poorly understood for soft wheat even in the production of soft wheat products requiring gluten development. We determined the gluten strength of 1,302 U.S. eastern soft wheat (ESW) genotypes grown in 2013-2016 using SDS sedimentation volume (SDSS) and lactic acid solvent retention capacity (LA-SRC) tests. The 149 selected ESW genotypes grown in 2016 were also analyzed for HMW-GS composition and rye translocation using SDS-PAGE and DNA marker-assisted PCR analysis. ESW genotypes exhibited large differences in gluten strength, as indicated by LA-SRC ranging from 64 to 154% and SDSS ranging from 7 to 52 mL. A total of 15 HMW-GS alleles (4 alleles at Glu-A1, 6 alleles at Glu-B1 and 5 alleles at Glu-D1) were identified in ESW. A subunit with a molecular weight between 1Ax1* and 1Ax2* (named 1Ax1*) and 1Dy12* were newly observed in ESW, with frequencies of 1.6% and 21.9%, respectively. The subunits 2* at Glu-A1, 7+8 at Glu-B1, and 2+12 and 5+10 at Glu-D1 were observed to be dominant in ESW genotypes with frequencies of 71.1, 47.7, 36.7 and 35.2%, respectively. The 1B/1R and 1A/1R translocations were observed in 21.5% and 11.4% of the ESW genotypes, respectively. Four HMW-GS profiles (2*, 7+8, 2+12), (2*, 7+8, 5+10), (2*, 7+9, 2+12) and (2*, 7+8, 2+12) were predominately observed, making up 13.3, 13.3, 13.3 and 10.2% of the tested ESW varieties, respectively. Gluten strength of ESW genotypes, as determined by SDSS and LA-SRC, was ranked in the order of subunits 13+16>7*+8>7+9>6+8>7* at the Glu-B1 locus and 5+10>2+10>2+12>2+12>3+12 at the Glu-D1 locus, but was little affected by allelic variation at the Glu-A1 locus. The 1B/1R translocation exhibited a negative influence on SDSS and LA-SRC. The ESW genotypes carrying the HMW-GSs 1 or 2*, 13+16 or 7+8 and 5+10, with no rye translocation, are expected to produce wheat grain containing strong gluten proteins, whereas wheat grain containing weak gluten proteins is expected from the genotypes carrying HMW-GSs 7* and 2+12, and the B/1R rye translocation. The information obtained in this study will be greatly helpful for identification and selection of ESW genotypes possessing required gluten strength.

**Benefits of bioprocessing technologies in extruded foods**

N. SOZER (1)

(1) VTT Technical Research Centre of Finland Ltd., Espoo, Finland

Bran is an excellent grain ingredient for dietary fibre (DF) fortification of cereal foods. Use of bran as a DF in extruded products is challenging as it interferes with the continuity of the starch matrix which has an adverse effect on the structural and textural properties. Microbial exopolysaccharides (EPS) are natural hydrocolloid polymers produced by several food grade organisms, such as lactic acid bacteria. EPS could provide a wide range of different structures and functionalities to the food matrix where they are involved. Dextran, are one of the most interesting EPS, which could be utilized in bran modification enabling incorporation even as high bran addition levels as 40% of flour weight. Also, enzymatic modification of bran, particularly the arabinoxylan part, at reduced water contents could have significant benefits on the techno-functional properties during extrusion. The first part of the presentation will focus on how fermentation with EPS producing strains can have an impact on the structure, texture, mastication and in vitro starch digestibility of high fibre rye extrudates. In the second part, we will see the effect of hydrolytic enzymes on wheat bran modification and its impact on structure and texture of extrudates.
The effect of amylose content on gelatinization, ice melting, and glass transition behaviors of rice starches
D. Y. JEONG (1), S. J. Lee (2), J. H. Lee (3), H. J. Chung (1)
(1) Chonnam National University, Gwangju, South Korea; (2) Suseong College, Daegu, South Korea; (3) Shinhan University, Uijeongbu-si, South Korea

The role of water in food is very important, and it has an absolute impact on the quality of solid food depending on the mobility of water. The objective of this study was to determine the thermal transitions (gelatinization, ice melting and glass transition) of starches isolated from various rice cultivars according to amylose contents (4.2%–46.4%) using a differential scanning calorimeter. This study was also to try development of quality index of rice-based foods by using thermal transitions based on the water behaviors. High amylose type rice starch (Dodam cultivar, 46.4%) showed the highest onset (T_o) gelatinization temperature but the lowest gelatinization enthalpy. The ice melting enthalpy measured in excess water (67% water content) of rice starches was substantially decreased due to the reduction of freezable water content as compared to that of the distilled water. The high amylose type rice starches showed lower ice melting enthalpy than the other rice starches. The glass transition temperature (T_g) of waxy type rice starches had greater than that of the normal and high amylose rice starches. The onset temperature of ice melting in rice starches was increased during the storage of 7 days at 4°C, but the ice melting enthalpy was decreased possibly due to the retrogradation of starch. The glass transition temperature (T_g) of rice starches at 12% water content were ranged from 40.4°C to 53.0°C. Among the tested rice starches, the high amylose type rice starch (Dodam cultivar) had the highest T_g, while the waxy type rice starch (Dongjinchal cultivar) had the lowest T_g. From the results, it could be suggested that the thermal transitions were highly influenced by amylose content in rice starches.

Cereal co-product polysaccharide analysis for biorefinery operation and development
M. Alyassin (1), M. Dimopoulou (1), N. T. Powles (2), H. Masey O’Neill (3), M. R. Bedford (4), G. M. CAMPBELL (1)

Understanding the response of functional polysaccharides (predominantly arabinoxylans, AX) to enzyme activity and processing conditions is required as a basis for co-product production in biorefineries, and requires the ability to characterise the polysaccharides at various stages of intactness. However, measuring small oligosaccharides is difficult and has hindered the development of processes to produce AX co-products. The purpose of this project was to develop approaches to cereal polysaccharide analysis, in order to inform enzyme studies of AX degradation. Using a gel permeation method, small oligosaccharides containing from 2 to 8 sugar units (DP2–DP8) plus monosaccharides (DP1) were identified. This was used to investigate the activity of a commercial xylanase on a range of substrates and extracts under a range of conditions of enzyme dosage, time, pH and temperature. Distillers wet grains (DWG) and sugarcane bagasse were treated with enzyme to measure the production of oligosaccharides. The enzyme was also applied to AX extracts from the two substrates, and applied in combination with other enzymes. A time trial in which xylanase was applied to DWG showed, for the first time, the evolution of a profile of DP1–DP7 as the enzyme produced and then degraded oligosaccharides. However, the absolute amount of oligosaccharides was low at around 1–2% in total. A range of strategies were applied to enhance the oligosaccharide production, including pretreatment with arabinosidase and feruloyl esterase, thermal pretreatment, and application of the enzymes to AX extracts rather than to the raw substrates. Bagasse AX was found to be more responsive to the xylanase treatment. Subsequent work has developed anion-exchange chromatography approaches to separate mono- and oligosaccharides more precisely, in order to explain the in vivo mechanisms of feed enzymes and to enhance enzymatic production of arabinoxylan oligosaccharides.

Insights on corn characteristics and processing conditions for gluten-free pasta production
A. BRESCIANI (1), M. A. Pagani (1), A. Marti (1)
(1) DeFENS, University of Milan, Milan, Italy

Flours from corn, together with rice flours, are the most common ingredients in gluten-free pasta production. Despite the high variability in amylose content and chemical composition among varieties, the selection of corn for gluten-free pasta production is currently based solely on the absence of gluten, while neglecting the evaluation of both chemical and physical characteristics of the raw material. In this context, this study aimed at investigating the role of amylose content and particle size of flour on the cooking quality of corn pasta. Three corn varieties different in amylose content were used: conventional (CONV; 18% amylose), waxy (W; 2% amylose) and amylomaize (H; 40% amylose), the latter alone or in combination with CONV (50:50). For each corn variety, two flours from different seed regions were obtained during milling: a fine meal (F) from the external part of the kernel (less than 150 μm), and a coarse meal (C) from the inner part (300–500 μm). Samples were characterized for their chemical composition and starch pasting properties. Dried gluten-free pasta (containing 0.3% of mono-
Not everybody feels well on wheat: Separating facts from fiction
F. F. BROUNS (1)
(1) Maastricht University, Maastricht, Netherlands

Along discussions on the role of fat, high fructose corn syrup, fructose, and added sugar, gluten containing grains consumption are also suggested as a significant cause of obesity, syndrome X and other chronic diseases. Causal factors are suggested to be related to components that compromise gut permeability, induce leptin resistance, insulin resistance, intestinal dysbiosis and intestinal distress caused by FODMaPs (rapid fermentable carbohydrates). In addition, effects of “addiction to continued eating” induced by gluten epitopes with opiate like activity. Part of the discussion is fuelled by suggestions that our modern bread wheat is the result of genetic modification resulting in higher contents of gluten, toxic gluten epitopes, amylase trypsin inhibitors (ATIs) and lectins. Over the last decade, these developments have lead to many people avoiding gluten based and FODMaPs containing foods. However, the suggested general influence of grains on detrimental health effects appears to be questionable in the light of data from countries in which the major part of daily energy intake is obtained from wheat based foods. In such countries no history of a higher prevalence of mentioned chronic diseases is present. In contrast, from available data it appears that the consumption of whole grain foods (of which on a global scale >80% come from wheat) is associated with significant risk reductions for diabetes, CVD and colon cancer. Yet, as is the case with many other foods, also cereals may cause intolerance in some individuals. Celiac disease (globally ±1% of the population) and wheat protein allergy (0.3% of population) is well known in this respect. In these conditions exposure to gluten and/or wheat be avoided. In addition, ATIs are known to be potent allergy inducers. Recently it has been suggested that about 30% of persons who suffer from a hypersensitive gastrointestinal system (irritable bowel syndrome, IBS), may be sensitive to ATIs resulting in gut epithelium irritation-inflammation, as a cause of intestinal discomfort and general malaise and fatigue. This condition is now referred to as non-celiac wheat sensitivity (NCWS). Others may suffer solely from feelings of intestinal bloating and rumbling, caused by FODMaPs, present in the diet. However, the content of FODMaPs in whole grain foods is relatively low and does not cause discomfort in non-IBS patients. A general advise to avoid whole grain foods, only for reasons of containing gluten or FODMaPs should be discouraged because this will also lead to significant reductions in fiber and micronutrient intake.

Impacts of sulphur fertilizer application on wheat flour protein and bread crumb structural features
X. LI (1), D. Kaiser (1), G. A. Annor (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Sulphur fertilizer application is known to affect the bread baking quality of wheat flour. However, limited information exits on sulphur fertilizer application effects on bread crumb structural features. These features are important in defining bread quality. This study aimed at understanding the effect of different sulphur fertilizer application levels on wheat protein content, color of bread crust, specific volume and size, number and average area of air cells in bread crumb. Faller, Vantage, Select, Glenn, Mayville and RB07 Hard Red Spring wheat varieties grown in Crookston Minnesota, USA were used. Sulphur rates of 0, 7.5 and 15 lb per acre were applied to the wheat varieties. Grain protein content, bread specific volume, and crumb structural features were measured. The Image J scientific image analysis software (NIH) was used for bread crumb structural features analysis. The L, a* and b* colour parameters were measured using the CR-40 Chroma meter. Seed protein contents ranged from 14.32% to 15.91% for the samples. The addition of sulphur up to 15 lb per acre did not have significant effects on seed protein contents. Addition of 7.5 and 15 lb sulphur per acre in resulted in increased specific volume of breads, which ranged from 2.29 g/cm³ to 3.32 g/cm³. The Faller variety was significantly different from the other varieties with respect to specific volume. As the sulphur concentration increased from 0 to 15 lb per acre, the number of air cells in the bread crumb decreased. An opposite trend was observed for average size of air cells. There was a significant increase in percent area of air cells when more than 7.5 lb per acre was used. Sulphur application did not significantly affect the crust color of the breads. It can be concluded that...
sulphur application beyond 7.5 lb per acre significantly affected the bread crumb structural features of the wheat samples studied.

Processing for health
C. M. COURTIN (1)
(1) KU Leuven – Laboratory of Food Chemistry and Biochemistry, Leuven, Belgium

Cereals in general and wheat in particular have to be technologically processed to make them ready for consumption. The first transformation is milling of the grain, involving size reduction and/or refinement. With the second transformation, we turn the milled cereal into an edible product. With a focus of industry and science on transformation technology and safety, very often, the consequences of processing for the health aspects of the final product, positive or negative, are overlooked. Such knowledge can, however, help to steer processing to match technological and nutritional needs. It can furthermore provide additional counterweight to tackle the increasing demonization of processing for the production of cereal foods. This topic is discussed in this review paper and illustrated by several case studies.

Changes to wheat arabinoxylans during bread-making process
Y. NISHITSUJI (1), K. Whitney (2), K. Nakamura (1), K. Hayakawa (1), S. Simsek (2)
(1) Nisshin Flour Milling Inc., Tsukuba-city, Ibaraki, Japan; (2) North Dakota State University, Department of Plant Science, Fargo, ND, U.S.A.

Arabinoxylans (AXs) are one of the main non-starch polysaccharides in wheat, but their effect on bread-making is not completely clear. In this study, Changes to AXs during bread-making was investigated. Straight dough bread-making tests (AACC 10-09.01) were performed with three flour samples (Bolles, Glenn and Elgin-ND from 2015) and samples were taken at seven stages (flour, mixing, 1st punching, 2nd punching, molding, proofing, and baking) during the bread-making process. The samples were divided into water extractable fraction and water unextractable fraction. The amount of water extractable arabinoxylans (WEAXs), water unextractable arabinoxylans (WUAXs) and arabinose to xylose ratio (A/X) of WEAXs and WUAXs were measured using a gas chromatography. The water extractable fraction was treated with protease and amyloglucosidase and then, WEAXs were isolated. The purified WEAXs were dissolved into D2O and analyzed by nuclear magnetic resonance (NMR). Proton NMR (1H-NMR) analysis was carried out to investigate the changes in structure of WEAXs. The amount of WEAXs slightly increased (Bolles; 0.60 to 0.69% (w/w), Glenn; 0.50 to 0.60% (w/w), Elgin-ND; 0.60 to 0.67% (w/w)) at mixing and increased significantly (0.91, 0.81, 1.04% (w/w), respectively, P < 0.05) at 1st fermentation stage. The amount of WEAXs was stable until the proof stage, and then WEAXs decreased at baking. On the other hand, the amount of WUAXs showed the opposite trend. Structural changes were investigated using 1H-NMR. The resonances at 5.50–5.20 and 4.70–4.40 ppm corresponded to the anomeric protons of arabinoses and xyloses, respectively. The ratio of peak areas which represent unsubstituted xylose and disubstituted xylose significantly increased (P < 0.05) at mixing or 1st fermentation stage. On the other hand, the proportion of mono substituted xylose significantly decreased (P < 0.05) at mixing and 1st fermentation stage. These results indicate that AXs in wheat flour dramatically changed at mixing and 1st fermentation stage. These results suggest that the mono substituted xylose is hydrolyzed and becomes unsubstituted xylose in WEAXs. Also, the WUAXs containing a high degree of disubstituted xylose are solubilized releasing WEAXs with more disubstituted xylose. Laboratory conditions with a lean bread formulation were used in this study; however changes to AXs will be continuous during bread-making. Therefore, changes to the AXs in bread dough and bread from this study can represent changes that may occur to the AXs in commercial bread processing. Additionally, this study can lead to investigation of changes in AXs during many commercial wheat processing methods.

Nitrogen and sulfur fertilization affects on wheat end-use quality and safety
Y. Li (1), G. Chen (1), R. Hu (1), N. Nelson (1), M. Guttieri (2), G. Smith (1), A. Fritz (1)
(1) Kansas State University, Manhattan, KS, U.S.A.; (2) USDA, ARS, CGAHR, HWWGRU, Manhattan, KS, U.S.A.

Sufficient nitrogen (N) and sulfur (S) fertilization during wheat plant growth is essential for grain yield and quality. Previous studies showed that deficient N could limit crop growth potential and yields, and S deficiency could exert a large influence on protein synthesis and amino acid composition. Acrylamide has been a serious public health concern, and bakery products contribute significantly to the total daily acrylamide intake. Till now, relatively less information is available on wheat products quality and safety as related to N and S application, especially the formation of acrylamide during bread-making. Our objectives are to systematically investigate the effect of N/S fertilization on product characteristics of four hard winter wheat varieties, including flour and gluten composition, dough and bread-making properties, and safety assessment of acrylamide formation. The experiment is a 4 × 2 × 3 factorial design where there are 4 levels of genotype (Everest, Fuller, Jagger and 2137), 2 levels of S (0 and 20 lb/ac as ammonium sulfate), and 3 levels of N (50, 90 and 130 lb/ac as urea) grown in
Manhattan, Kansas, USA, with four replicates. Flour characteristics and dough and bread qualities were measured. A RP-HPLC procedure was developed to determine different gluten fractions. Reducing sugar content of flours was quantified. Amount of free asparagine in flour and acrylamide content of bread were analyzed using GC-MS. Both N and S application greatly affected flour protein content. The S/N interaction had a significant effect on dough properties from extensibility and viscoelasticity measurements (P < 0.05). N/S fertilization contributed to the different distribution of gluten proteins, whereas extractability of gliadin content was significantly increased with the increasing of N fertilizer with or without S application (P < 0.05). No significant effects of S, and S nested within N treatment were found in acrylamide concentration of bread crust for Everest (P > 0.05), while N application had a stronger effect, which was attributed to the change of concentration of asparagine and reducing sugar in the flour. The average acrylamide concentration was from 144.8 to 222.7 μg/kg in Everest fresh crust. Our study showed that an appropriate N/S fertilization is critical when considering the positive influence in dough and bread-making properties. It will also help producers manage their practices to limit the acrylamide potential and optimize the winter wheat cultivars to enhance end-use quality.

Protein engineering of barley limit dextrinase activity

S. Andersen (1), M. S. Møller (2), S. Andersen (1), M. S. Møller (2), B. SVENSSON (2)

(1) Technical University of Denmark, Lyngby, Denmark; (2) Department of Biotechnology and Biomedicine, DTU, Kgs Lyngby, Denmark

Objectives: Structural elements of barley limit dextrinase N-terminal and catalytic domains are subject to characterization with regard to roles in the level of debranching activity and in preferred substrate specificity. This addresses two enigmas on cereal debranching enzymes, namely the importance of the N-terminal putative starch binding domains for activity as well as features of the active site region that determine the high activity on α-limit dextrins as compared to a low activity level on amylopectin. This seems a particular substrate preference distinct from other debranching enzymes having high activity on polysaccharides. Methods: Site-directed mutagenesis in limit dextrinase investigating structure function relationships of substrate specificity is guided by the uniquely available crystal structure of an enzyme-substrate complex obtained using inactive catalytic residue mutants of limit dextrinase prepared in Pichia pastoris as heterologous host. Additionally, site-directed mutagenesis was used to explore the role of residues in the N-terminal domain for the level of activity as hypothesized based on genetic variants of limit dextrinase in sorghum and rice. The different mutants were characterized for kinetic parameters towards polysaccharides and an oligosaccharide model substrate. Results: Single mutants guided by genetic variants at the N-terminal domain that resembles starch binding domains of family CBM21 impacted on enzyme function despite being remote from the active site and showed 15–40% catalytic efficiency for a-limit dextrin, amylopectin and pullulan, while a double mutant had 27% catalytic efficiency for β-limit dextrin and 64% for the other two polysaccharides. Mutant activities for the short 4,6-O-benzylidene-4-nitrophenyl-6’-α-D-maltotriosyl-maltotriose (BPNPG3G3) were 51–109% of wild type suggesting an allosteric function of the N-terminal domain. At the active site, Phe533 sandwiches the substrate main chain at subsite +2 with Phe512 that is highly conserved among different debranching enzymes. Phe553 Gly lost 53% and 75% activity towards pullulan and the BPNPG3G3 oligosaccharide, respectively, confirming its role at subsite +2. Remarkably for Phe620 and Asp621, situated at subsite +3, Phe620Ala lost 20–33% activity on the three polysaccharides and 57% on BPNPG3G3, while the double mutant Phe620Ala/Asp621Ala lost 86% and 75% activity for these substrates. This emphasised the combined effect of these two residues and hence the importance of Asp621 in action on poly- and oligosaccharides at subsite +3. The findings guide substrate-enzyme complex modelling to describe the interaction of cereal limit dextrinase with polysaccharide substrates.

Acknowledgements. This work is supported by The Danish Council for Independent Research | Natural Sciences and a DTU PhD fellowship (to SA).

Impact of different S. cerevisiae yeast strains on gluten-free dough and bread quality parameters

J. J. ATZLER (1), S. W. Horstmann (1), M. Heitmann (1), E. Zannini (1), E. K. Arendt (1,2)

(1) University College Cork, School of Food and Nutritional Sciences, Cork, Ireland; (2) APC Microbiome Institute, Cork, Ireland

Yeasts have been used for centuries for the leavening of bread. The main emphasis on the selection of yeast strains has been in relation to wheat products. This study is the first evaluation of different yeasts coming from the baking and brewing industry in a gluten-free system. Recent market studies performed, revealed that gluten-free breads are still lacking flavour and structure. Five different yeast strains (US-05, WB-06, T-58, S-23, baker’s yeast) of the species S. cerevisiae were evaluated for their suitability to leaven gluten-free dough. A wide range of dough quality characteristics such as the time and temperature-dependent rising behaviour, the chemical composition of the dough and the pH were determined. In addition to this the bread quality attributes such, volume, texture, structure, aroma and flavour were evaluated. The results indicated different activity levels of the five yeast strains. Doughs prepared with US-05 showed during proofing a slower dough rise and a decreased height, in comparison to baker’s yeast control. The application of WB-06 and T-58 however, resulted in a faster dough rise and increased dough height with greater gas cells. These observations were also found in the baked
breads, where these two yeasts reached a higher specific volume and a softer bread crumb than the baker’s yeast. In conclusion significant differences both in the dough as well as in the bread characteristic were found. The S. cerevisiae WB-06 and T-58 which originated from the brewing industry performed better than the traditional baker’s yeast in bread quality parameters, such as volume and hardness.

**Potential effects of climate change on mycotoxins in grain**

P. Battilani (1)

(1) Department of Sustainable Crop Production, Università Cattolica del Sacro Cuore, Italy, Piacenza, Italy

Mycotoxins are expected to impact significantly on food security and safety in the ongoing climate change. It is confirmed that temperature and CO₂ will increase in the future, but uncertainty will remain the main sureness in climate change. Extreme events are announced, wide variability between years but also during each year. Different biogeography of plants is estimated, fungi (and related toxins) of main concern are expected to change between and within years. Overall, climate change is considered to increase health risks, but this conclusion is not obvious. Maize in central-southern Europe is an interesting example to justify this statement. Maize is a suitable host plant for several very relevant mycotoxin-producing fungi. Fumonisins are the prevalent mycotoxin detected in maize, frequently above the legal limit fixed by the European Commission for human consumption.

Aflatoxins, even typical of tropical areas, are actually the main concern, both for food and feed. After their first outbreak in 2003 and the current year, at least 4 critical seasons can be mentioned, causing uncertainty to farmer income and contributing significantly to the reduction of maize growing hectares. During the last 14-year period, 2014 showed high deoxynivalenol contamination and 2011 was a safe year, with very low detection of all mycotoxins. Therefore, uncertainty and variability are the main sureness also regarding mycotoxin contamination. Predictions regarding the impact of climate change on mycotoxin in grain highlight aflatoxins as the main concern for the future, but they also stress the wide variability expected in mycotoxin occurrence between years and places. Predictive models can be very useful in this uncertain future, to support both farmers, extension services and stakeholders to rationalize pre- and post-harvest crops and products management and policy makers to define emerging risks and related actions.

**TD-NMR characterization of crumb in gluten-free bread baked under partial vacuum**

C. Rondeau-Mouro (1), M. Cambert (1), C. Godfrin (1), J. Rouillac (1), Y. Diascorn (1), T. Lucas (1), D. Grenier (1)

(1) IRSTEA, Rennes, France

Based on spin-spin T₂ relaxation time measurements, the time-domain NMR (TD-NMR) spectroscopy has been used to provide relevant information on the water and biopolymer motion and transfer in bread [1]. This technique permits to characterize molecular interaction and transformations in a non-invasive and non-destructive way, in real time during a process (heating, freezing, hydration…). In bread, proteins of gluten when hydrated form a viscous mass that confers to the dough, structure, viscosity, mixing tolerance and gas holding ability [2]. On the other hand, starch, in presence of water and increasing temperature, undergoes a series of changes known as swelling, gelatinization and retrogradation that induce variations in water distribution, in starch structure and interactions between them [3]. This study aimed at understanding and ranking the contribution of these biochemical transformations that contribute to the crumb structure and the textural properties of bread made with a gluten-free mix (Schär). The water transfers and the extent of starch gelatinization in crumb were studied by TD-NMR after the heating/cooling process of dough hydrated at 55% and 48% (wet basis). Two baking processes were compared, one at the atmospheric pressure while the other was carried out at reduced pressure (−20 kPa). Bread baking using partial vacuum results in greater oven-rise and greater gas fraction in the crumb, giving an increased softness of the crumb for a more pleasant mouthfeel. Under reduced pressure, the boiling point of water decreases but, until now, no study was conducted to check if this baking condition may modify the starch gelatinization and protein denaturation. By comparing rheological measurements (modulus of elasticity using a compression stress relaxation experiment) with TD-NMR data, it was shown that the crumb softness was mostly driven by the gas fraction while the biochemical changes (starch gelatinization, protein denaturation), monitored by TD-NMR, were little modified when dough was baked under partial vacuum. [1] C. Rondeau-Mouro, M. Cambert, R. Kovrlija, M. Musse, T. Lucas, F. Mariette, Food and Bioprocess Technology 8 (2015) 777-790. [2] T. van Vliet, Journal of Cereal Science 48 (2008) 1-9. [3] C.G. Biliaderis, Food Technology 46 (1992) 98-109.
Hydrothermal pre-processing for milling sorghum
K. SILIVERU (1), R. A. Miller (2)
(1) Grain Science and Industry, Kansas State University, Manhattan, KS, U.S.A.; (2) Kansas State University, Manhattan, KS, U.S.A.

The current sorghum milling industry is small to medium scale and uses hammer mills for milling sorghum, in order to produce the whole grain flour. This results in high milling losses, bran contamination, and inconsistent flour quality. Appropriate pre-processing methods prior to roller milling could produce the white sorghum flour and also helps in improving the milling yields and flour quality. In this study, the effect of water temperature and tempering time on sorghum kernels and flour quality properties were studied. Structural changes in kernel, single kernel characteristics (SKCS), abrasive hardness index (AHI), milling, and flour quality parameters were evaluated as an effect of pre-processing conditions. Three sets of tempering methods were carried out: (i) cold tempering (at 24°C); (ii) hot tempering (at 60°C); and (iii) steam tempering (at 15 psi for 0.5, 1, and 1.5 min). The cold and hot tempering methods were conducted with targeted moisture contents (m.c.) of 16 and 18% (% wet basis) at 12 and 24 h tempering times. At 16% m.c. cold water tempered sorghum had both higher SKCS hardness and abrasive hardness than hot water and steam tempered sorghum kernels. With increase in tempering time, the AHI of hot water treated sorghum kernels increased due to toughening of the pericarp. The scanning electron microscope (SEM) images of steam treated kernels revealed that these kernels had a high degree of penetration of water into the pericarp when compared to cold and hot water tempering methods. This high degree of penetration is reflected in their milling yields as well. The milling study revealed that, the sorghum kernels tempered to 16% moisture had higher milling yields when compared to those tempered to 18% moisture. This is due to flaking of endosperm particles at higher moisture content. The steam treated sorghum kernels (1 min) and hot water tempered sorghum (16% moisture at 24 h tempering) produced white flour with less damaged starch when compared to the flour obtained from other treatments. Overall steam tempering for 1 min and hot water tempering to 16% m.c. (24 h tempering) led to a better separation of bran and endosperm with high milling yields and lower starch damaged flour. The purpose of this study is to develop an efficient roller milling process to produce white sorghum flour, however the tempering methods evaluated in this study are cost intensive and the feasibility of this will be evaluated in the future work.

Study on health function of Sphacelotheca reiliana(Kühn) based on mice’s gut microbiota
C. Lu (1), Y. Li (2), J. Zhou (1), J. Han (1), X. SU (1)
(1) Ningbo University, Ningbo City, China; (2) King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

Sphacelotheca reiliana (Kühn), known as a traditional food “Umi” in China, cause the head smut of Sorghum bicolor (L.) (Moench), belongs to basidiomycotina fungi. It is rich in protein, carbohydrate, minerals, vitamins and other nutrients, and has been widely used as an edible fungus in the USA. In this study, 24 four male mice were randomly allocated to receive a standard chow diet (control group) or a chow diet supplemented with Umi (Umi group) continuously for 12 weeks. On the one hand, the Umi treatment attenuated the body weight gains, improved the anti-fatigue and anti-oxidation abilities, as well as the blood lipids levels. On the other hand, the Umi treatment induced a totally different gut microbiota structure compared with the control, with reduced community richness and diversity. Firmicutes and Bacteroidetes were the most abundant phyla, accounting 97.69% and 89.8% in the control and Umi groups, respectively. However, a lower Firmicutes/Bacteroidetes index was observed in the Umi groups compared with the control, which is considered to be associated with obesity. In addition, the Umi treatment increase the genera Bacteroides, Coprococcus, Clostridium, Roseburia and Ruminicoccos, all of which are short-chain fatty acid (SCFA) producers in the intestinal tract, and various studies indicated that the gut microbiota benefits humans via SCFA production, and deficiency in SCFA production is associated with diseases. In conclusion, this study confirmed the probiotic-like effects of Umi dietary supplementation and showed that Umi supplementation induced alterations in the composition of the gut microbiota. Further research will be needed to elucidate the causal relationship between the probiotic-like effects and gut microbiota modulation and developed the Umi as a novel microbiota-directed food for healthy.

Pumping iron: Altering expression of a wheat iron transporter gene improves the mineral content of white flour
J. CONNNORTON (1,2), C. Uauy (1), J. Balk (1,2)
(1) Department of Biological Chemistry, John Innes Centre, Norwich, U.K.; (2) School of Biological Sciences, University of East Anglia, Norwich, U.K.

Iron is an essential nutrient but over a billion people worldwide suffer from iron deficiency diseases. The majority of these eat predominantly cereal-based diets low in bioavailable minerals. Biofortification is an attractive method for increasing the mineral content of grains, but iron is under strong homeostatic control in plants. So far, attempts to breed for high grain iron in cereals have not been successful. As a transgenic approach to increase grain iron content, we searched the wheat genome for vacuolar iron transporter (VIT) genes, and found two
milled from transformants showed a 2–4 fold increase in iron content compared to controls. Preliminary experiments suggest the iron in flour milled from transformed grain is more bioavailable to Caco-2 cells than control flour, and further bioavailability analysis is currently underway.

Production and characterization of ready-to-eat pulse flakes
S. CORK (1,2), C. L. Blanchard (1,2), J. Mawson (1,3), A. Farahnaky (1,2)
(1) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (2) School of Biomedical Sciences, Wagga Wagga, Australia; (3) School of Agricultural and Wine Sciences, Wagga Wagga, Australia

Pulses are a food of global significance due to their high protein and dietary fiber content. Pulse consumption is below recommended levels in developed countries and is also declining in developing nations. Pulse flakes are currently only present in the ready-to-eat (RTE) market as niche products, but could be a means of increasing pulse consumption if the challenges of their structural weakness, “unpleasant” flavors and long cooking times can be overcome. We analyzed the influence of processing conditions on the flaking properties of Australian chickpea and faba bean splits using a pilot scale flaking line and the physicochemical properties of the flakes produced from these processes. Chickpea or faba bean splits were first precooked for six minutes with different steam injection times (one, three or five minutes). The precooked splits were then passed through a roller flaker with different roller gaps ranging from 0.6–1.9 mm and the pulse flakes were finally dried using a fluidized bed drier at either 150°C or 200°C. The hard-brittle splits, through the heating and live steam injection, transitioned to a rubbery state that were flaked successfully. Moisture content and hydration properties were determined gravimetrically and differential scanning calorimetry was used to evaluate the degree of starch gelatinization and protein denaturation. Flake hardness was evaluated using a texture analyzer and flake structures investigated using scanning electron microscopy. Starch gelatinization increased with steaming time, while protein denaturation was not significantly affected. Cellular structures were conserved in the flakes produced. Flake hardness was negatively correlated to steaming time. Successful production of chickpea and faba bean flakes offers opportunities for the production of healthy, high-protein high-fiber RTE foods.

Tritordeum, a new cereal for healthy products
P. BARCELO-ENSESA (1)
(1) Agrasys, Barcelona, Spain

Tritordeum (×Tritordeum Ascherson et Grabner) is a novel cereal crop. It is the hybrid between durum wheat and a wild barley (Hordeum chilense) native of Chile and Argentina. It is the second “modern” cereal crop to be created, following-on from triticale and has been developed with human food use in mind. Tritordeum was first synthesised in the early 1980s and a breeding programme was established at the CSIC Institute for Sustainable Agriculture in Córdoba, Spain to develop the new hybrid into an alternative cereal crop. Both octoploid and hexaploid tritordeums exist, but breeding work has focussed on hexaploid forms, which have the genetic constitution AABBHchHch. Morphologically, tritordeum resembles wheat and has awned six-row ears. At the agronomic level, tritordeum is grown as a winter cereal and current varieties are best adapted to Mediterranean-type climates. Tritordeum is a robust crop suited to production in integrated and organic production systems. It has good resistance to several important cereal diseases, including yellow and brown rusts and Septoria. Tritordeum has naked, elongated grains with a thousand grain weight in the range 33–38 g. In terms of grain composition, tritordeum lines typically have higher protein content than bread wheats, in the range 12–14%, tritordeum is also characterised by higher levels of fibre (4–7%) and by higher levels of fatty acids (2–4%, with preponderance of oleic acid) and it is characterised by very high levels of lutein (in the range 4–6 μg/g, more than 10 times the levels typical for bread wheat). The high lutein content is a distinguishing trait for tritordeum, as flours and baked products have a golden-yellow colouration. Tritordeum gluten is characterised by having reduced levels of omega gliadins and when analysed using the R5 or G12 ELISA assays tritordeum lines are seen to have significant reductions in the levels of immunogenic gliadins (60–70%) by comparison with typical bread wheat varieties. This characteristic makes the new cereal of interest for consumers with gluten intolerance and nutritional trials have demonstrated that by comparison with a wheat diet a tritordeum diet can reduce the levels of immunogenic gliadins in the intestine by more than 70%. An overview of the history, development and current status of tritordeum as an alternative cereal crop will be given and its nutritional and functional properties suitability for use as an ingredient for healthy cereal food applications will be discussed.
Effect of nitrogen fertiliser rate and timing on grain quality parameters and protein composition of rice grown in south-eastern Australia

(1) ARC ITTC for Functional Grains, Wagga Wagga, Australia; (2) Southern Cross University, Lismore, Australia; (3) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia; (4) NSW Department of Primary Industries, Yanco, Australia

Nitrogen fertiliser is an important crop management practice used to increase yield. Growers use the previous growing history of a paddock to determine the correct nitrogen (N) rate, as there is no appropriate soil N test for rice. In south-eastern Australia, the total N rate is often split into two applications to reduce the risk of sterility induced by cold temperatures and high N uptake. This strategy involves a basal N application applied pre-permanent water (PW) and the second application following panicle initiation (PI). While previous research demonstrates that split N application (pre-PW and PI) affects crop yield, data investigating the impact on grain quality is relatively sparse. Using the medium-grain, semi-dwarf rice variety YRM70, we compared the effect of eight N treatments (five N rates applied pre-PW and three split treatments with the same total N rate) on grain quality parameters and protein composition. These data revealed increasing the rate of N applied pre-PW significantly increased head rice yield (HRY; the proportion of unbroken grain expressed as a percentage of harvested grain), however, splitting the same total N rate into two application reduced HRY. HRY decreased as the rate of the first N application decreased and the second dose increased. This trend was also observed for RVA setback with the split N treatments producing a more negative than the pre-PW N treatments. When analysing protein composition, glutelin and globulin showed significant positive correlations with N uptake at PI while albumin was negatively correlated. Prolamin concentration increased as the N rate applied after PI increased which concurrently reduced the globulin concentration. We found that albumin and globulin were significantly negatively and positively correlated with head rice yield and RVA setback, respectively. Applying N after PI increases the prolamin and albumin concentrations which significantly decreases HRY and RVA setback. These results indicate altering the nutritional management of rice changes the protein composition affecting grain quality parameters.

Transforming the Australian grains industry through the development of grain based functional foods that deliver health benefits

C. L. BLANCHARD (1)
(1) ARC ITTC for Functional Grains, Graham Centre for Agricultural Innovation, Wagga Wagga, Australia

Australia is a significant producer and exporter of grains including wheat, barley, oats, sorghum, rice, canola, chickpeas and lentils. The majority of the grain crops grown in Australia are exported as relatively low value commodities. While grains are well known as a good source of nutrients, they are also an important potential source of high value functional proteins and bioactive compounds. These bioactive compounds have the potential to improve health outcomes for consumers. This presentation will outline some of the research undertaken in the Functional Grain Centre to identify bioactive properties of Australian grown cereals, oilseeds and pulses. Peptides produced from canola proteins were fed to spontaneously hypertensive rats and their blood pressure was monitored. Administration of peptides was found to reduce blood pressure. Bioactive compounds extracted from canola meal were used in assays that measured topoisomerase enzyme inhibition. Assays demonstrated canola peptides inhibited topoisomerase enzymes which may prove useful in anti-cancer therapies. Extracts from faba beans and pigmented rice were shown to induce apoptosis in cancer cells but not non-cancerous cells when applied in vitro. Extracts from pulses, canola and coloured rice were also assessed for potential anti-obesity properties by applying the extracts to differentiating stem cells to see if adipocyte formation could be inhibited. Extracts were found to inhibit adipogenesis in differentiating fat cells by reducing the expression of key genes. Rats were fed with rice bran containing enhanced levels of gamma aminobutyric acid (GABA) to determine the impact on weight gain. Rats fed with GABA enhanced rice displayed a reduction in weight gain as well as a range of other improved health outcomes.

Digital food design of cereal products by means of additive manufacturing (3D printing)

M. W. J. NOORT (1), K. Van Bommel (2)
(1) Wageningen Food & Biobased Research, Wageningen, Netherlands; (2) TNO, Eindhoven, Netherlands

Additive manufacturing, also known as 3D-printing, is an upcoming production technique based on layer-by-layer deposition of material to reproduce a computer generated 3D design. Digitalization, personalization and consumer empowerment are important drivers for the strongly increasing interest in additive manufacturing for local on-demand, flexible food production. Additive manufacturing offers specific potential to create cereal based food products, and original research progress in this field will be presented. One of the most developed additive manufacturing techniques is fused deposition modelling (FDM). This technique was used for 3D printing of biscuits. Suitable biscuit formulations were developed based on their rheological properties and thermomechanical behaviour to be printable and remain their printed structure during baking. Baked biscuits can be
How the addition of different proteins influences characteristics of gluten-free breads optimizing their hydration level?
M. Sahagun (1), M. GOMEZ PALLARES (1)
(1) University of Valladolid, Palencia, Spain

Most gluten-free products usually have lower protein content than their counterparts with wheat flour. The solution to compensate this lack could be the addition of proteins. Moreover, the addition of exogenous proteins could be also a tool to create gluten-free products with high protein content. Most studies that deal with the incorporation of protein in gluten-free breads use a formulation with the same amount of water for all elaborations. However, each protein has different water binding capacity and this fact could modify dough rheology and, in turn, would affect bread volume. Thus, the hydration conditions are very important for optimizing the use of each protein since protein adequacy not only depends on their own characteristics but also on the hydration level of the formulation. Therefore, the aim of this study was to analyze the incorporation of a high percentage (30%) of several proteins (rice, pea, egg white and whey protein) in gluten-free breads whose hydration levels were adjusted for each protein to achieve the maximum volume. For the optimization, the evolution of specific volume against the hydration level was modelling, so that the maximum volume could be obtained; and, the influence of hydration level changes on specific volume was studied. The bread formulations with the optimized hydration level were elaborated and the rheological batter properties and bread characteristics (specific volume, weight loss, texture and color) were measured. The vegetal protein breads required a higher amount of water than the enriched animal protein and control breads. All enriched breads exhibited lower maximum volume values than control, being the ones with whey protein the lowest. Moreover, a reduction of hydration level led to a volume drop, moving away from maximum values, except the egg white protein breads for which the volume drop is lower. Regarding rheological properties, the whey protein batters presented the highest $G'$ and $G''$ values because of their hydration level that was the lowest. Meanwhile, the ones with egg white protein had the most liquid behavior. As for bread characteristics, the addition of vegetal proteins hardly modified the bread hardness, while breads with animal proteins exhibited higher hardness than control due to the coagulation process of egg white protein and the low specific volume of whey protein breads. Regarding color, the protein enriched breads were darker than control, being the whey protein the one that gave rise to the darkest crust.

Using multiple linear regression based quantitative and qualitative testing to indicate quality of white salted noodles
A. DUBAT (1)
(1) CHOPIN Technologies, Villeneuve la Garenne, France

Twenty-four samples composed of 8 varieties of Australian wheat grown in 3 different locations have been analyzed using quantitative data (protein, falling Number, flour ash, starch damage and flour swelling volume) and by analytical devices (Chopin-SRC and Mixolab). White salted noodles (WSN) (Udon) style were made using same flour samples and analyzed for noodle quality by sensory and objective tests. Eating quality of noodles was evaluated by a trained sensory panel and also by TA-XT2iPlus (cutting blade TA-047s). Color of noodles was also analyzed by a trained sensory panel as well as measured with the Minolta Chroma Meter (CR-300) at time zero and 24 hr of noodle making. Boiled noodle color was also analyzed. The aim of the study was to determine which parameter, or combination of parameters, are the most indicative of end product (WSN) quality. Relationship and color changes during the process have been investigated. The cooked noodle color was a major quality attribute for this product. By using Multiple Linear Regression (MLR) this study allowed to establish good prediction models for $L^*$ ($r^2 = 0.81$), $a^*$ ($r^2 = 0.92$) and $b^*$ ($r^2 = 0.77$), combining data from the SRC (SUC-SRC, LAC-SRC, NAC-SRC, GPI-SRC) and the Mixolab (WA, C3, C5). Texture analyzer (TA-XT2iPlus) parameters of interest were firmness and work of shear. These parameters were respectively well predicted ($r^2 = 0.76$ and $r^2 = 0.73$) by combining quantitative data (flour protein and flour ash) and qualitative parameters obtained from both SRC and Mixolab tests. Noodle scoring is composed of 5 different indicators. "Total noodle score" and "boiled noodle surface appearance" were very well predicted using MLR with respectively $r^2 = 0.80$ and 0.70. "Elasticity/stickiness" was well predicted ($r^2 = 0.70$) and "smoothness" and "softness/hardness" scores were showing less strong prediction with both showing $r^2 = 0.62$. This study showed that correlating complex quality
indicators such as noodle color and texture to only one analytic parameter can be quite limited. On the contrary, having a wider approach, using regression models, allows to improve the prediction models and also to determine which are the main analytical data is really useful for determining WSN quality. Such technique can show very useful applications for breeders but also for building efficient specifications books.

**Chemical and physical properties of quinoa (Chenopodium quinoa Willd.) as affected by germination**

D. P. Suárez Estrella (1), A. Marti (2), M. A. PAGANI (2)

(1) University of Milan, Milan, Italy; (2) DeFENS, University of Milan, Milan, Italy

Awareness of the several agronomic, environmental, and health benefits of quinoa has led to a constant increase in its production and consumption not only in South America, where it is a native crop, but also in Europe and the United States. Producing quinoa-enriched products alters some quality characteristics, including sensory acceptance, due to the presence of bitter and astringent compounds (i.e. saponins). Developing processes to decrease or modify the bitterness of quinoa can enhance palatability and thus consumption of quinoa. In addition to the production of sweet varieties of quinoa, other processes have been proposed. Some of them (i.e. washing, pearling and the combination of the two) have a direct effect on saponins, either by solubilisation and/or the mechanical removal of seed layers. Others, such as fermentation, are able to mask the bitterness with aroma compounds and/or sugar formation. In this study, controlled germination has been explored as an alternative treatment to decrease quinoa bitterness and improve technological performance of the related flour. Seeds were germinated at 22°C for 12, 24, 48 and 72 hours, then dried at 55°C for 6 hours. Untreated and pearled quinoa were used as references. Chemical, physical, technological and sensory changes were assessed in both seeds and flours. Enzymatic activity developed during germination highly affected the starch content, its pasting properties and water affinity. Foaming capacity of quinoa flour decreased from 30.5 to 18.4%v/v, nevertheless, its stability increased from 47.0 to 54.1%. Germination process promoted a significant decrease in saponin content (from about 4 mg/g in native seeds to 2.61 mg/g after 48 h), evaluated by the official Ecuadorian method NTE INEN 1672, an indirect approach, based on the foam height developed after vigorous agitation of seeds in water. Nevertheless, this trend is opposed to that shown by the spectrophotometric method: the latter exhibited an increase in saponin content during germination, from 5.3 to 6.6 mg/g db after 48 h. Moreover, other potential bitter compounds, such as phenols and flavonoids, increased from 2.06 to 3.57 mg GAE/g db and from 3.18 to 4.09 mg QE/g db, respectively. Nevertheless, germination enhanced sugar formation, likely responsible for masking the perception of bitter taste, as shown by e-tongue results. The main effects occurred during the first 48 hours of the process. Information about the effects of germination on technological properties of quinoa flour will be useful for the development quinoa-enriched products.

**Physical structure and dissolution of wheat bran and its comprised layers**

A. L. Mense (1), Y. C. SHI (1)

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

Wheat bran is a by-product of the wheat flour milling industry. The number of food products containing wheat bran is on the rise because it is a well-recognized good source of dietary fiber. Currently, bran is a low-value commodity used mostly in animal feed, but it has the potential for more extensive applications. To understand the functional and nutritional properties of wheat bran and better use wheat bran in food, it is critical to understand the physical structure of wheat bran. The objectives of first part of the work were to 1) determine the physical structure of untreated wheat bran and the differences in physical structure between its dissected layers; 2) evaluate how bran hydration affected bran crystallinity and polymer order; and 3) determine how enzymatic treatment of wheat bran affected its physical structure. For the first time, X-ray diffraction (XRD), small angle X-ray scattering (SAXS), and solid-state 13C cross-polarization magic-angle spinning nuclear magnetic resonance (13C CP/MAS NMR) were used to study the physical structure of wheat bran and its dissected layers. The XRD and solid-state 13C CP/MAS NMR both confirmed the presence of crystalline cellulose in untreated bran, enzymatically treated bran, and dissected bran layers. Most of the crystalline cellulose was present in the outer pericarp with a much lower proportion in the intermediate layer. The aleurone layer was completely amorphous. Hydration of the outer pericarp increased the signal intensity of its XRD diffractogram and CP/MAS NMR spectrum and indicated a possible increase in polymer order. In the second part of the study, we applied a NaOH/urea solvent to solubilize wheat bran and determined the structure of soluble materials. Destarched and deproteinized wheat bran (DSDPB) was treated with a mixture of either 7 or 9% sodium hydroxide and 12% urea solvent and structure of the extracted polymers was investigated. Three and 6 cycle dissolution schemes, were examined involving the repeated cooling of the solvent bran mixture to −12.6°C and then agitating it at 25°C. When 7% NaOH/12% urea (6 cycle) was applied to DSDPB, 84.1% of the material was solubilized including 89.8% of the arabinoxylans (AX). This procedure recovered more wheat bran AX for characterization than any previous study using alkaline dissolution. In addition, wheat bran was enzymatically and hydrothermally treated in water to maximize the soluble fraction, which could be used in food applications.
Evaluation of dough rheological properties of wheat samples from various geographical regions and wheat cultivars
A. DUBAT (1), G. Tawil (1), O. Le Brun (1), G. Vericel (1)
(1) CHOPIN Technologies, Villeneuve la Garenne, France

One-hundred fifty wheat samples originating from various geographical regions (17 countries distributed on the 5 continents) were evaluated for their rheological properties using the Mixolab according to the Chopin+ protocol. The technique measures the dough changes when subjected to large deformations and to temperature sweeps. Several parameters were used to evaluate a Mixolab curve. Water absorption (%b14), WA; stability (min), initial maximum consistency (Nm), C1; torque at the end of the holding time at 30°C (Nm), C5; minimum consistency produced by dough passage while being subjected to mechanical and thermal constraint (Nm), C2; are related to protein quality, whereas peak torque reached during the heating stage (Nm), C3; minimum torque reached during cooling to 50°C (Nm), C4; final torque reached after cooling at 50°C (Nm), C5 are related to the starch characteristics. As depicted from the Mixolab patterns, significant variations during mixing, pasting and gelling were noticed among the wheat samples depending on both the geographical regions and wheat cultivars. WA, stability, C5, C2, C4 and C5 varied from 49 to 66%, 1.9 to 11.7 min, 0.76 to 1.14 Nm, 0.32 to 0.70 Nm, 1.45 to 2.62 Nm, 0.77 to 2.64 Nm and 1.12 to 4.19 Nm, respectively. Focusing on the geographical regions, the largest variations were found among the wheat samples collected from the USA, France, Canada, Argentina, Spain and Kazakhstan rather than those collected from India, South Africa, Greece, Turkey and Italy. Wheat cultivars also influence the rheology of wheat dough. Our results showed great differences between hard and soft wheat, while less variations were noticeable within each category. Higher WA, stability, C5 and C2 were observed for hard wheat, while lower C3, C4 and C5 were found in comparison to soft wheat. Average values of WA, stability, C5, C2, C3, C4 and C5 were 59.2 ± 4.1%, 9.4 ± 1.7 min, 1.07 ± 0.04 Nm, 0.48 ± 0.04 Nm, 2.07 ± 0.21 Nm, 1.77 ± 0.14 Nm, and 2.99 ± 0.34 Nm for hard wheat while 50.8 ± 0.8%, 5.9 ± 2.2 min, 0.88 ± 0.10 Nm, 0.37 ± 0.04 Nm, 2.47 ± 0.07 Nm, 2.18 ± 0.09 Nm, and 3.83 ± 0.06 Nm for soft wheat, respectively. This study confirmed the strong variability in wheat quality depending on both the geographical regions and wheat cultivars. Analytical tools were shown successful in classifying the wheat samples and in evaluating their rheological performances.

Microbiological challenges and milling interventions to address emerging concerns related to the safety of wheat-based products
A. BIANCHINI (1)
(1) University of Nebraska, Lincoln, NE, U.S.A.

In the last few years the milling industry has been involved in several outbreaks associated with wheat flour. In the US and Canada, more specifically, outbreaks and associated recalls have been caused by the contamination of wheat flour with Salmonella and E. coli non-O157 STEC strains. This presentation will focus on the microbiological challenges faced by this industry along with some potential interventions to address this issue. In general, control measures discussed will include those associated with the general microbial assessment of the milling environment and those applied during the tempering step. These interventions and information regarding their effectiveness or potential effect on flour functionality will be discussed in this presentation. Additionally some consumer behaviors that deserve consideration regarding safety of cereal based products will be addressed as well, along with some future perspectives in this area.

Understanding the genetics of wheat quality using MAGIC populations
(1) CSIRO Agriculture and Food, Canberra, Australia; (2) CSIRO Data 61, Canberra, Australia; (3) Murdoch University, Perth, Australia; (4) 3 Baron Hay court, Perth, Australia; (5) Department of Primary Industries and Regional Development, Bentley, Australia

Wheat breeding requires assessment of both agronomic and quality parameters to ensure the varieties developed meet both farmers and end users requirements. Throughout the breeding process, grain and flour are valuable and scarce—a limiting resource. This limitation and the cost and complex nature of wheat based end-product evaluation mean quality assessment occurs late in the breeding cycle. This creates a bottle neck in wheat breeding programs and can result in agronomically advantageous lines being eliminated late in the breeding cycle. This represents a loss to breeders and growers, and thus robust genetic markers for end-product quality are required to mitigate against this. To identify robust markers of quality CSIRO undertook the development of multi-parent advanced generation intercross (MAGIC) populations capable of overcoming the limitations of bi-parental and association mapping populations. The resulting 4 and 8 parent MAGIC populations were used in a multi-year, multi-site study to identify genetic markers of wheat quality. These assessments include test weight, grain protein, milling yield, water absorption, wet gluten content and straight dough baking. Three site years from the 4-parent, two from Eastern Australia, and one from Western Australia, and four site years (from both Eastern and Western Australia) from the 8-parent MAGIC population were assessed. Here we present the results from three site years for the 4-parent MAGIC population and discuss the implications for enhancing breeding for quality traits.
The challenges and opportunities of data sharing across complex industrial value chains
E. TSIPORKOVA (1), T. Tourwé (1), N. González-Deleito (1)
(1) EluciDATA Innovation Lab, Sirris, Brussels, Belgium

Data can be a real game changer for companies, but data sharing in an industrial context is complicated. Especially in sectors where complex value chains are in place, access to data is not always possible for every stakeholder. Next to enabling new data-driven business models, data allows one to acquire new insights to optimise production processes, predict the quality of the end-product, profile product usage or set up data-oriented start-ups. However, having access to data and/or collecting it might not always be trivial, and one of the main obstacles to further advance in regard to data-driven innovation remains data sharing. In many situations, not every party in the value chain has access to the data or has the right to exploit the data, and therefore cannot make an intelligent use of this data. The talk aims to provide an answer to the following questions: Why is sharing data beneficial and the sensible thing to do? What are the risks, uncertainties and challenges related to sharing data? What can we learn from different domains about how to approach data sharing?

Impact of long-grain rough rice storage conditions on cooked rice sensory profile
M. Rodríguez-Arzuaga (1), B. GÓMEZ (1), N. Ponce de León (1), M. A. Billiris Julien (1)
(1) Latitud – Latu Foundation, Montevideo, Uruguay

Rice undergoes different biochemical and physiological scenarios when stored inside a bin. Operating conditions during storage such as location in the bin, aeration regime and ambient conditions define grain temperature (T) and moisture content (MC). Grain conditions as well as storage period (t), impact rice quality. The objective of this investigation was to study the effect of different storage conditions (MC, T and t) on the sensory attributes of cooked rice. Rice (cv El Paso 144) was harvested in Rocha (Uruguay) at an average MC of 21.4%, cleaned and mixed before random division in two lots. The two lots were gently dried (in a lab chamber at 25°C and 65% relative humidity) until 15 and 13% MC, respectively. After drying, samples were packed in sealed multilayer bags and stored at different temperatures (T: 5, 10, 20 or 30°C). Sensory descriptive analyses were performed after 0, 3, 7 and 10 months of storage. Sixteen panelists selected and trained to evaluate cooked rice, developed 39 attributes related to aroma, flavor, appearance and texture. Samples were cooked in an electronic rice cooker with a 1:2 rice-to-water mass ratio. Immediately after cooking, subsamples were placed in soufflé cups, covered with plastic lids and let stand for 10 min before evaluation. Each panelist evaluated every ample in duplicates using 15-point numerical scales. Starchy, sulfur and sweet aroma and flavor attributes were only significantly affected (p < 0.05) by t. The highest sulfur and sweet notes were obtained at the beginning of storage (t = 0) and a decline was observed over time. On the other hand, for toasted aroma, MC, t and the interactions between the three factors were significant, obtaining the highest toasted notes for samples with 15% MC stored for 10 months at the higher studied T (20 and 30°C). Glossiness decreased significantly with increasing T, t and MC. Glossiness of the 15% MC samples decreased from 10.5 at t = 0 to 7.0 after 10 months at 30°C. Hardness and springiness were only affected by t. In conclusion, storage conditions affected the sensory aroma, flavor, appearance and texture of cooked rice. The results of the study confirmed the importance of controlling temperature during storage, since it was found that lower temperatures helped maintaining the initial sensory profile for longer times. Moreover, samples dried until 13% MC showed less sensory changes during the studied storage period.