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ABSTRACTS

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AACC INTERNATIONAL
Annual Meeting
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2011

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Chair: Elizabeth A. Arndt, *ConAgra Foods Inc., U.S.A.*
Vice Chair: Rajen S. Mehta, *Sunopta Ingredients Group, U.S.A.*

2011 Annual Meeting
Abstracts of Symposia or Science Café Presentations

Abstracts submitted for presentation at the 2011 annual meeting in Palm Springs, California, October 16–19. The abstracts are listed in alphabetical order by title of symposium or science café. Abstracts are published as submitted. They were formatted but not edited at the AACC International headquarters office.

Advances in Genetics for Quality, Functionality, and Nutrition of Wheat and Other Grains

A grain processor's perspective on the future state of genetics to impact quality, functionality, and nutrition
G. L. WEAVER (1)
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Cereal Foods World 56:A1

This presentation will focus on the complexities facing the limitation of genetic enhancements that could impact quality, functionality, and/or nutritional traits. This might be as simple as dealing with the perceptional of conventional breeding and biotechnology. Or we can delve into the grain-handling infrastructure changes in transportation or elevators. It may be defining these two letters - IP. Does IP mean Identity Preservation or Intellectual Property or Integrated Processing or something else? I would appreciate your participation and thoughts on this timely subject with the recent infusion of capital in wheat/grain genetics.

Novel genetic approaches to understanding the genetic basis of wheat and barley processing and consumer traits
M. MORELL (1)
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Cereal Foods World 56:A1

Rapid advances in our knowledge of plant genome sequences has opened the door to a range of strategies for enhancing crop performance. However, it is important to recognize that a range of attributes of the wheat crop are wheat specific and therefore we can not rely on the use of model systems to identify the full range of genes that are important to wheat quality and performance. The approach we have taken to identifying and utilizing information on wheat genes and their impact on the crop has been to develop a series of related genetic platforms. First, for the dissection of gene/trait associations, we have established large multi-parent "MAGIC" populations that allow identification of important regions of the wheat genome at high resolution across diverse wheat genetic backgrounds. Second, we have established mutagenesis populations based on heavy ion bombardment and chemical mutagenesis to allow the identification of candidate genes underlying key traits. Finally, for the validation of candidate genes and the generation of modified germplasm, we utilize transgenic approaches to modifying wheat performance. Our work is informed by utilizing barley and rice as diploid model systems allowing the exploitation of their simpler genetic structure. In this presentation, the genetic resources will be described and examples will be given of their application in areas of wheat quality and functionality.

Candidate gene approach for wheat quality improvement
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(1) USDA, Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.
Cereal Foods World 56:A1

Wheat breeding for milling and baking quality has typically relied on phenotypic selection of milling and flour characteristics. Genomics has enabled selection at the level of genotype for many end-use quality traits. The most effective forms of genetic selection have involved direct selection for genes of known function. The first and most commonly used candidate genes for milling and baking quality are the HMW-glutenin alleles, which are now selected with PCR-based markers. Other examples of candidate gene selection include grain hardness (*Ha* or *Pin*), polyphenyl oxidase (PPO), starch pasting viscosity (*Wx*), and more recently variants for high amylose (*Ae*). Genes that affect total phenology or development of the plant also appear to affect milling and baking quality. For example, in soft wheat semi-dwarf genes (*Rht1*, *2*), reduced flour particle size and photoperiod insensitivity (*Ppd*) increases flour protein concentration. Another class of variation in milling and baking quality is associated with chromosome translocations. These include rye translocations but also translocations affecting grain protein concentration and expression of puroindolines in the A genome. Despite enormous investments, selection for improved quality has no reported success when using minor quantitative trait loci that are not directly related to a candidate gene. The talk will propose new candidate genes for milling and baking quality improvement and some of the likely technologies for exploiting variation at those loci.

Combining genetics and biotechnology to improve wheat nutrition and processing attributes
A. BLECHL (1), W. Vensel (1), W. Hurkman (1), C. Tanaka (1), B. Beecher (1), S. Altenbach (1)
(1) USDA ARS, Albany, CA, U.S.A.
Cereal Foods World 56:A1

In their efforts to improve wheat for food processors and consumers, today's geneticists can employ a range of techniques, including traditional cross-breeding, molecular marker-assisted selection, and genetic transformation. This presentation will illustrate these developments with two examples: discovery and deployment of a gene from wild emmer wheat that increases the protein, zinc, and iron content of grains, and improvements in mixing

tolerance by engineering decreases in rye seed storage proteins in a wheat variety that contains a rye translocation chromosome.

Genetic progress in rice quality
M. FITZGERALD (1), D. Daygon (1), M. Calingacion (1), X. Zhao (1)
(1) International Rice Research Institute, Metro Manila, Philippines
Cereal Foods World 56:A2

Over the past couple of decades, our progress in genotyping capacity has significantly increased, almost to a point where it can be used routinely to locate a particular locus underlying a trait. However, the limitation to capitalising on genotyping is the capacity to carry out trait-based phenotyping of the traits of grain quality. For traits of grain quality that can be described, such as chalk, aroma, gelatinisation temperature, and gel consistency, these descriptions can be used to associate with genetic maps. However, we are currently at a plateau in our understanding of the sensory experience of eating rice, therefore, it is difficult to find loci for sensory quality. Our limitation is demonstrated by the persistence of old varieties for many decades and the inability of breeding programs to replace them with higher yielding versions. This talk will present our current progress in understanding the genetics of the traits we can currently phenotype and our progress in identifying new traits and phenotyping tools for subsequent association mapping.

Agricultural Biotechnology: Considerations to Ensure a Sustainable Future

Evaluation of novel input/output traits in soybeans
T. E. CLEMENTE (1)
(1) University of Nebraska, Lincoln, NE, U.S.A.
Cereal Foods World 56:A2

The University of Nebraska-Lincoln has established the infrastructure for the development and agronomic evaluation of transgenes in commodity crops. The infrastructure, collectively referred to as the agriculture biotechnology pipeline, consists of a plant transformation core research facility coupled with a plant biotechnology field facility. The former possesses the wherewithal for the genetic engineering of the major commodity crops, including soybean, sorghum, wheat, and maize, while the latter is dedicated acreages for the field-testing of regulated transgenic events. With respect to soybeans, two input traits will be discussed, the evaluation of transgenic events carrying a triple hairpin element that imparts a high level of resistance to the three main viral agents that infect soybean within the north central region of the U.S., *Alfalfa mosaic virus*, *Bean pod mottle virus*, and *Soybean mosaic virus*, along with the introduction of cyanobacterial genes investigating approaches to enhance photosynthesis. In regards to output traits, our efforts have primarily targeted fatty acid modification for food and feed applications. To this end, one of the target applications is the designing of a sustainable soybean-based feedstock for aquaculture.

Analysis of drought tolerance candidate genes in transgenic plants
R. D. ALLEN (1)
(1) Oklahoma State University, Stillwater, OK, U.S.A.
Cereal Foods World 56:A2

Among the many factors that limit worldwide crop productivity, unfavorable environmental challenges caused by nonliving (abiotic) factors are the most critical. Human population growth and the resulting increased demand for agricultural products, progressive loss of arable land and water resources, and climatic instability will make it increasingly difficult to meet these needs. One part of the solution to this problem will be the creation of new crop varieties that are able to maintain high productivity under suboptimal environmental conditions. Clearly, improvements will continue to be made through crop breeding but it is likely that new strategies will also be necessary to increase global agricultural production from a fixed amount of land with no increase in irrigation or other inputs. These strategies will depend on thorough knowledge of the molecular mechanisms used by plants to acclimate to harsh environmental conditions. Recently, rapid progress in our understanding of these processes has come through research in model plant species such as Arabidopsis and the application of this knowledge to crop plants is ongoing. For example, research in my lab has focused primarily on functional evaluation of stress-responsive regulatory proteins such as transcription factors and ubiquitin ligases. Cotton plants that express some of these transgenes show dramatic changes in their stress tolerance phenotypes, though adverse secondary effects are also sometimes seen. Therefore, while increased expression of protective genes and modification of the regulatory mechanisms that control the expression of these genes in response to abiotic stress holds significant promise for future agricultural systems, additional research will be required to determine how to apply these techniques most effectively.

The regulatory bottleneck for biotech crops
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(1) University of California, Davis, CA, U.S.A.
Cereal Foods World 56:A2

Unlike crops developed using other genetic improvement methods, varieties developed using recombinant DNA technology must receive approval from appropriate national regulatory authorities before being released for commercial use. These “genetically engineered” or “biotech” crops have been highly successful, achieving high use rates (over 90% of crop area) in cotton, maize, and soybean in countries where they have been commercialized. However, the regulatory system presents a number of hurdles for the introduction of new biotech crops and traits, particularly for specialty crops (e.g., vegetables and fruits) for which the regulatory costs are prohibitive. Market restrictions, particularly for exported crops, add additional impediments for new biotech advances. Recent court decisions have also affected the regulatory process for biotech crops. This presentation will review the current situation for the regulation and commercial release of biotech crops and discuss the impacts of the regulatory bottleneck on the application of biotechnology to sustainable food, fiber, and fuel production in the future.

Regulation of agbiotech: Science shows a better way
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(1) Hoover Institution/Stanford University, Stanford, CA, U.S.A.
Cereal Foods World 56:A2

National and international regulation of recombinant DNA-modified, or ‘genetically engineered’, organisms is unscientific and illogical, a lamentable illustration of the maxim that bad science makes bad public policy. Instead of regulatory scrutiny that is proportional to risk, the degree of oversight is actually *inversely* proportional to risk. The current approach to regulation, which captures organisms to be field tested or commercialized according to the techniques used to construct them rather than their properties, flies in the face of scientific consensus. This approach has been costly in terms of economic losses and human suffering. The poorest of the poor have suffered the most because of hugely inflated development costs of genetically engineered plants and food. Scientists, regulators, and politicians must find and implement more rational ways to guarantee public health and environmental safety while encouraging new discoveries. Science shows the way: An approach to regulation of field trials known as the “Stanford Model” is designed to assess risks of new agricultural introductions—whether or not the organisms are genetically engineered, and independent of the genetic modification techniques employed. The approach, which is patterned after quarantine systems such as the USDA’s Plant Pest Act regulations, offers a scientific, rational, risk-based basis for field trial oversight. The introduction of such a risk-based system would rationalize significantly the regulation of field trials and reduce the regulatory and other disincentives to the use of molecular techniques for genetic modification.

Best Student Research Paper Competition

Identification of disulfide bonds in wheat gluten proteins by means of mass spectrometry/electron transfer dissociation
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Cereal Foods World 56:A2

Wheat gluten proteins (gliadins and glutenins) play an important role in the breadmaking process because they form a continuous network that gives wheat dough its unique visco-elasticity and gas-holding capacity after addition of water to flour. While gliadins exclusively contain intramolecular disulfide bonds and provide viscosity to the dough, glutenins are responsible for dough strength and elasticity due to their polymeric nature with disulfide bonds as cross-links between subunits. The aim of this study was to apply a new LC-MS technique to identify disulfide bonds in wheat gluten. After thermolytic digestion of wheat flour (pH 6.5, 37°C, 16 h), cystine-containing peptides were identified by means of high-performance liquid chromatography - mass spectrometry (LC-MS) with alternating electron transfer dissociation (ETD)/collision-induced dissociation (CID). While in CID the disulfide bond

remained intact, disulfide bond cleavages were preferred over peptide backbone fragmentations in ETD. The simultaneous observation of disulfide-linked and disulfide-dissociated peptide ions in the mass spectra not only provided distinct interpretation with high confidence but also simplified the conventional approach for determination of disulfide bonds, which often requires two separate experiments with and without chemical reduction. The studies have shown that it is possible to identify cystine-containing peptides in complex mixtures of peptides by LC-MS and alternating ETD/CID fragmentation. Three cystine peptides previously obtained from thermolytic digests of gluten proteins were selected for testing the method. The fourth peptide has been described for the first time. It represented a "head-to-tail" cross-link between HMW subunits of glutenin. This cross-link has been postulated in a glutenin model recently published.

Arabinoxylan distribution and functionality in selected flour mill streams and effect on flour blending

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Cereal Foods World 56:A3

Arabinoxylans (AX) in wheat flour affect end-use quality; determining the distribution and functionality of AX in mill streams is important in order to better formulate flour blends. Thirty-one genetically pure grain lots representing six wheat classes were milled on a Miag Multomat pilot mill. Ten flour streams were collected and analyzed for AX content, ash, protein, and oxidative cross-linking potential. A two-way ANOVA indicated that mill streams were the greater source of variation compared to grain lots for all response variables. Total AX content was highly correlated with ash at r = 0.94; the correlation for water-extractable AX and ash decreased in magnitude at r = 0.60. Oxidative cross-linking potential of mill streams was determined with Bostwick viscosity measurements. Flour slurries were made with either water alone (to measure the endogenous oxidative cross-linking) or with added hydrogen peroxide-peroxidase (to measure the enhanced oxidative cross-linking). Mill streams with high oxidative cross-linking potential were those with the largest differences between water and peroxide-peroxidase viscosity; these included 1st Break, 1st and 2nd Middlings, and 1st Re-dust. Conversely, the 3rd Break and 4th and 5th Middlings mill streams were the least likely to form oxidative cross-links. The ability to form oxidative cross-links is understood to depend on the availability of ferulic acid and tyrosine residues. Thus, the arabinoxylan and protein polymers in mill streams that have a high oxidative cross-linking potential have a structure that is more conducive to form oxidative cross-links. Straight grade and patent flour blends were also tested for oxidative cross-linking potential. Patent flour was more likely to form oxidative cross-links. Indeed, the functionality of flour blends is directly related to which mill streams were selected for the formulation.

Couscous process engineering: Toward a better understanding of the contribution of the mechanical input during agglomeration

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Cereal Foods World 56:A3

During couscous production, the agglomeration of durum wheat semolina is a critical step that involves wetting and mixing stages leading to particles' size enlargement. To achieve a better control of the agglomeration at the industrial scale, it is necessary to better characterize the mechanical energy added by the mixing device. We conducted an original approach to study stress distributions and particles' motions in the bed of semolina particles based on the development of a new experimental mixing device with a unidirectional moving flat blade coupled with an image analysis system and force measurements directly on the blade. Under static conditions, force measurements at various depths allow to establish the vertical stress profile in the bed of semolina particles, highlighting a characteristic depth of 7.81 cm (relative to the surface), below which the vertical stress reaches a plateau. This phenomenon is known as the Janssen's law and explained by the presence of force chains between the particles which redirect vertical stresses laterally to the side walls. Under dynamic conditions, the upward blade motion at different speeds (10, 20, 30, and 40 $mm.s^{-1}$) reveals two zones which are on both sides of the characteristic depth. Below the characteristic depth, the obtained profiles depend on the blade speed and display periodical fluctuations. A particle image velocimetry (PIV) analysis was conducted with a high-speed camera placed in front of the mixing device and demonstrate a relationship between the observed fluctuations and different types of particles' motion (e.g., collapsing, avalanches). The influence of particle properties (e.g., diameter) and process variables (e.g., water content) on the mechanical behaviour of the powder bed is discussed in relation with the characteristic depth which has been identified as an important criterion for the design of mixers used in couscous production.

Understanding bran-gluten protein interactions during dough development using rheology and tomography

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Cereal Foods World 56:A3

Phytochemicals associated with the bran portion of the cereal grains have been proven to have significant health benefits like type 2 diabetes risks. The inclusion of the bran in dough systems, however, presents technological challenges. The effects of bran on dough physical properties, which are attributed to disruption of the gluten protein matrix, are not well understood on a fundamental level. The objective of this study was to investigate the effects of bran source, bran size (coarse and fine), and inclusion level (0, 5, 10%) on water absorption and rheological properties of dough systems of different strength and their bread quality and air cell microstructure using x-ray microtomography. Hard red spring (HRW) and soft white (SW) wheat samples were milled on a Buhler mill. Water absorption rates, mixing properties, and starch pasting behavior of the dough systems were studied using Farinograph, Mixograph, and Mixolab. Water absorption increased with increased bran percentage irrespective of bran source and size additions (59.6–71.0%). Dough development time of HRW flour systems decreased with increased bran percentage (16.4–11.2 min) except for SW bran coarse size additions. The loaf volume of HRW breads decreased up to 26.5% with bran addition and significant difference was observed in source of bran. SW bran addition resulted in relatively less detrimental effect on the loaf volumes and void volumes of HRW breads compared to the breads with HRW bran. Number of cells decreased with increased bran addition irrespective of bran source or size additions, indicating coalescence of air cells due to the presence of bran. Bran addition, irrespective of the source and size, increased the mean cell wall thickness, and air cell sizes indicated gradual shift toward higher values. SW bran additions in HRW flour has improved texture quality as compared to HRW bran additions.

Slow digestion of synthesized highly branched starch-based structures at the mucosal α-glucosidase level suggest slow glucose delivery to the body

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Cereal Foods World 56:A3

For digestion of starch to glucose, α-amylase reacts with starch and then complete hydrolysis takes place through mammalian mucosal maltase-glucoamylase (MGAM) and sucrase-isomaltase (SI). In this research, waxy corn starch (WCS) was modified using a combination of branching enzyme (BE) and β-amylase (BA) for increasing branched ratio. Then, digestion properties were tested using mammalian recombinant MGAM and SI subunits as well as in vivo test using rats. We hypothesized that this process can be utilized to produce slowly digestible starch (SDS) products at the mucosal α-glucosidase level with tailor-made α-(1,4)/(1,6)-linkage ratios. The structural changes were analyzed, and the results showed that different structures of enzyme-modified starches were produced by BE and BA treatments: increased α-1,6 ratio, decreased molecular weight, and changes in side-chain distributions. These enzyme-modified starches were hydrolyzed by human pancreatic α-amylase with the remaining portion of branched α-limit dextrins showing an increase in α-1,6 linkage ratio. The enzyme-treated α-limit dextrins (1%, w/v) were then digested with the four subunits contained in MGAM and SI (100U) at 37°C with PBS. Increased branching at the α-limit dextrin level resulted in decreased released amount of glucose from MGAM and SI subunits; the released glucose pattern was different among the subunits due to their different digestion properties. Without prior α-amylase treatment, structures were not digested with the 100U of mammalian mucosal MGAM and SI used in the study. Also, the level of glucose from BE/BA-treated starch in the rat test was significantly higher than glucose as well as BE-treated WCS at 60 min after gavaging. In conclusion, highly branched structures by enzyme treatments produce a comparably slow digesting α-glucan product at both α-amylase and mucosal α-glucosidases levels.

Anti-inflammatory properties of cowpea phenotypes with different phenolic profiles

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Cereal Foods World 56:A3

Cowpea (black-eyed pea) is a drought-tolerant crop with several agronomic advantages over other legumes. This study associated phenolic properties of various cowpea phenotypes with their ability to prevent inflammatory states when challenged with an endotoxin (lipopolysaccharide, LPS) in noncancer colonic (CCD18co) cells. Chemical composition and antioxidant properties were determined in six cowpea phenotypes (black, red, green, white, light

brown, and golden brown). Only the black and green phenotypes had detectable anthocyanins. Condensed tannins content was higher in the light brown, followed by black and red phenotypes. Oxygen radical absorbance capacity (ORAC) followed similar trends. Except for the white variety, polyphenolic extracts (10 mg/mL) from all cowpea phenotypes reversed LPS-induced inflammation. This effect was via down-regulating transcription factor NF-kappaB and proinflammatory cytokines (IL-8 and TNF-alpha) produced by immune response. Only the red and brown phenotypes decreased the production of adhesion molecules involved in monocyte recruitment (ICAM-1 and VCAM-1), suggesting modulation pathways could be different and phenotype dependent. The reduction of mRNA expression of inflammatory biomarkers was dose dependent, with higher suppression at 20 mg/mL. These results reflect the potential health benefits of cowpea consumption. Further understanding of the molecular mechanisms of action is crucial in evaluation of phenotypes with superior anti-inflammatory activity. Ongoing research investigates the effect of processing on these properties.

Carbohydrates and Colonic Health

Recent advances in the area of carbohydrate function and colonic health
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Cereal Foods World 56:A4

Of the health claims allowed by FDA, five are related to dietary fiber and three are specific to fiber and cancer. There is, therefore, strong support for dietary fiber nutritional interventions when considering improvements in colonic health indices. Today, Americans are ingesting about 50% of the DRI fiber recommendation. In order to achieve a fiber intake of 25–38 g/day (the DRI recommendation), carbohydrates other than traditional dietary fibers will be needed. Two such carbohydrate categories are oligosaccharides and resistant starches. In this presentation, we will discuss (a) properties of carbohydrates that contribute to their action in the gastrointestinal tract, (b) colonic function and physiology to include health issues that may occur with the colon, (c) the evidence that exists for the role of fermentable carbohydrates in maintenance/improvement of colonic health, (d) the nature of the carbohydrates that reach the colon, and (e) the relationship between carbohydrate properties and colonic health to include physicochemical properties and those of the gut microbiota. There are many carbohydrates to choose from to ensure proper colonic health of humans. The challenge is to provide them in a form that is efficacious from the colonic metabolism perspective while being sufficiently acceptable such that adequate intakes are assured.

Wheat bran-derived arabinoxylan oligosaccharides: A novel soluble dietary fibre with prebiotic properties
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Cereal Foods World 56:A4

Prebiotics were initially defined as nondigestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improve host health. A recent refinement of this definition maintains that prebiotics are selectively fermented ingredients that allow specific changes, both in the composition and/or activity in the gastrointestinal microflora that confer benefits upon host well-being and health. The most studied prebiotics are the fructans inulin and fructo-oligosaccharides. Over the past years, we used a multidisciplinary approach—in part funded by Healthgrain—to study the properties of arabinoxylan-oligosaccharides (AXOS) as a novel prebiotic dietary fibre. We here report on a pilot-scale process for extraction of AXOS from wheat bran and on studies of their prebiotic effects in chickens and rats as well as in humans. We also demonstrate the feasibility of in situ production of AXOS in breadmaking by using appropriate enzyme technologies.

Constraints and work-arounds on the genetics of starches for beneficial colonic health
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Cereal Foods World 56:A4

Starch structure is a significant (although by no means the only) factor in foods which have beneficial colonic health properties. Starch breakdown in digestion involves the rate, the extent (to anything from a grain fragment through to glucose), and the location (particularly small vs. large intestine) of the enzymatic degradation of a starch-containing food. “High amylose” (longer-branched) maize and barley have been developed and have positive effects on bowel health in monogastrics. However, the types of starch structure that have been made are limited: the chain-length distributions show relatively small changes. The development of a mathematical model (Wu & Gilbert, Biomacromolecules 11 353, 2010) for the CLDs in terms of the activities of the various types of biosynthetic enzymes (SS, SBE, and DBE) explains this: theory gives the surprising result that changes in CLDs which can be achieved by knockout and/or “natural” mutations are very restricted if the plant is produce the semicrystalline structure which provides the plant’s compact energy storage. It will be shown how novel GM methods can work around these constraints. This methodology is also extended to higher structural levels. Expressing in vitro digestion rate data in terms of heterogeneous and homogeneous limits enables digestibility data to be expressed in a small number of physically meaningful parameters. Structural and digestibility data for a wide range of starch varieties then provide mechanistic insight into those aspects of higher starch structural levels (branching structure, overall, i.e., fully branched, molecular size and weight distributions, crystallinity, etc.) are important in digestibility. Theoretical developments for the biosynthetic processes controlling these higher structural then provide indications of how new starch structural parameters can be controlled for improved colonic health.

Carbohydrates and satiety
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Cereal Foods World 56:A4

Population studies indicate a clear association between higher fiber diets and body weight or other measures of obesity. The prevailing hypothesis is that fiber intake may improve satiety and reduce hunger and food intake. Results of clinical studies indicate that high-fiber foods may impart a greater satiety effect than low-fiber foods, however, results are equivocal and differ by fiber type. The efficacy of a fiber ingredient may work through different physiological mechanisms, such as stomach distention, delayed gastric emptying, or gut hormone signaling. Viscosity, bulking, water holding capacity, etc. are aspects of the ingredient that may lead to reduced appetite. These distinct characteristics of a fiber that impart satiety benefits may be the very characteristics that create formulation challenges. The macronutrient ratio of the food or meal composition may also be key factors dictating acute responses to fiber feeding. The effect of fiber on satiety and food intake will be discussed, with specific emphasis on the types, amounts, and delivery of fiber.

Cereal Based Inhibitors of Enzymes-Implications on Cereal Processing, Nutrition, and Agriculture

Small molecule inhibitors to dissect starch degradation during cereal germination
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Cereal Foods World 56:A4

Understanding the nature and control of starch degradation in cereal seed will help to improve the flour and malting quality of grain, impacting directly on bread, beer, and whisky production. While we know much about the individual enzymes involved in starch degradation, biological control of the overall process is poorly understood. Given the lack of a complete genome sequence for barley, identification of mutants lacking specific proteins of interest is extremely difficult. We have therefore adopted a complementary chemical genomics approach, which relies on small molecule inhibitors to selectively and directly interfere with starch metabolism at the enzyme level. Evaluation of inhibitors in vivo using whole-seed screening has revealed changes in morphology and in the endosperm carbohydrate profiles when compared to untreated seeds. A range of iminosugars, commercial drugs, and natural products have been investigated. With the aid of in vitro assays, high throughput screening, and protein crystallography, the effects of these compounds are being rationalised and improved inhibitors are being designed.

Inhibitory effect of 0.19 AI inhibitor from wheat kernel on the activity and stability of porcine pancreas alpha-amylase

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Cereal Foods World 56:A5

Plants contain a large number of inhibitors against amylases and proteases. Wheat kernel contains a number of proteinaceous alpha-amylase inhibitors (AIs), which are by-products of starch and gluten manufacture. Interest in wheat AIs has focused on their therapeutic effects on obesity and non-insulin-dependent diabetes. The inhibitory effect of 0.19 alpha-amylase inhibitor (0.19 AI) from wheat kernel on the porcine pancreas alpha-amylase (PPA)-catalyzed hydrolysis of para-nitrophenyl-alpha-D-maltoside (pNP-G2) was examined. 0.19 AI is a homodimer of 26.6 kDa with 13.3-kDa subunits under the conditions used. The elution behaviors in gel filtration HPLC of PPA and 0.19 AI indicated that a PPA molecule bound with a 0.19 AI molecule (homodimer) at a molar radio of 1:1. 0.19AI inhibited PPA activity in a competitive manner with an inhibitory constant of 57.3 nM at pH 6.9, 30°C, and the binding between them was found to be endothermic and entropy driven. The activation energy for the thermal inactivation of 0.19 AI was determined to be 87.0 kJ/mol, and the temperature giving 50% inactivation in a 30-min incubation at pH 6.9 was 88.1°C. There are five Tyr residues in a 0.19 AI subunit. When one of these residues was nitrated or aminated, the inhibitory activity was completely lost. This suggests that steric hindrance on Tyr residue(s) should play a significant role in the interaction between 0.19 AI and PPA. The high inhibitory activity of 0.19 AI against PPA and its high thermal stability suggest its potential for use in the prevention and therapy of obesity and diabetes.

The inhibition of alpha-glucosidase by specific lipid components in wheat bran and germ

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Cereal Foods World 56:A5

The bran and germ of whole wheat are widely accepted as important ingredients in many low glycaemic index (GI) foods, which helps with glucose management in patients with the disease and may prevent the progression of type 2 diabetes. There have been numerous studies to assess the GI of whole grain wheat and wheat bran; however, the results are contradictory and confusing, particularly as the glycaemic control mechanisms of whole wheat and wheat bran are unknown. Alpha-glucosidase inhibitors that reduce postprandial hyperglycaemia play a key role in the treatment of type 2 prediabetic states and also have the potential to reduce the progression to complications of diabetes. Wheat bran and germ may contain active phytochemicals, which inhibit alpha-glucosidase and reduce postprandial hyperglycaemia. The in vitro alpha-glucosidase inhibitory activity of compounds in wheat brans, bran layers, and germs was studied. Active compounds were selected using in vitro enzyme-inhibitory assay guided fractionation. Potent alpha-glucosidase inhibitory compounds from wheat germ were identified as phosphatidic acids, 1,2-dilinoleoylglycero-3-phosphate and 1-palmitoyl-2-linoleoyl-glycero-3-phosphate. The low GI property of whole grain wheat may be attributed to these phosphatidic acids, which have the potential to manage the progression of type 2 diabetes.

Endoxylanase inhibitors in cereals: Discovery and biochemical characterisation

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Cereal Foods World 56:A5

Since their discovery in 1997, work on proteinaceous wheat xylanase inhibitors (XIs) led to the identification and thorough biochemical and structural characterization of three classes of XIs, namely TAXI-type (*Triticum aestivum* xylanase inhibitor), XIP-type (xylanase inhibiting protein), and TLXI-type (thaumatin-like xylanase inhibitor) XIs. Several of these inhibitor classes have also been found in other cereals. Here, the discovery and biochemical characterisation of these proteinaceous xylanase inhibitors, ranging from basic amino acid sequence information to structural data on xylanase—xylanase inhibitor complexes, is presented. The emphasis will thereby be on the TAXI- and TLXI-type inhibitors as these two types of xylanase inhibitors were first described by the research group led by the presenter.

Xylanase inhibitors in cereals: Relevance for plant physiology and cereal processing

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Cereal Foods World 56:A5

Since the discovery of the first proteinaceous xylanase inhibitors in 1997, research has focused on their structure and biochemical properties, but also on their relevance in plant physiology and biotechnological applications. In plants, xylanase inhibitors may restrict the invasion of pathogens by inhibiting xylanases produced by phytopathogenic microorganisms involved in plants infection. Data at the genomic, transcriptomic, and proteomic levels increasingly provides evidence that XIs, occurring as large polymorphic families, do indeed participate in plant defence. In breadmaking, high xylanase dosages are needed for sufficient functional effect when inhibition sensitive xylanases are used in the dough system. In refrigerated dough storage, the addition of an excess of xylanase inhibitor reduces xylanase-induced syruping. The strong but reversible interaction between xylanases and their proteinaceous inhibitors has been utilized to purify xylanases from microbial preparations. Understanding of inhibition mechanisms and molecular engineering have led to the production of xylanases which are no longer inhibited by the endogenous inhibitors, drastically increasing their efficiency. In this overview, both plant physiological as well as technological relevance of proteinaceous xylanase inhibitors are discussed.

The Evolving World of Pasta—The Role of Non-Traditional Ingredients and Processing on Finished Product Quality

Beyond wheat—Review of pasta products made with multigrains, pulses, fibers, and other ingredients

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Cereal Foods World 56:A5

Nontraditional ingredients, such as pulses, oilseeds, fibers, and proteins, are being used in pasta manufacturing as functional ingredients in improving cooked weight, decreasing cooking loss, and improving canning stability. In addition, nontraditional ingredients have been associated with high nutritional values and have received considerable attention in the nutrition community due to the interest in dietary fiber, protein, omega-III, and micronutrients. In this presentation, processing technology, physical, chemical, nutritional, and rheological attributes, and end-product quality utilization of nontraditional ingredients will be discussed.

The fine structure of pasta and its connection with raw material characteristics and processing conditions

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Cereal Foods World 56:A5

Several studies focused on the semolina characteristics required to make high-quality pasta. Protein characteristics were associated with pasta textural and cooking properties due to the protein role in the formation of a tenacious dough structure during mixing and of a firm viscoelastic matrix during cooking. Starch—the major component of semolina—has received much less attention. In an attempt to identify which starch (micro) structure can provide good cooking performances, the physical and chemical modifications induced by the processing conditions were determined both by conventional and advanced approaches. Regardless of semolina composition, pasta drying created a new starch structure. A low-temperature (LT) cycle promoted the formation of a less compact and more hydrophilic structure than a high-temperature (HT) cycle, as shown by protein solubility, starch accessibility to enzymatic action, swelling capacity, peak viscosity, and spectroscopic approaches. Water takes longer time to penetrate inside the HT pasta matrix. Consequently, starch gelatinization is slower, giving a higher melting temperature and confirming the presence of new ordered structure. As for raw materials, semolina characterized by high viscosity (MVAG test) resulted in a sticky and less firm product with a greater tendency to macromolecule leaching into cooking water. Multiscale and complementary approaches were used to clarify the structural properties of starch and its relationship with cooking performances also in gluten-free matrices, where the structural organisation is greatly affected by the sequence and the conditions of heating and cooling steps. Attention will be paid on understanding the relationship between starch structure and processing conditions to develop gluten-free pasta with textural properties similar to the semolina-based product.

Production and processing of whole grain pasta products in relation to end-product quality

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Cereal Foods World 56:A6

As the demand in the marketplace continues to shift toward more diverse and nutritious products, pasta manufacturers and food companies are perhaps more than ever being tasked with producing and using whole grain pasta products. Historically, pasta has been manufactured primarily with durum wheat semolina. As whole grain flours are added to pasta formulations, the functional properties of the dough change in relation to the chemical and physical properties of the whole grain flour(s) and amount being used. These changes generally have a negative impact on pasta quality. Secondary processes such as freezing and retort cooking often challenge whole grain pasta quality even further and create obstacles for companies wishing to use whole grain pasta in a finished meal application while still maintaining the quality of traditional non-whole grain pasta. For these reasons, it is important to gain a better understanding of both pasta formulation with respect to whole grain ingredients as well as extrusion and drying process adjustments needed specifically for whole grain pasta in order to optimize whole grain pasta quality. This presentation is intended to provide a review of existing whole grain pasta research with emphasis on formulation and processing conditions and discuss practical applications for pasta manufacturers and food companies wishing to make and use whole grain pasta.

Cooked pasta texture method evaluation

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Cereal Foods World 56:A6

Traditional methods to evaluate cooked pasta texture include sensory and the mechanical measuring of the peak force achieved during cutting or by work required to cut through pasta using a knife "tooth" probe as described by Pasta and Noodle Cooking Quality–Firmness, AACCI Method 66-50. Method 66-50 is well suited for long goods with spaghetti or noodle shapes. However, using the knife "tooth" probe on short goods with their unconventional shapes can be challenging. Research was conducted to determine the suitability of other texture probes in determining cooked pasta texture. Probes evaluated were knife probe, Ottawa cell, modified Ottawa cell, Kramer Shear cell, mini Kramer Shear cell, and rectangular compression probe, sometimes called a stickiness rig. All probes, except the knife probe, were run to yield the texture profile analysis curves. Pasta shapes included spaghetti, rotini, lasagna, and elbow macaroni. Pasta was made from semolina, 51% whole wheat + 49% semolina, and 100% whole wheat and was cooked to the optimum cooking time (OCT), OCT+2 min, and OCT–2 min. The ease of use of the different probes varied with pasta shape. For example, there was some difficulty in using the Kramer Shear cell to evaluate spaghetti and elbow macaroni texture since these shapes tended to fall through the slots of the cell. However, there was no difficulty in evaluating rotini or lasagna. Results for compression-type probes (Ottawa, modified Ottawa, and rectangular compression probes) tended to be similar. Results for shearing/cutting-type probes (knife, Kramer Shear cell, and mini Kramer Shear cell) tended to be more variable and occasionally differed from results from the compression-type probes. Thus, conclusions could differ depending on the probe used.

The changing world of pasta—Regulatory challenges for blended pasta products

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Cereal Foods World 56:A6

The standard of identity for macaroni products limits the type and amounts of ingredients that can be added. Many new types of pastas are being introduced that are made with whole grain flour, flour blends, and ingredients that do not fit within the standard of identity. Nonstandard pasta products often use ingredients not allowed in the standard to improve nutritional value. Developers can formulate products to better meet the Dietary Guidelines, make health claims, nutrient content claims, or add the latest nutrient identified by nutrition research. Many retort and frozen products need functionality that cannot be delivered within the standard of identity. These nonstandard pasta products provide regulatory, labeling, and marketing challenges. The presentation will discuss strategies and pitfalls in labeling and marketing nonstandard pasta products in a changing regulatory environment.

Healthy Food Manufacturing: Process Challenges & Solutions for Salt Reduction, Fat Reduction, and Fiber Enhancement

Grain-based foods in the marketplace: Opportunities for health and technical challenges

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Cereal Foods World 56:A6

The 2010 Dietary Guidelines for Americans recommends consumption of foods higher in whole grains and dietary fiber and lower in calories, fat, sugar, and sodium. However, current evidence suggests that most consumers fail to meet dietary guidance, while the availability of foods in the marketplace to support these recommendations remains a small proportion of our food supply. A successful transformation of dietary recommendations from theory to consumer practice will require a cultural shift in how the food supply chain supports dietary guidance. Grain-based foods can serve as an excellent vehicle for developing, delivering, and enhancing consumer intake of foods that more closely meet dietary guidance. The availability of healthier grain-based foods in the marketplace hinges on consumer demand along with industry's ability to produce healthier products with taste appeal. For certain foods, the inclusion of whole grain, fiber, and modifications in ingredient content (e.g., fat, sugar, and sodium) may ultimately lead to healthier, lower caloric dense products, but with the taste appeal necessary for consumer adaptation. Technological approaches related to grain-based foods will emphasize gradual ingredient modification and increased consumer availability of foods that more closely meet dietary guidance. Ultimately, we must allow the necessary technology and supply-chain infrastructure to evolve and coincide with the appealing taste, product quality, and health attributes that the public expects and demands.

Enhancement of antioxidant capacity and dietary fiber profile of expanded snacks utilizing fruit and vegetable pomaces

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Cereal Foods World 56:A6

Extrusion is a widely used technology for processing ready-to-eat snack and breakfast cereal products. However, nutritional value of many of these products is limited. One alternative for addressing this shortcoming is the incorporation of fruits and vegetables as a source of dietary fiber and antioxidants. Blends of corn flour and apple pomace (0–28%) were extruded to produce directly expanded cellular products, with total dietary fiber content of 1.1–22.5%. Macrostructural properties and cellular architecture were found to be a function of phase transition properties and extensional capacity of the high fiber melt. Inclusion of pomace increased nucleation and favored axial expansion. Cellular anisotropy and cell size explained the higher mechanical strength due to pomace. A subsequent study was designed to gain a better understanding of the interactions between individual fiber components (cellulose, lignin, xyloglucan, and pectin), starch, and process moisture during extrusion, and their impact on expansion and structure formation. Compatibility between various carbohydrate fractions and starch was found to be critical for good dispersion in the matrix, and therefore good expansion and structure forming properties. The antixoidant profile and activity of apple pomace-based formulations were also characterized before and after extrusion. Results pointed toward a decrease in antioxidant content, but an increase in antioxidant capacity due to processing. These results are presented in the context of various challenges and opportunities that exist relating to the processing of food matrices with high fiber content.

Healthy carbohydrates for the manufacture of food and nutrition

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Cereal Foods World 56:A6

Carbohydrates play an important role in our lives, especially starches. They are the most common source of energy. Foods that are high in starches are bread, pasta, beans, potatoes, bran, rice, and cereals. Starch is not only a key player in the delivery of energy but has also a key role in the formation of structure and texture of food. Starch is widely applied as thickener in soups, sauces, etc. Nowadays there is a lot of debate about the role of food on human health. Concerns were raised with the respect to the role of starch as an energy supplier. Starch can be a source of so-called "fast" carbohydrates. This causes a fast increase in blood glucose levels after eating food, which is more and more pointed by nutritionists to be associated with negative effects (i.e., diabetes II, obesity). There are also concerns about the relatively low intake of

dietary fibers (<26 g per day), which are known to have good properties related to health and diseases. The Health Council of the Netherlands recommends eating 32–45 g of dietary fibers per day. These health-related issues prompted the food industry to develop new foods that consist of health-promoting ingredients such as starches with slow digestion properties or high dietary fiber content. In both causes, substituting "fast" starch by "slow" starch or introducing more dietary fibers will have a considerable impact on the production of the food product (water uptake, swelling) and the structure, texture and sensory of the food product (viscosity, stability, etc.). In this paper I like to discuss the latest developments in this field.

Potential roles for sodium during the creation of cereal products
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Cereal Foods World 56:A7

The role of sodium in cereal products would seem to play important roles in the processing and quality of the product far beyond just acting as a tastant. The impact of the ion is seen across a very wide range of moisture contents. Products ranging from breads to breakfasts cereals and snack foods are all influenced. One possible mechanism for the major role of salt could be due to its influence on water levels and mobility within the matrix of the products. This can be investigated using different methods, but these need to be interpreted by considering the different length scales which they probe. As well as considering where and how the water is behaving, it is also possible to probe the amounts and mobility of the sodium ions in cereals using 23Na nuclear magnetic resonance. Sodium ions seem to exert a major influence as a product cooks and dries. Rather than this just being due to the salts influence on water/mobility, there is strong evidence that the ions, at levels that are relevant to many food products, greatly influence the starchy component. Using this concept, the reasons for variation in texture, color, and flavor when salt levels are reduced may be explainable.

The use of starch derivatives in reduced or low-fat formulations
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Cereal Foods World 56:A7

With rising consumer awareness of overweight and obesity, the food industry is searching for ingredients that help in making low- or no-fat products with acceptable taste and texture. Native starches and starch derivates can contribute to reduce the amount of fat in a food product while maintaining taste and texture. Starch is a biopolymer present in small granules composed of the glucose polymers amylose and amylopectin. Most native starches contain both amylose and amylopectin, while waxy starches contain almost exclusively amylopectin. A number of potato starch solutions that help can be used in formulating reduced-fat products will be discussed. One is Eliane, a natural waxy potato variant, that can substitute regular starch in various coatings, yielding a better expansion during oven baking cf. frying. Nuts coated with Eliane starch show more expansion after oven baking than nuts coated with regular starch after oil frying. Another example is Etenia, an enzymatically modified, high-molecular-weight starch that has thermo-reversible gelling properties. Etenia can be used as creaminess enhancer in yoghurts, substituting a major amount of the fat present while creating a creamy texture. Etenia can also be used in bakery margarines with a reduced fat content or in cakes with significantly reduced amounts of fat.

In Vitro Digestion Models for Cereals and Cereal-Based Ingredients

Introduction: Physiological relevant in vitro digestion models
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Cereal Foods World 56:A7

The science café on in vitro digestion models for cereals and cereal-based ingredients aims to give an overview of current aspects of in vitro digestion models and their application for the development of carbohydrate-based novel food products. In the design and development of novel food products especially, health-promoting properties are emphasized. Equally important as the development is the proof of concept. This means a need to investigate whether the claimed health-promoting properties are physiologically relevant after gastrointestinal passage and digestion. This should be done prior to in vivo trials, since they are costly and time consuming. In addition, the human gastrointestinal tract is a "black box" that does not easily allow answering questions, e.g., related to mechanistic effects, digestibility, or bioavailability issues. In vitro models may represent an interesting possibility, hence they appropriately mimic the complexity of the human gastrointestinal tract. Thus, the understanding of those processes and the gastrointestinal physiology is equally crucial as its translation into relevant in vitro models. In addition, in vitro models have no biological variability, conditions are controlled and can be standardized. Some very simplified models represent the group of so-called "static" models. These models have the advantage of being simple and easy to set-up and use. In the recent years also more complex models, so called "dynamic" models were developed. Those models in contrast may be more laborious but hence more physiologically relevant and therewith showing an increased predictive power for the in vivo situation.

Prospects and considerations of in vitro digestion models applied to cereal ingredients
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Cereal Foods World 56:A7

Cereals are digested in the intestinal tract except its dietary fibre (DF) complex, which by definition enters the colon. It consists of nondigestible carbohydrates and phytochemicals. Colon contains diverse microbial population, which degrades the DF and releases monosaccharides and phytochemicals for microbes. Both digestion processes of the upper intestine and the colonic microbial conversions can be simulated by the in vitro digestion models. At VTT, the digestion models are divided to the simulations of the upper intestine (mouth, stomach, duodenum) and of the colon by using fecal microbiota as an inoculum. Time course of metabolite formation (short-chain fatty acids [SCFA], phenolic acids and lactones, gas) is followed, and further data analysis of the metabolite profiles is performed. Rye, wheat, and oat brans and their dry-processed fractions were subjected to the upper intestinal model and colonic microbiota in strictly anaerobic conditions. Digestibility was affected by the structure and physicochemical properties (water absorption capacity, solubility) of the cereal or its fraction. Colonic responses were affected by the type of cereal bran or fraction. Gas evolution and SCFA production were most pronounced from the rye bran and its aleurone fraction, whereas phenolic acid metabolites showed highest extents for wheat bran and its aleurone fraction. Differences in individual metabolites reflected the cereal grains and fractionation enhanced the response. Methodological considerations will be discussed in terms of in vitro upper intestinal digestion and colonic microbial conversions of cereal ingredients.

How to simulate the physiological parameters of the colon using in vitro models
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Cereal Foods World 56:A7

This contribution describes the application of well-established in vitro models of the gastrointestinal (GI) tract. Such models can be used to perform simplified experiments under uniform and well-controlled conditions. However, simulating such a complex system as the GI tract carries the risk of oversimplification. Most models of the GI tract do not successfully simulate the dynamic conditions in its lumen (such as bile and enzyme concentrations, transit of chyme, and uptake of digestion products or microbial metabolites), which is necessary to answer the variety of questions that have been raised by specialists in the functional food arena. Therefore, good predictive models should mimic the in vivo conditions to a high degree in order to be used for functional foods design. If this is accomplished, mechanisms can be studied that underlie some of the processes occurring in the lumen of the GI tract. Validation of such models should also be an integral part of the development of the systems. After all, what good is a model if it does not mimic the real world? Several examples are given in this contribution of the use of well-validated models in applications on fiber-based research, focused on fermentation by the microbiota in the colon.

Evaluating the effect of carbohydrate matrices on the bioaccessibility of antidiabetic botanical compounds using the TNO intestinal model
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Cereal Foods World 56:A7

Despite the widespread use of botanicals for treatment and prevention of disease, including metabolic syndrome, the bioavailability of the active

compounds, to the best of our ability to measure, is generally very low. However, understanding the fate of phytochemicals in the GI tract prior to absorption is critical for the effective use of botanical supplements or functional foods for the treatment and/or prevention of disease. We have shown that an extract of *Artemisia dracunculus* decreased hyperglycemia in animal models for type 2 diabetes and improved insulin sensitivity in humans. We have also shown that anthocyanin-enriched extracts from low-bush blueberries were hypoglycemic in diabetic C57Bl6J mice, while a clinical study recently conducted in patients treated with blueberry puree showed improved in insulin resistance in the test group. Therefore, we evaluated the bioaccessibility of the bioactive compounds from *Artemisia* and blueberry using the TNO intestinal model (TIM) of the upper GI tract of humans. The standardized extracts were introduced to TIM in either the fasted or fed state with defined meal matrices. Absorption samples were collected from the jejunal and ileal compartments over a 4-hour run. Using HPLC-MS or HPLC-PDA, the 6 bioactive *Artemisia* compounds were quantified as highly bioaccessible with a meal matrix while a much lower percentage of blueberry anthocyanins were bioaccessible (4–23% depending on the anthocyanin structure). Carbohydrate content of the matrices had significant effect on the bioaccessibility of different types of bioactive compounds. Thus, TIM can be a useful tool to evaluate the potential of natural products for treatment and prevention of metabolic syndrome-related disorders.

Small intestinal mucosal α-glucosidases: A missing feature of in vitro digestion models

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Cereal Foods World 56:A8

To evaluate the digestion of glycemic carbohydrates, it is common to apply the combination of porcine α-amylase and fungal glucoamylase in in vitro models. The role of fungal glucoamylase, with activity on both α-1,4 and α-1,6 linkages, is to rapidly transfer α-amylase hydrolysates to glucose for measurement purpose. In the human body, two gut α-glucosidases, maltase-glucoamylase (MGAM) and sucrase-isomaltase (SI) both with N- and C-terminal (Ct-) subunits, are required in addition to the two α-amylases for dietary glucose production from starch. Our group investigated the digestion patterns of the individual mammalian recombinant α-glucosidase subunits. A notable finding is that one or more of the four gut α-glucosidase subunits have activities on various α-glycosidic linkages, including α-1,2 of kojibiose, α-1,3 of nigerose, α-1,4 of maltose and linear glucans, and α-1,6 of both isomaltose and palatinose. Three subunits can digest most of the branched fraction of α-limit dextrin (LDx). Different starch structures show different susceptibility to the four subunits, and we showed that α-LDxs from various maize cultivars were not digested equally by gut α-glucosidases. When gut α-glucosidase were compared with fungal glucoamylase, the combination of α-amylase and individual subunits had lower glucose production from gelatinized waxy maize than the equivalent glucose production from the combination of α-amylase and fungal glucoamylase. Collectively, the dietary glucose production at gut brush border area appears not to be the rapid and simple process of converting α-amylase hydrolysates to glucose as found in in vitro assays, but a more complex, and possibly slow process. Additionally, glycemic carbohydrates with α-1,2 and α-1,3 glycosidic linkages, resistant to α-amylase and fungal glucoamylase, can be slowly digested by gut α-glucosidases.

Gut feelings: How can we construct good models for human digestion?

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Cereal Foods World 56:A8

Model digestion assays are a cost-effective way to screen potential ingredients/foods that provide nutritional benefit, including reduced glycemic response, fermentability, satiety, and other important nutritional aspects in the consumption of food. Mimicking in vivo digestion with in vitro or animal models presents challenging issues and building relevant models is difficult. Not only is it necessary to consider the chemical and biochemical aspects of digestion, the shear and mixing in the mouth, stomach, and small intestine must also be taken into account. The physical state of food is also important. Particle size, solubility, water content, and nonhomogeneity of foods can affect results. Animal models can be useful but their digestive tracts have notable differences in length, stomach volume, transit time, and cecal versus colonic fermentation that impact results. In vitro models are often focused on one aspect of digestion and neglect other parameters. In building a valid digestion model, it is important to be aware of which factors make a difference in the final results because it is impossible to account for everything and build a perfect model that correlates exactly to human digestion. Conscious decisions need to be made as to what is relevant to the desired results and what is not so as to simplify models. Results should be carefully evaluated as to what is measured and what might not be measured by a particular model and how the results can be interpreted in a meaningful way. This presentation will review various in vitro and animal models in terms of strengths and weaknesses and what information can be derived regarding human digestion by these methods. Cost-effective digestion models can be valuable in screening potential ingredients/foods that improve human health, but they must be thoughtfully designed and interpreted to give results that reflect reality.

Lowered Microbial Grain Ingredients: Challenges and Opportunities

Microbiological profile and food safety risk of wheat flour

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Cereal Foods World 56:A8

The objective of this presentation is to provide a review of the microbial and food safety issues associated with wheat and wheat flour. The microbial profiles and associated chemical hazards will be covered. Specific information will include the aerobic plate count, mold and yeast counts, internal mold infection, and microbial pathogens data of wheat. Microbial data from wheat surveys conducted in North America, Australia, and Turkey will be presented as a means to demonstrate the environmental effects on microbial counts. Microbial data from a 20-year time period will be presented. Mycotoxins and masked mycotoxins will be defined and information from a durum wheat survey will be presented. Variability of microbial and mycotoxin data exists in the literature. The aerobic plate counts in wheat and flour ranged from 2 to 9 log cfu/g and 1 to 6 log cfu/g, respectively. Mold and yeast counts of 1 to 5 log cfu/g and 1 to 6 log cfu/g have been reported on wheat, respectively. In general, the mold and yeast counts drop to less than 3 log cfu/g after wheat milling into flour. *Salmonella* spp. was not detected while *Bacillus* and *E. coli* were detected at very low levels (less than log 1 cfu/g). Deoxynivalenol was the predominant (nondetected to 23 µg/g) mycotoxin present in durum wheat. Semolina and flours contained less than 9.5 µg/g deoxynivalenol. The data presented will provide grain handlers, ingredient suppliers, and food manufactures with information that will serve as a basis for developing microbial specifications.

Strategies to reduce microbial load in wheat flour and the effects of processing on functional properties
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Cereal Foods World 56:A9

The cereal products industry has been built upon the assumption that low-moisture flours and other grain products will be cooked prior to eating and therefore microbial contamination is of limited concern. However, recent consumer habits have prompted the development of ready-to-eat wheat flours and other grain ingredients. Ensuring the quality and safety of such products does not come without challenges. While many strategies have been suggested as means of reducing the microbial load of flours and other low-water-activity ingredients, many of these treatments can have detrimental effects on flour functional properties. Examples of processes used to reduced microbial contamination include, but are not limited to, the use of ozone, radiation (gamma, infrared, microwave), pulse electric field, and heating. Both pre- and postmilling treatments have been suggested; however, especially with premilling treatments, strategies to prevent postprocessing contamination of treated flours must be developed.

Supply chain management for maintaining microbiological integrity of processed grain ingredients
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Cereal Foods World 56:A9

Grain ingredients, such as heat-treated wheat flour, may be processed in order to achieve a reduced microbiological profile. However, these ingredients are subject to microbiological recontamination in the post-process handling environment. Specific operations that present challenges to maintaining the microbiological integrity of processed grain ingredients may include pneumatic material transfer systems, bin storage, packaging and bulk load out operations, and transportation. In this presentation, the author will discuss supply-chain management tools, including sanitation and sanitary design principles, to help overcome these challenges in order to maintain the microbiological integrity of processed grain ingredients in the post-process handling environment.

Molds and Mycotoxins in Grain-Based Food and Feed Products: Current Status and Future Challenges

Molds, mycotoxins, and mycotoxicoses—Current status, problems, and future needs
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Cereal Foods World 56:A9

Mycotoxins continue to pose problems throughout the grain industry and to consumers of these grains and/or products derived from them. The diseases caused by mycotoxins, called mycotoxicoses, are difficult to diagnose due to the nonpathognomonic nature of most of them, the lack of a representative sample of food involved in the intoxication, and the lack of long-term studies of low concentrations of mycotoxins in food fed to animal species. The occurrence of mycotoxins in U.S. grains varies from year to year due to changes in weather and/or agricultural practices. Sampling for mycotoxins in these commodities and products remain problematic, sometimes leading to product recalls from the manufacturer. Various methods have been used to prevent the occurrence of mycotoxins in foods or their toxicity. Recent work with biocompetitive exclusion is apparently successful as well as some breeding of crops for resistance to fungi and selected mycotoxin production. Testing for mycotoxins, especially in marketing channels, requires rapid, simple, accurate, and inexpensive methods. However, testing difficulties occur due to mixed mycotoxins present in a sample or the presence of "masked" mycotoxins that can occur naturally in grains. International standards for the occurrence of mycotoxins in grains and foods are varied and require a scientific evaluation for a reasonable balance between risk and security or safety. Awareness of the potential for mycotoxin occurrence and a company-wide understanding of the risks associated with mycotoxins is required to assure that the manufacturing process, including testing, does not allow for their occurrence in products.

The business impact of mycotoxins
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Cereal Foods World 56:A9

Many grains are susceptible to infection by various microorganisms that produce harmful mycotoxins. These mycotoxins present a food safety risk and are carefully controlled by food companies and governmental agencies. This control comes at a cost to the food manufactures all along the value stream and ultimately the cost is passed to consumers. This presentation will discuss the impact of mycotoxins on the food industry through a series of case studies. Also, we will present a case for better testing to provide early warning and better management of crops when these infections are present.

Strategies to reduce mycotoxin contamination in grain and grain-based food
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Cereal Foods World 56:A9

The first step toward reducing the impact of mycotoxins in the grain supply chain is to recognize the critical points where contamination occurs. The major sources are preharvest diseases caused by mycotoxin producers and grain stored at unsafe moisture conditions. The best management strategies use monitoring techniques at the critical points to prevent contaminated grain from entering the system. New technologies are being developed and tested that detect the molds that produce mycotoxins and grain that may contain mycotoxin-producing molds. These technologies include real-time analysis based on nucleic acids sequence, specific volatiles, and near-infrared absorption. Once grain is found to be contaminated with mycotoxins, strategies for decontamination are limited. New technologies being tested include microwave, ozone, adsorptive materials, gamma irradiation, and microbial degradation. The challenges for all technologies that monitor or remediate are cost and functionality under grain facility conditions.

Optimizing Processing to Preserve, Create, or Enrich Bioactivity of Cereal Components

Overview of bioactive compounds in common cereal grains, their benefits and processing challenges
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Cereal Foods World 56:A9

A growing segment of the population is interested in improving its consumption of nutritious foods. Whole grain foods are becoming better recognized as a source of biologically active or "bioactive" components that contribute to good nutrition. While literature documents the presence of many bioactive components in the whole grain kernel, there may be challenges associated with retaining this nutrient activity through various processing steps and storage prior to consumption. For instance, the broad range of antioxidants include the functional property of preferential oxidation to preserve other compounds and avoid rancidity and other forms of degradation, and biological activity that can suppress reactions that may lead to carcinogenesis. Do the mechanical, thermal, and oxidative processes that take place during different processing steps have an effect on the efficacy of these compounds and their benefits? This presentation will review what we know about several cereal bioactives, where most of them are found in the kernel, and their recognized benefits. It will also identify some of the challenges that must be addressed to preserve these nutritional benefits through typical food processes.

Techniques to produce enriched bioactive components in cereals (wheat) with outlook on fermentation to improve bioavailability
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Cereal Foods World 56:A9

Most of the bioactive components are located in the outer layers of the wheat kernel, more specifically in the aleurone layer but also in the wheat germ. Innovative processing techniques have been developed to isolate the most promising fraction, the wheat aleurone layer in high purity with a high amount of arabinoxylans and bioactive components like ferulic acid, betaine, and folate from the outer layer of the wheat kernel. The fractions have been

applied in food products and in vitro as in vivo studies were carried out with the aim to examine the physiological effect. The bioavailability of the bioactive components in the grain fractions of the outer layers can be increased by specific fermentation processes.

Effect of particle size on fiber and other bioactives in wheat bran and whole wheat flour
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Cereal Foods World 56:A10

Because the particle size of whole wheat flour used in grain foods influences the sensory attributes and may alter the bioactive components and resulting benefits, researchers and manufacturers have investigated different methods of further reducing the particle size of bran and whole wheat flour. There is interest in adding value to these ingredients to increase the potential range of uses in foods. However, data on the effect of particle size on fiber and other bioactive components and health benefits are variable. In addition to the effects of process and resulting particle size on the sensory and nutritional impact of bran and whole wheat flour, it is important to assess the manufacturing feasibility. The impact on food regulations and labeling must also be considered. This presentation will provide an overview of the effect of particle size on the nutritional and sensory attributes of bran and whole wheat flour and of the processes used.

Effects of postharvest-processing conditions on endogenous amylase activities of cereal
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Cereal Foods World 56:A10

Drying temperature of corn grains has shown to affect the quality and storage stability of the grain. After 6 month storage at 27°C and 85–90% RH, corn grains dried at 35°C showed 5.1% starch hydrolysis and 6.8% reduction in the content of intact amylopectin molecules, whereas that dried at 80°C air temperature showed 1.2% starch hydrolysis and 3.6% reduction in amylopectin content. Starch in dry-ground corn is hydrolyzed substantially faster (45.8%) after one hour of incubation with porcine pancreatic alpha-amylase than isolated starch counterpart (32.6%). These results indicated that endogenous enzyme activities present in the dry-ground corn grains in addition to the presence of damaged starch granules increased the rate of starch hydrolysis in the dry-ground grains. Ethanol production using the cold-fermentation process with uncooked dry-ground corn grains as the substrate also showed that the greatest ethanol yield was produced from corn grains dried at the ambient temperature (25°C). To gain a better understanding on how drying air temperatures affected endogenous amylase activities, ground grains dried at different temperatures were incubated at 40°C for 20 hours. The grains dried between 10 and 65°C air temperature showed 11.5–11.8% reducing sugar production, whereas that dried between 85 and 125°C showed 5.5–8.7% reducing sugar. After the endogenous amylases were extracted and separated using a native-gel electrophoresis, the enzyme activities were detected using a zymogram with an I2/KI solution. Among the endogenous amylases, beta-amylase lost its activity after the grain was dried at 45°C, and pullulanase and isoamylase lost their activities at 85°C. The alpha-amylase was relatively stable up to 85°C but significantly lost its activity after drying at 105 and 125°C air temperature.

Antioxidant properties of regular- and whole wheat spaghetti and LC/MS analysis of their C-glycosyl flavones and secoisolariciresinol diglucoside
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Cereal Foods World 56:A10

Consumption of whole grain products is associated with beneficial health effects. Antioxidant properties of whole grain have been studied as one of the mechanisms in providing these effects. However, there is limited data on the antioxidant properties of pasta made from regular and whole wheat semolina. We evaluated the antioxidant properties of ten brands of commercially available regular and whole wheat spaghetti using total phenolic content (TPC), 2,2-diphenyl-1-picryhydrazyl (DPPH) free radical scavenging activity, and oxygen radical absorbance capacity (ORAC). Ferulic acid, flavonoid glycosides, and the lignan diglucoside, secoisolariciresinol diglucoside (SDG), as potential contributors to the health-promoting properties of whole wheat spaghetti, were investigated using LC/MS techniques. Whole wheat spaghetti exhibited significantly higher levels of TPC (1389 μg/g) than regular wheat spaghetti (865 μg/g). Whole wheat spaghetti (234 μg/g) had significantly higher content of ferulic acid than regular spaghetti ($p < 0.05$). Flavonoid glycosides present in spaghetti samples were identified as 6-*C*-glucosyl-8-*C*-arabinosyl apigenin and the sinapic acid adduct of apigenin-*C*-diglycoside. The levels of these compounds were found to be significantly higher in whole wheat spaghetti (16.95 and 15.15 μg apigenin equivalent/g) compared to the regular brands (9.47 and 5.83 μg apigenin equivalent/g). SDG content was also found to be significantly higher in whole wheat spaghetti (41.8 μg/g) compared to the regular brands (12.9 μg/g). There was a significant difference in ORAC values (10.8 and 18.4 μmol (TE)/g among whole wheat and regular spaghetti, respectively. These findings lend further support to the notion that phenolics bound with dietary fibre are concentrated in the bran layers of the wheat kernel and hence consumption of whole grain products is strongly recommended to obtain significant levels of health promoting phytochemicals.

Protein Enrichment in Cereal Products

Plant proteins—A sustainable alternative providing new opportunities
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Cereal Foods World 56:A10

The world's population is expected to reach 9 billion by 2050. At the same time the middle class in countries like Brazil, Russia, India, and China (BRIC) is growing rapidly. According to a report by the United Nations Food and Agriculture Organization (FAO), this projected population and socio-economic growth will double current food demand by 2050. Therefore, it will be imperative to ensure the availability of protein, one of the three macronutrients in the human diet. Animal proteins dominate the protein ingredient market. However, there are growing concerns regarding the impact of animal protein production on the environment. It is estimated that 18% of the greenhouse gas emissions (as measured in CO_2 equivalents) is generated by the livestock industry. Plant proteins offer a sustainable alternative if they can be consumed by humans directly without the conversion into animal protein. However, the use of plant proteins has not been fully explored mainly due to limitations regarding solubility and flavor. For example, only about 3% of soy meal is used to produce soy protein ingredients which are used directly in the human diet. In order to increase the market share of plant proteins, it is important to invest in research to develop protein ingredients that provide balanced nutrition, good functionality, and most importantly great taste. Recent innovations in the protein ingredient industry have resulted in the development of revolutionary plant protein isolates that are 100% soluble, completely transparent, and heat stable in solutions at acidic pH values. These new protein products possess a very clean flavor profile and they should open up multiple new applications for plant proteins like the use in acidic beverages.

Adding grain protein to food products: Challenges and opportunities
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Cereal Foods World 56:A10

Protein fortification of food products is a growing trend. Challenges involved with adding protein to food include cost, taste, texture, nutritional profile, and formula stability over shelf life. Selection of the correct protein source for fortification is critical to product acceptance. Concentrated forms of dairy and soy protein are typically the food proteins of choice for protein fortification. Adding grain protein to food products represents an opportunity for the cereal products industry, but current ingredient tools are limited in this area. This discussion will focus on how cereal proteins could play an important role in food protein fortification and what technologies are needed to achieve this goal.

Protein enrichment in cereal products: A nutrition perspective
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Cereal Foods World 56:A10

With the rising global trend for overweight and obesity, the food industry has been asked to be a part of the solution. Food formulation opportunities include reductions in the energy density of the food and formulation with ingredients that improve satiety characteristics of the food. Two such ingredients found to be associated with reduced food intake include fiber and protein, with the glycemic index of a food also being suggested as a potential modulator of appetite. Increased consumption of dietary protein has been associated with increased satiety and diet induced energy expenditure and improved weight loss outcomes. Several studies suggest that high-protein diets improve weight loss and provide for a greater retention of lean muscle mass and improved fat loss, particularly in the first six months of a weight-reducing diet.

Additionally, a recent study reported that a high-protein, low-glycemic index diet improved maintenance of weight loss and prevented weight regain. The purpose of this discussion is to highlight potential consumer benefits that are found with incorporation of protein into cereal products.

Protein in snack foods
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Cereal Foods World 56:A11

Food companies utilize many health and wellness ingredients to provide better-for-you products. One such ingredient of interest is protein. Advancements in protein technologies have made them more suitable for use in shelf-stable snacks. In general, proteins are derived from plant, animal, or single-cell microorganisms. Typical plant proteins are obtained from cereals, beans, legumes, nuts, and seeds. Animal proteins are sourced from dairy, eggs, or meats and single-cell microorganism, including those from fungus and blue-green algae. Proteins provide essential amino acids that are not inherently produced by the body and therefore must come from the diet. A complete protein provides all nine essential amino acids the body requires. Incomplete proteins lack one or more of these essential amino acids. The nutritional value of the protein system can be enhanced by utilizing proteins from various sources that complement each other by providing essential amino acids. Processing techniques also aid in improving proteins' nutritional properties as well as functionality, color, taste, and texture. Such techniques include the use of heat, acid, alkali, or enzymes on certain proteins. The treatment enables these proteins to be used in shelf-stable snacks such as crackers, chips, bars, cookies, and cakes, which are produced using standard snack technologies such as sheeting, shredding, extrusion, rotary molding, batter deposition, etc. Research has shown that it is possible to incorporate a high level of protein in snacks by modifying the formula and process without compromising taste and texture. While the desire to eat healthier foods remains top of mind for consumers, it is important to factor in the convenience of these healthy foods. The advances in protein technology increases protein functionality and its use in shelf-stable snacks.

Low-cost protein-enriched products
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Cereal Foods World 56:A11

Grains for Hope student members are collaborating with engineers, educators, cereal chemists, and extrusion experts to produce micronutrient-enhanced extruded grain food products in several forms. Prepared and individually packaged and ready to eat as an emergency food source, individually packaged and ready to eat as a meal, extruded and puffed product meal replacement bar are some of the areas of investigation for research projects. The most recent endeavors include a nutritious candy and a nutritious sports drink. The grains most commonly used in Grains for Hope foods include wheat, corn, pulses, sorghum, and soybeans. The high protein content of the soybeans lends itself well to certain innovative recipes. Earlier shipments of Grains for Hope foods have been well received in Haiti and Mozambique. The wider goal of the project is to complete a an extrusion training/production facility in Sabetha, Kansas, and further to place similar facilities around the would. These in-country plants will be staffed by local residents to improve nutrition and the local economy.

Recent Advances in Understanding Gluten Structure

Unfolding gluten: An overview of the current understanding of gluten structure
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Cereal Foods World 56:A11

The functional attributes of gluten separate wheat from all other grains by providing a unique structure in products that has been difficult to replace. The functionality of gluten derives from specific interactions between two classes of proteins, gliadin and glutenin, in the presence of water and energy. These interactions include the dynamic interaction of sulfydryl groups to form disulfide bonds and/or hydrophobic interactions within and among these proteins. While gluten proteins remain a significant focus of research, the primary mechanisms and kinetics of gluten structure in different product systems remain unclear. A better understanding of these mechanisms will facilitate focused studies on evaluating wheat quality as well as on ingredient interactions in product matrices to achieve specific process/product attributes. This symposium highlights some of the recent advances in this area of research. This talk will summarize the current state of knowledge on gluten structure some of the challenges in studying gluten proteins and highlight areas that require further investigations.

Mapping the molecular determinants of inter-protein network formation in gluten
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Cereal Foods World 56:A11

Formation of an interprotein network in gluten implies three fundamental events: 1) solvation of gluten proteins; 2) mechanical deformation of the solvated protein; 3) stabilization of a 3-D interprotein network through disulfide exchange reactions and rearrangement of hydrophobic patches upon drying/cooking. This report presents some novel approaches for addressing the molecular determinants of the individual steps listed above that were studied in flours of different strength and in various types of semolina. Among the novel tools developed for these purposes, focus will be placed on 1) spectroscopic techniques making it possible to address water distribution and to describe the interaction of water with biological polymers in flour, in semolina, and in raw and cooked pasta products; 2) the significance of intrinsic fluorescence and of noncovalent fluorescent probes to monitor structural rearrangements in proteins at all stages of the various processes; 3) the combined use of proteomics techniques (2D-electrophoresis) and of fluorescent thiol-labeling agents for mapping the free thiol content in flour and semolina having different properties; and 4) the application of selective protein solubilization and of appropriate labeling methods for understanding the molecular events involving thiols and disulfides on specific protein components during development of the interprotein network. Selected examples of the combined use of these methodologies for characterization of starting materials and of finished products will be presented and discussed, also in terms of the possible implementation of some of these protocols for predictive purposes.

Gluten proteins: Genetic control and modification
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Cereal Foods World 56:A11

Wheat gluten is composed of two types of proteins, monomeric gliadins and polymeric glutenin subunits. The latter are further subdivided into two classes, the high-molecular-weight (HMW) glutenin subunits and the low-molecular-weight (LMW) glutenin subunits. Gluten proteins derive from multigene families and are produced from complex genetic loci on wheat group 1 and group 6 chromosomes. Extensive genetic variation exists in both gliadin and glutenin subunit composition, to the extent that gluten protein of nearly every wheat cultivar is unique. While gluten proteins with major effects on gluten strength and elasticity have been identified, much of the observed genetic variation actually is neutral in effect. Over the past two decades, attempts have been made to alter gluten functionality via genetically engineering wheat to produce additional copies of specific HMW or LMW glutenin subunits. Overexpression of glutenin proteins also can influence grain hardness and other grain traits but does not necessarily depress average grain yield. Transgenic events can result in doughs with unusual mixing properties, many of which are not likely to be useful in commercial applications. Loaf volumes often are depressed, but to variable degrees by different transgenic events. Recent experiments resulting in slight overexpression of one particular subunit, HMWGS 1Dy10, have resulted in less dramatic increases in dough strength and could eventually lead to improved breadmaking quality by if expression levels can be optimized.

Gluten structure and celiac disease—Multidisciplinary approaches
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Cereal Foods World 56:A11

In cereal research, the term "gluten" refers to different materials. In the starch industry, gluten is the water-insoluble residue of starch preparation (vital gluten, corn gluten meal). In cereal chemistry and the baking industry, the term gluten stands for the storage proteins of wheat that are responsible for the unique viscoelastic properties of wheat dough and allow the production of yeast-leavened bread. In terms of celiac disease (CD), the term gluten is defined in the Codex Alimentarius-Standard for gluten-free foods and means celiac active proteins from wheat, rye, barley, and their crossbreeds. In all these fields it is the structure of gluten that determines its techno- or bio-

functionality. Specific amino acid sequences (epitopes) within gluten proteins causing CD have been identified. In particular the high proline content makes gluten proteins resistant to complete gastrointestinal digestion. Medium- to long-chain peptides accumulate in the small intestine, enter the enterocytes, and trigger the immunological response. CD is a multidisciplinary issue. Research is being conducted aimed at further understanding the mechanisms that trigger CD. Because patients have to adhere to a strict, lifelong, gluten-free diet, methods are required to properly prepare gluten-free foods and to check whether they are in fact gluten free. Novel approaches aim at using gluten-containing raw materials and degrading gluten during food processing, thereby providing gluten-free food with nutritional, textural, and sensory attributes that are comparable to those of gluten-containing foods. Another promising way to deal with CD is to use specific peptidases as drugs, which extensively hydrolyze dietary gluten and, thus, inhibit toxic gluten peptides from entering the small intestine. Finally, approaches aim at breeding novel wheat cultivars with good baking activity but reduced or no CD activity.

Dough as a power law gel material

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Cereal Foods World 56:A12

In attempts to better understand the complex nature of wheat gluten structure, we have examined the shear modulus of dough over a very wide frequency range. We created doughs from a hard red spring wheat flour at optimal water absorption and measured the complex shear modulus in the linear viscoelastic regime using small-strain shear rheometry and low-intensity ultrasonic shear wave measurements. Standard rheometry was used to determine shear moduli at low frequencies, while an inclined incidence wave reflection technique was used to measure the complex shear modulus in the hundreds of kHz frequency regime. This first characterization of the rheological behaviour of dough over a frequency range of more than eight decades demonstrates that previous descriptions of the constitutive properties of this rheologically complex material do not incorporate a sufficiently broad range of relaxation times to comprehensively model its properties. Modelling the dough as a power-law gel material permitted its linear viscoelastic response to be described well over the full frequency range. A consequence of this fuller characterization of the properties of dough is that the shear modulus of dough must be described with a broad range of relaxation times and that a progression of short timescale relaxations contributes significantly to the rheology of dough. Nevertheless, the two-parameter model of power-law gel materials has great advantages for predicting the mechanical response of dough at both the high and low strain rates that occur during dough processing.

Role of Grain-Based Foods in Addressing the Obesity Epidemic

Grain-based foods and body weight—Overview

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Cereal Foods World 56:A12

Most population-based studies reveal an inverse relationship between grain intake and body mass index (BMI; weight, in kg, divided by height, in meters squared). This is largely due to the inverse relationship between whole-grain intake and BMI. This is not unexpected, as whole-grain intake is positively correlated with carbohydrate intake and dietary fiber, both of which are inversely associated with BMI. The data on refined-grain intake are less clear. Despite the negative perception of refined grain, and claims that it contributes to obesity, refined-grain intake is not consistently linked to higher BMI. In fact, some studies have reported an inverse relationship. In the Physician's Health Study, intake of refined-grain breakfast cereal was associated with lower BMI and was inversely associated with body weight gain over 8 years. Similarly, in the Women's Health Study, servings/day of refined grain was inversely related to BMI. Even in studies reporting a positive relationship between BMI and refined-grain intake, the relationship is modest at best. In one large cohort of women, there was only a 0.2 BMI unit difference (~1 pound) between the lowest (4 servings/week) and highest (30 servings/week) refined-grain intake groups. Thus, current data from large cohort studies are not sufficiently consistent to conclude that refined-grain intake has a deleterious effect on BMI. Diets rich in grains are frequently associated with higher fiber intake and greater overall diet quality. Cereal fiber in particular appears to be associated with better weight control and reduced risk of type 2 diabetes and cardiovascular disease. Public health recommendations to increase consumption of grains, particularly fiber-rich whole grains, should have multiple health benefits, facilitate weight control, and possibly reduce prevalence of overweight and obesity.

Ready-to-eat cereals and breakfast: Association with healthy body weight and other indicators of healthy lifestyle

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Cereal Foods World 56:A12

Consistent breakfast and cereal consumption are patterns of eating have been shown to be associated with positive health outcomes. This talk provides a review of the contributions of habitual breakfast consumption and focuses on breakfasts that include ready-to-eat cereal, specifically, in relation to nutrient delivery, health-related outcomes (body mass index [BMI], levels of blood lipids, physical activity, and waist circumference), and behavioral outcomes. Data have consistently demonstrated that breakfast is the most important meal of day because of its nutritional benefits. Research has shown that those who eat breakfast consistently are more likely to consume diets that contain enhanced micronutrient intake, a favorable macronutrient profile characterized by a lower percentage of fat and a higher percentage of carbohydrate. This is particularly evident among those breakfast eaters who choose fortified cereal for breakfast. Cross-sectional research has suggested that regularity in breakfast consumption has been related to a reduction in risk for overweight. Longitudinal data indicate that those adolescents who are overweight who reported consuming breakfast on a consistent basis had a lower BMI at the beginning of young adulthood. It is evident that persons who consume breakfast routinely engage in healthier lifestyle, which includes higher levels of physical activity, a more even distribution of energy intake across meals throughout the day, consumption of fewer snacks, and consumption of healthful food choices throughout the day, compared with those who do not eat breakfast. Clearly, these behaviors can assist with body weight regulation. A healthful breakfast meal consisting of whole grains, fortified milk, and cereals should be encouraged. Breakfast is one significant component of a healthful lifestyle that may contribute to a betterment of long-term health.

Whole grains and body weight

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Cereal Foods World 56:A12

The 2010 Dietary Guidelines for Americans recommend that individuals "Consume at least half of all grains as whole grains" and "Increase whole-grain intake by replacing refined grains with whole grains." One reason for this recommendation is growing evidence that substituting refined-grain with whole-grain foods may be an effective strategy to prevent weight gain or promote successful weight loss. A literature search of articles published between 1985 and 2010 for terms related to whole grains and weight in humans identified 18 cross-sectional and 6 prospective observational studies and 6 intervention studies examining the effects of whole grains on body weight and adiposity. Cross-sectional studies overwhelmingly point to inverse relationships between whole-grain intake and overall and central adiposity. Evidence from the prospective studies suggest that individuals who consume greater amounts of whole grains gain less weight over time. However, some shortcomings of the aforementioned studies—such as failure to apply the strict FDA definition of whole grains, the observational nature of the studies, and the limited research in nonwhite ethnic groups, or in children, adolescents, and the elderly—limit our ability to draw definitive conclusions on the role of whole grains in body weight. Unfortunately, intervention studies have yielded inconsistent results on the effects of whole grains in relation to body weight. Although most tend to report no change in body weight, interesting findings have been observed related to central adiposity and related metabolic markers, such as insulin sensitivity and inflammation. This presentation will review the scientific evidence linking whole grains to weight and attributes of whole grains that may produce health benefits.

Fiber and body weight

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Cereal Foods World 56:A12

Higher intake of dietary fiber is linked to lower body weight and less weight gain over time in prospective, cohort studies. Intervention studies find that consumption of higher fiber diets results in 10% less calorie intake. Fiber may affect body weight by different mechanisms. First, high-fiber foods are lower in energy density, may require more chewing, and take longer to digest and

absorb than low-fiber diets. Fiber may affect glucose, insulin, and gut hormones as a mechanism to reduce body weight. Finally, fibers are fermented in the large intestine. This fermentation results in production of short-chain fatty acids which play a role in energy capture in the body. Additionally, certain fibers are “prebiotics”, increasing levels of bifidobacteria and lactobacillus in the gut. Animal studies and small clinical trials suggest that the gut microflora play a role in obesity prevention. Subjects who lose significant body weight have changes in their gut microflora. Finally, different fibers can alter satiety and thus decrease food intake. Not all fibers are equally effective in changing satiety. Early thinking suggested that more soluble and viscous fibers were most effective in enhancing satiety. More recent studies find that insoluble fibers that survive gut transit may also be effective in enhancing satiety. Thus, high-fiber diets are effective in limiting weight gain. Not all fibers are equally effective, likely because of the many mechanisms for fiber’s role in body weight.

Food technology innovations to help incorporate grain-based foods into the diet

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Cereal Foods World 56:A13

The 2010 Dietary Guidelines for Americans recommends that half of all grains should be consumed as whole grains and that whole grain intake should be increased by replacing refined grains with whole grains. A successful transformation of whole grain recommendations from theory to consumer practice will require a cultural shift in how the food supply chain supports U.S. dietary guidance. This approach emphasizes that whole grain foods will need to be available in an affordable, convenient, and tasty form. Factors that influence quality and acceptability of whole grain products include stability, storage, and handling of grain ingredients; product formula and processing methods; and storage and handling of products including packaging, shelf life, and storage conditions. This challenge calls for an infrastructure that will more effectively integrate the food supply chain with the purpose of developing, delivering, and increasing consumer intake of likable, affordable, and better-for-you whole grain foods available through food service and retail markets. An integrated supply chain can leverage multidisciplinary communication across the various sectors, such as government, industry, academia, and nonprofit organizations, to facilitate technology development around healthier ingredients and encourage formulation of new products that support dietary guidance.

2011 Annual Meeting
Abstracts of Oral Presentations

Abstracts submitted for oral presentations at the 2011 annual meeting in Palm Springs, California, October 16–19. The abstracts are listed in alphabetical order by first author's last name. Abstracts are published as submitted. They were formatted but not edited at the AACC International headquarters office.

Phenolic acid composition and antioxidant capacity of high-lutein whole grain bakery products

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Cereal Foods World 56:A14

Due to the health benefits associated with lutein and its low intake worldwide, three functional foods, high-lutein whole grain bread, cookie, and muffin, have been developed to enhance the daily intake of lutein and consumption of wholegrain foods. In our previous studies, the products were evaluated based on lutein stability during baking process and lutein bioavailability in vitro. The current study aims at further evaluating the products in terms of antioxidant capacity and composition of phenolic acids, the main antioxidants in whole grain products. Free phenolic acids were based on aqueous methanol extraction, while diethyl ether/ethyl acetate was used to extract bound phenolic acids released after alkaline hydrolysis. Free and bound phenolic acids were separated and quantified by HPLC, and antioxidant properties were based on scavenging capacity of DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2-azino-di-[3-ethylbenzthiazoline sulphonate]) radicals. The unfortified and lutein-fortified whole grain bread, cookie, and muffin products were found to contain similar contents of free and bound phenolic acids, with the bread products exhibiting highest levels of free and bound phenolic acids. On the other hand, the lutein-fortified products were found to possess higher antioxidant capacities compared with the unfortified or control whole grain products. The results suggest that lutein contributes to the overall antioxidant capacity. Additionally, the developed products would boost the daily intake of lutein and antioxidant components present in the whole grain foods.

Triticale bran: A novel dietary source of prebiotics and antioxidants in fermented dairy products

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Consumption of whole grains has been shown to have health benefits such as reduction of cholesterol, blood sugar, and the risk of cancer. Triticale (Triticosecale) is a hybrid of wheat (*Triticum* sp.) and rye (*Secale* sp.) and contains high levels of nutritionally beneficial compounds in the bran, including an abundance of soluble fibers. Prebiotics are typically soluble fibers that are resistant to human digestive enzymes but serve as food for probiotics to promote their growth and activity. In turn, probiotics, which are live microorganisms commonly contained in yogurts, confer a positive effect on the human digestive system. The objectives of this study were to evaluate the prebiotic activity of triticale bran (TB) in yogurt and the antioxidant capacity of TB carbohydrate extracts using an oxygen radical absorbance capacity (ORAC) method. Yogurts containing 4 and 0% triticale bran were prepared; the latter served as a blank. *Lactobacillus bulgaricus* and *Streptococcus thermophilus* were used as starter cultures. *Lactobacillus acidophilus* and *Bifidobacterium lactis* were used as probiotics. Enumeration of lactic acid bacteria in yogurts was measured by testing for the total titratable acidity (TTA) and the number of colony-forming units (CFU) at day 1, 7, 14, 21, and 28. Results indicated that TTA and the CFU counts was significantly higher ($P < 0.05$) in yogurts containing triticale bran. Carbohydrates were extracted from triticale bran using microwave-assisted technology and a conventional method. The antioxidant activity of these extracts was measured and the ORAC value of microwave-assisted extracts (44 TE µmol/g) was higher than that of conventional extracts (34 TE µmol/g). This study suggests that TB can serve as a new and valuable prebiotic source with antioxidant properties in functional foods and nutraceutical applications.

Structural complexity of A, B, D genomes of wheat (*Triticum aestivum* L.) starch

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Cytogenetically, wheat is an allopolyploid consisting of three genomes (AABBDD; 2n=6x=42). A wheat grain stores carbohydrates primarily as starch, which is composed of one-quarter amylose and three-quarters amylopectin. Amylopectin synthesis involves an array of enzymes, which include starch synthases (SSI, SSII, SSIII), starch-branching enzymes (SBE), and debranching enzymes (DBE). Amylose is exclusively synthesized by granule bound starch synthase-I (GBSSI). Absence of GBSSI results in amylose-free (waxy) starch. Wheat carries three isoforms of GBSSI, one from each genome. We hypothesize that GBSSI from different genomes would have differential enzymatic activity and affect the starch composition, structure, and function. The objective of the work was to study the effect of GBSSI from the three genomes, on amylopectin fine structure, and in vitro enzymatic hydrolysis. Thirty-six near-isogenic lines with a combination of functional waxy locus, i.e., $A^+B^-D^-$, $A^-B^+D^-$, $A^-B^-D^+$, $A^+B^+D^-$, $A^+B^-D^+$, $A^-B^+D^+$ along with normal $A^+B^+D^+$, and completely waxy $A^-B^-D^-$ parents were studied. Total starch was determined enzymatically. Debranched starch was analyzed using high-performance size-exclusion chromatography to determine amylose concentration. The absence of B and D genomes reduced amylose concentration to 18–19% compared to normal parent. Amylopectin structure was determined using fluorophore-assisted capillary electrophoresis, which revealed higher number of shorter chains (DP9-12) in completely waxy lines over normal line. In vitro starch hydrolysis assay showed fully waxy lines with higher hydrolytic index (meal:101; pure starch:171) compared to

partially waxy or normal wheat (meal:59; pure starch:135). This indicates that waxy lines with higher number of shorter chains are more susceptible to enzymatic hydrolysis as compared to the normal parent.

Toward understanding the genetic and molecular bases of rice quality
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Cereal Foods World 56:A15

Young Scientist Award

Rice is one of the most important crops for human consumption in the world. It is well-known that the physicochemical properties of rice grain determine its quality. The objective of my studies is to understand the genetic basis of rice quality which will facilitate the efficient selection of the desired quality rice breeding lines by breeders. We found that the major quantitative trait loci (QTLs) identified by linkage mapping for starch quality colocate at the starch-synthesizing gene loci, e.g., *Wx* locus controls the genetic basis of amylose content, pasting viscosity, gel texture, and retrogradation properties, while the starch synthase IIa (*SSIIa*) locus is responsible for the gelatinization temperature (GT). We then developed gene tagged markers, such as simple sequence repeat (SSR) and single nucleotide polymorphism (SNP), that were inside or close to those starch-synthesizing genes, and conducted association mapping for starch quality using these starch metabolic gene markers. Results indicated that *Wx* SSR and SNPs were strongly associated with amylose content, pasting viscosities, gel hardness, and retrogradation properties, whereas the *SSIIa* GC/TT SNPs were strongly associated with the pasting temperature and retrogradation properties, which confirmed the findings from linkage mapping. Using SNPs developed from six rice ADP-glucose pyrophosphorylase (*OsAGP*) genes, we found that *OsAGPL4* and *OsAGPL2* might be associated with 1000-grain weight of rice, a trait important for rice yield. In addition, we also conducted association mapping for nutritional quality traits, such as phenolic and flavonoid contents, and antioxidant capacity and have identified markers strongly associated with them. These markers are useful in molecular breeding for improvement of rice quality and yield.

Impact of different sodium replacers on starch re-crystallization kinetics
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Cereal Foods World 56:A15

Using NaCl in the production of food has been discussed controversially since a high intake of sodium is discussed to be associated with hypertension. However, the traditional use of sodium chloride (NaCl) fulfils various important rheological, technological, and sensory properties while manufacturing of baked goods. NaCl causes impact on bread texture and accordingly on bread staling. Several paper dealed with the theory that starch retrogradation (recrystallization) is the major influencing factor on bread staling. Therefore, the analyzation of starch alteration as a function of various sodium replacers is the aim of this study. Starch-water suspension with different chloride salts (LiCl, NaCl, KCl, $MgCl_2$, $CaCl_2$, NH_4Cl) were heated for gelatinization of the starch in a DSC, stored from 0 up to 504 h at 8°C and reheated again. Avrami equation has been used for evaluation of the rate of recrystallization of corn starch. The gelatinization behavior subjected to the salt type was analyzed and illustrates relationship to the aW value of the starch-water systems. The retrogradation results indicate the starch re-crystallization rate (k) is significantly ($p < 0.01$) reduced with addition of all cations compared to the reference (starch-water systems without salt). Further, bivalent cations as Ca^{2+}, Mg^{2+} decreased the starch recrystallization rate (k) more than univalent cations (Li^+, NH^{4+}, Na^+, K^+). Therefore, a theory for the dependency for starch retrogradation on the kind of cation was developed. The results illustrate important results for predicting starch quality change whiles using sodium reduced salts. Thus, the study shows the possibilities and technological changes regarding starch-based food alteration due to using of sodium replacers.

Cluster structure of amylopectin in barley *amo1* mutants
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Starch granules from barley possessing the *amo1* mutation are known to have increased apparent amylose content; however, it is not clarified which enzyme is affected. Nevertheless, it was also shown that the unit chain profile of the amylopectin component is affected, so that less long chains and more short chains, especially with DP approx. 12–20, are synthesised. In this work, we analysed into further detail the structural changes in the amylopectin component of the Amo1 barley variety Glacier Ac38, with slightly elevated amylose content, and a *wax amo1* double-recessive mutant (variety SW 49427) with 3.7% amylose. The samples were compared with two single-recessive *wax* mutants (Cinnamon and Cindy with 0 and 10.2% amylose, respectively). From the internal unit chain profiles, it was clarified that the reason for the elevated number of short chains in the *amo1* mutants was an increase of short B chains, especially "fingerprint" B_{fp} chains, whereas the number of A chains was unaffected. Clusters were isolated using alpha-amylase and, generally, *amo1* mutants possessed large clusters composed typically of about 17 chains as compared to normal barley clusters having about 12 chains. All barleys possessed also small clusters with 8~10 chains. The branching zone of the clusters was build up by tightly branched building blocks with an interblock chain length of 5.5–6.1 residues. The large clusters of *amo1* mutants contained elevated number of large building blocks with up to ~11 chains, apparently contributing to a more dense structure of the amylopectin; the average internal chain length was 4.9, as compared to 5.5 and 5.8 in the normal amylopectins.

Barley starch bioengineering for high phosphate and amylose
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Cereal Foods World 56:A15

Starch is a biological polymer that can be industrially produced in massive amounts in a very pure form. Cereals is the main source for starch production and any improvement of the starch fraction can have a tremendous impact in food and feed applications. Barley ranks number four among cereal crops and barley is a genetically very well characterized. Aiming at producing new starch qualities in the cereal system, we used RNAi and overexpression strategies to produce pure amylose and high-phosphate starch, respectively, using the barley kernel as a polymer factory. By simultaneous silencing of the three genes encoding the starch-branching enzymes SBEI, SBEIIa, and SBEIIb using a triple RNAi chimeric hairpin construct we generated a virtually amylopectin-free barley. The grains of the transgenic lines were shrunken and had a yield of around 80% of the control line. The starch granules were irregular and showed no distinct melting enthalpy and very weak X-ray scattering. Hyperphosphorylated barley starch was achieved by endosperm specific overexpression of the potato glucan water dikinase1 (StGWD1). The content of phosphate esters in this starch was tenfold higher than the control lines. Amylose content was not affected but the starch granules had several pores on the surfaces and a decreased melting enthalpy indicating starch degradation stimulated by phosphate-induced amorphisation. Our work demonstrates the feasibility of starch bioengineering to produce completely novels starch-based polymers implementing two new strategies for in planta starch bioengineering of cereals.

Bran influences water distribution and gluten secondary structure in model dough systems
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The aim of this work was to investigate the underlying physical mechanism(s) by which bran influences whole grain dough properties by monitoring the state of water and gluten secondary structure in model flour–bran systems consisting of 25–40% moisture and 0–10% bran in three particle size ranges. The system was studied using ATR-FTIR spectroscopy. A series of H_2O – D_2O blanks were created to more accurately correct for the original water contribution. Analyses of the OH stretch band revealed two water states in the dough. The primary OH stretch peak (~3150 cm^{-1}) shifted toward lower frequencies as moisture content increased with concurrent decreases in peak intensity and area. On the other hand, the peak intensity and area of the secondary OH stretch (~3575 cm^{-1}) increased with moisture content, but the frequency remained constant. The effect of bran addition on the distribution of water in these peaks varied by flour type. Analysis of the amide I region revealed that the content of hydrated β-turns increased with increasing moisture content at the expense of pseudo-β-sheets or aperiodic structure depending on flour type, but subsequently decreased with bran addition. Bran particle size had no impact. These FTIR results indicated that two separate populations of water exist in dough systems: bound (primary peak) and free (secondary peak) water. Addition of bran reduces the amount of free water in the system, corroborated by the decrease in secondary OH stretch peak absorbance and area. Additionally, bran increases the overall energy requirement to excite bound water, which may correlate to stronger water–bran interactions. These data indicated that water redistribution in the presence of bran is dependent on flour type and may drive changes in gluten secondary structure, which may in turn influence bread and dough properties in whole grain systems.

Influence of the particle size of pulse flours on their incorporation of into pan and pita breads

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Cereal Foods World 56:A16

Pulse flours milled from green lentils, navy beans, and pinto beans into finely and coarsely ground flours were incorporated into pitas and pan bread formulations at varying levels to increase protein, fibre, antioxidants, some minerals and vitamins without adversely affecting quality. Pan bread quality was based on specific loaf volume (SLV) and crumb characteristics (color, structure, and texture) at levels of substitution up to 25%. Addition of navy and pinto bean flours produced higher SLV, oven spring, finer crumb structure, and softer crumb texture than breads from lentil flour. Pulse flours with the coarse particle size demonstrated superior dough handling properties, crumb color, and crumb texture than flours with fine particle size. Coarse navy bean flour could be incorporated into a pan bread formulation at 15%, producing bread with minor changes in quality, whereas all the remaining pulse flours (coarse and fine particles) could be only be added to a 10% replacement level. Pulse flours at levels of 25–100% substitution were used to make pita bread; the amount of liquid was adjusted based on Farinograph absorption. Pita bread quality was estimated by diameter, pocket height, specific loaf volume, texture, and crust color. All composite flours were able to produce pitas with pockets, but blends made from the pulse flours with coarse particle sizes demonstrated higher rates of water absorption and produced pitas with superior color and texture. Based on sensory evaluation, pitas containing 25% coarse pinto were preferred to the all wheat control and those containing 25% coarse navy bean flours were not significantly different from the control. Scores for overall acceptability of pitas made with 100% navy bean flour were significantly lower. Overall, coarse flours are preferred and level of substitution was limited when adding pulses to wheat breads.

Addition of grain legume or pulse flours on the quality of dried Asian white salted noodles

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Cereal Foods World 56:A16

Pulses, such as peas, lentils, and beans, are highly nutritious and contain high levels of dietary fibre, protein, vitamins, and minerals. Pulse flours have been successfully added to many baked products, various meat applications, and pastas to improve their nutritional properties. The objective of this study was to partially replace wheat flour with pulse flours in Asian white salted noodles to improve the nutritional value without compromising the texture and flavor of the end product. Whole flours of yellow pea, green lentil, and navy bean were blended with Canadian western red spring wheat at 25, 30, and 35% and processed into noodles using an Ohtake pilot-scale noodle machine and then dried according to standard industry practice. A 100% wheat flour control was also prepared for comparison purposes. Salt (2%) was added to all formulations and water levels were adjusted depending on the level of pulse flour added. The cooked noodles were evaluated for color using the Minolta chroma meter CR-130 using an L*a*b* color scale. Noodle firmness was measured using a TA-XT2 texture analyzer as force (*g*) to compress the noodle. A trained sensory panel evaluated the cooked noodles for flavor and texture. No differences ($p < 0.05$) in firmness were found among the noodles made from the various pulse flours. Pulse flours significantly affected cooked and dried noodle color ($p < 0.05$). The addition of pulse flours affected the flavor properties of the noodles. As the level of pulse flour increased in the noodle formulation, there was a corresponding increase in protein and dietary fibre. Overall, this study has shown that it is possible to improve the nutritional properties of Asian white salted noodles with the addition of pulse flours. Although end-product characteristics were affected by the addition of pulse flours the noodles maintained acceptable quality characteristics.

Phenolic distribution in wheat kernels—Chemical and physical structure for nutritional value

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In an effort to provide healthier ingredients, researchers are studying common foods that could better provide satiety and nutritional benefit. Wheat bran contains the majority of phenolic compounds, antioxidants, and some of the key vitamins found in the wheat berry. Germ, endosperm, and wheat bran all contribute differently to the structure and chemistry of the kernel. However, the distribution of phenolic compounds in different parts of wheat kernels has not been well studied. To accurately measure germ, endosperm, and bran contribution, the components must be separated before analysis. Multiple particle sizes of wheat bran, as well as roller-milled and hand-milled wheat fractions, were analyzed by high-performance liquid chromatography (HPLC) to study the effects of particle size reduction and wheat fraction on the amount of available nutrients, phenolic compounds, and phytochemicals. Analysis of the total phenolic content and phenolic, phytochemical, and vitamin concentrations were employed to detect the differences between germ, endosperm, and bran separated from the same wheat kernel. Significant differences in phenolic and phytochemical concentrations were observed between the fractions of germ, flour, and bran milled from the same kernel. Without altering particle size, ferulic acid extracts were quantified by HPLC. The germ contained an average of 824 µmol/100 g; significantly more than the flour and bran, 16 and 230 µmol/100 g, respectively (µmol ferulic eq). By total phenolic assay, hand-milled samples had total phenolic contents of 0.4 mg/g endosperm, 1.4 mg/g germ, and 3.6 mg/g bran (mg gallic eq).

Effect of water management on rice grain quality

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Water availability is a major problem of growing rice. To reduce water requirements, rice farmers plant rice using the bed-and-furrow (rows) system (BF). It is known that growing rice on rows can decrease yield and increase disease but there is little information on its effect on grain processing quality. Therefore, a field study was conducted using four cultivars: Bengal, CL 161, CLXL 729, and CLXL 745; four water management treatments: flood, row, flood-to-row, and row-to-flood; and two fertility rates: 100# N and 180# N. Apparent amylose concentration was affected by a two-way interaction between cultivar × fertilizer and cultivar × water. Apparent amylose concentration was lower for Bengal and CL 161in BF conditions, it remained unchanged in CLXL 729 and CLXL 745. Apparent amylose concentration for all cultivars was similar to the BF system when flooded conditions were changed to row conditions. When row conditions were changed to flooded, the same was only true for CLXL 729 and CLXL 745 and the apparent amylose concentration for Bengal and CL161 increased. The RVA profile was affected by a three-way interaction, cultivar × fertilizer × water. Peak viscosity for each of the cultivars, except CL 161, was higher under flooded conditions than BF system when 180# N was used; whereas when 100# N was used, the peak viscosity was highest for CLXL 745 and CLXL 729 under row conditions. When flooded conditions were changed to row conditions, peak viscosity was higher for CLXL 745 and CLXL 729 when using 100# N; whereas, for Bengal and CL 161 it was higher when 180# N was used. When row conditions were changed to flooded conditions, peak viscosity was higher for CLXL 745 when 180# N was used. This study shows that the effect of water management on grain processing quality is controlled mainly by the interaction of genotype and fertility with the water system used.

Thickeners from normal and high-amylose corn starch with sodium palmitate

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Our previous studies have shown that materials with applications as thickeners can be formed from aqueous dispersions of amylose helical inclusion complexes obtained from high-amylose corn starch and sodium palmitate. In order to prepare less-expensive materials, to broaden the range of possible materials and to examine the role of amylopectin in gel formation, dispersions were prepared containing normal corn starch. The starch was jet cooked under excess steam conditions and blended with aqueous solutions of sodium palmitate to form helical inclusion complexes with the amylose component of the starch. As prepared, the charged amylose complexes remained in solution and did not retrograde. However, upon lowering the pH by adding acid, the charge was partially neutralized, decreasing intermolecular repulsion and allowing junction zones to form and create a gel network throughout the sample. The rheological properties of these gels were measured to determine the effects of starch concentration, amylose content and pH. The maximum storage modulus was observed at a pH of about 6.3 for each sample. For 5% normal corn starch (1.25% amylose), the storage modulus at a frequency of 1 rad/s was 90 Pa, whereas for 2% high-amylose corn starch (1.4% apparent amylose) it was 300 Pa, indicating that the presence of amylopectin inhibited effective gel formation. At lower pH, the amylose interacts even more strongly and eventually precipitates from solution. For normal starch, 83% of the total starch solids were precipitated, suggesting that the amylopectin was part of the gel network. Samples were also prepared from blends of high-amylose, normal, and waxy corn starch to obtain a range of amylose/amylopectin ratios and gel properties.

Comparing digestibility of A- and B-type crystals and providing insight on digestibility of starches

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Starch is the most important source of food energy. It is well known that native starches with a B-type X-ray diffraction pattern are more resistant to alpha-amylase digestion than those starches with an A-type X-ray pattern, but the underlying mechanism is not well understood. It is not clear whether the enzyme resistance of B-type starch is due to its B-type crystalline structure or the organization of starch granules. The objective of this study was to compare the structure and enzyme digestibility of highly pure A- and B-type starch crystals and understand the roles of crystalline types in starch digestibility. Highly pure A- and B-type starch crystals were prepared from short-chain amylose generated from completely debranched waxy starches by manipulating the processing conditions such as solid concentration, crystallization temperature, and short-chain length. Digestion results showed that A-type crystals were more resistant to enzyme digestion than B-type crystals. A-type crystalline product produced from debranching of 25% waxy maize starch was 16.6% digested after 3 h, whereas B-type crystals obtained from debranching of 5% waxy maize starch had 38.9% digested. A-type crystals had a higher melting temperature than B-type crystals as determined by differential scanning calorimetry. Annealing increased the melting peak of the B-type crystals, making it similar to that of the A-type crystals, but did not improve the enzyme resistance. The possible reason for these results was due to more dense double helices packing pattern of A-type crystallites. Our observations were opposite to the fact that B-type native starches are more enzyme resistant. It seems that crystalline types are not the key factor that controls the digestibility of native starch granules. The resistance of native starches with B-type X-ray diffraction pattern is probably attributed by the organization of starch granules.

Retention of anthocyanins, phenolics, and antioxidant activity during blue corn extrusion

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Blue cornmeal is a natural source of anthocyanin water-soluble pigments. Consumption of these pigments aids health through antioxidant and anti-inflammatory activity and protection against chronic diseases. Anthocyanins are heat labile so foods containing anthocyanins are difficult to extrusion-cook for puffed snacks or breakfast cereals. Blue cornmeal was twin-screw extruded to obtain puffs with optimal anthocyanin content. Extrusion parameters included maximum barrel temperature (150 or 165°C) and 18, 21, or 24% feed moisture. Extrudates were characterized for total anthocyanins (ANC), total free phenolics (TFP), oxygen radical absorbance capacity (ORAC), physical properties, and sensory acceptability by 100 consumers using a 9-point hedonic scale. Data were analyzed by ANOVA with Tukey's test ($p \leq 0.05$). Three levels of rosemary extract were added to raw cornmeal (0, 0.1, 0.3% w/w) to improve ANC retention in one experiment; the effect of convection drying extrudates was also evaluated. Extrusion at 150°C & 21% moisture and at 165°C & 24% moisture resulted in the highest ANC, TFP, and AOX levels. Drying decreased anthocyanins 23–46%; rosemary addition had no effect. HPLC-MS revealed new anthocyanin-phenolic complexes were formed during extrusion. Drying darkened the puffs further but did not impact blue hues on the Hunter color scale. Lower temperatures and moisture in extrusion resulted in more blue color. Dried blue cornmeal puffs with 0.3% rosemary and extruded at 150°C & 24% moisture had significantly more acceptable color (7.3) and appearance (7.0) than other samples. Increased understanding of the fate of anthocyanins during extrusion cooking will lead to improved processing techniques for retaining these phytochemicals for their appearance and health benefits.

A new class of wheat offers opportunities for pasta and bakery products

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Cereal Foods World 56:A17

The kernel hardness ("texture") of durum wheat has dictated practices and constraints in processing and utilizing this important cereal grain. Semolina is the primary milling fraction of durum as the larger particle size results in a controlled level of starch damage, which in turn allows for the production of high-quality pasta. Durum flour has limited use due to its high starch damage, which increases absorption and limits its use in both pasta and bakery products. The recent development of a soft kernel texture durum wheat containing puroindoline a and puroindoline b provides new opportunities for value-added crop production, process efficiencies, food processing applications, and improved quality of products. Grain grown in Yuma, AZ, with a protein content of 17% was milled on a Miag pilot mill and used to produce pasta and a variety of bakery products. The expression of the puroindolines resulted in a soft kernel and flour particle size distribution and starch damage content similar to that of pastry flour. Optimum absorption for spaghetti made from the soft durum flour was determined from the alveograph to be 29% (on a 14% moisture basis) vs. 32% for semolina. Spaghetti made from soft durum flour resulted in lower cook loss and was similar in firmness to that made from commercial semolina. Soft durum flour was also demonstrated to enhance the color, flavor, and texture of a wide variety of baked products where standard durum flour with high starch damage would have created processing or textural issues.

Use of wheat bran protein hydrolysates in cereal-based food systems

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Cereal Foods World 56:A17

Wheat bran (WB) is an abundant coproduct of industrial wheat milling, and its main application is limited to animal feeding. Nowadays, wheat bran use as a source of dietary fiber increases. To the best of our knowledge, little is known about the proteins present in wheat bran, their functional properties, and their enzymatic degradability. Moreover, the overall use of protein hydrolysates in cereal-based food systems has been poorly documented in literature. The aim of our work was to provide a scientific basis for valorizing wheat bran proteins. Their enzymatic conversion to hydrolysates with techno-functional properties and their use in cereal-based food systems was studied. After treatment of WB with amylase and xylanase, a protein concentrate (WBPC) was prepared by alkaline extraction followed by acid precipitation. WBPC was hydrolyzed in a pH-stat set-up at optimal peptidase conditions for different times in order to obtain hydrolysates with different degrees of hydrolysis (DH). Protein content and molecular weight distribution, as well as techno-functional properties, such as solubility as function of pH and emulsifying and foaming properties, were determined. In general, enzymatic hydrolysis of WBPC improved solubility and emulsifying and foaming properties. However, these properties strongly depend on the peptidase used and the DH of the resulting hydrolysate. After determination of these functional properties in simple model systems, the functionality was evaluated in cereal-based food systems. Their behavior depends on their intrinsic properties as well as on those of the food matrix.

A review on the impact of bran, cereal fiber, and whole grain intakes and risk reduction of type 2 diabetes

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A literature review was conducted on the impact of cereal fiber, bran, whole grains, and mixtures of whole grains and bran on weight control and the risks of type 2 diabetes. MEDLINE was used to search the scientific literature for relevant studies. Additional studies were identified by bibliographic searches for relevant reviews and articles. Editorials, reviews, and studies published in languages other than English were excluded. Bran, cereal fiber, mixtures of whole grains and added bran, and whole grains had consistent associations with risk reduction of diabetes or metabolic syndrome as well as with biomarkers of diabetes, including insulin sensitivity. The whole grains related associations were not significant after the models were adjusted for cereal fiber, magnesium (Mg), and other dietary components such as antioxidant vitamins. However, cereal fiber (but not whole grains or other types of fibers) was strongly associated with a reduced risk of type 2 diabetes or metabolic syndrome after adjustments for Mg and other dietary factors. Cereal fiber, bran, and Mg appear to be active components in whole grains. The public health messages for the health benefits of whole grain should also emphasize the importance of bran and cereal fiber.

Oat avenanthramides: Acute bioavailability in older adults when administered in an oat bran muffin containing high endogenous avenanthramides

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Avenanthramides (AV) represent the major soluble phenolics present in the oat kernel and normally occur at concentrations between 25 and 100 ppm in most material. We have shown that both purified AV and concentrated AV mixtures have anti-atherogenic and anti-inflammatory activity in IL-1β-

stimulated human aortic endothelial cell cultures, suggesting they may have similar effects in vivo if they are sufficiently bioavailable. Based on our previous studies, the bioavailability of pure AV in humans is only about 1% of an acute oral dose, and therefore an oat with about 2,000–4,000 ppm total AV would be required to be physiologically relevant. After developing a proprietary oat malting and abrasion milling process we produced an oat bran ingredient with 3,000–3,500 ppm total AV to meet the requirement. This bran was incorporated (30% by weight) into a 60-g bran muffin which contained about 45 mg total AV after baking. We then conducted a placebo-controlled, crossover study using these muffins to determine the acute AV bioavailability and pharmacokinetics in 10 healthy adults, age 50–70 years with BMI of 18.5–29.9. After a 2-day run-in period following a diet free of oat products, subjects consumed either a muffin made with the enriched oat bran or a placebo muffin, with a 1-week washout period between each intervention. Blood AV levels of the six major AV were determined at specified time points before and up to 24 h after muffin consumption. Preliminary results from six subjects indicate the maximal plasma concentration (C_{max}) and time to reach C_{max} (T_{max}) of these AV were 32.0 ± 16.1 ng/mL at 1.9 ± 0.4 h, respectively, with marked variation between subjects. Data suggesting that AV in this new innovative food source (malted oat bran) are indeed bioavailable in healthy older adults and the potential relevance of these findings to human cardiovascular health will be discussed.

Genotype and environment effects on functional properties of wheat starch

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Starch is a macroconstituent of many foods and the major source of energy in the human diet. The digestibility of starch has health implications and is the subject of much research in relation to human nutrition. Natural starch is highly variable, resulting in unpredictability of its functional performance in food processing and human nutrition. Our research seeks to fill critical knowledge gaps about how environmental factors during crop growth affect functional properties of wheat starch that are important for food processing and human nutrition. Starch was isolated from grain harvested from five commercial Australian wheat varieties that were grown in five different climatic regions of Australia in 2 years. Analyses were performed on the isolated starch to examine the extent to which genotype, growth location, and year influenced variability of functional properties, including thermal transitions in the DSC, pasting properties, gel strength and syneresis, and susceptibility of retrograded starch gels to in vitro attack by alpha-amylase. All of these functional properties for each of the genotypes were significantly affected (significant at $p < 0.001$) by growth location and year and there were significant interactions between genotype, growth location, and year. Statistical analysis indicated that growth location, rather than genotype, was the major contributor to variance of starch thermal properties and strength, syneresis, and enzyme digestibility of starch gels. Using these measured properties of the starches, and their well defined environmental histories, a model was developed for understanding and predicting environmental effects on starch quality.

Potential differences in the bran of red compared with white wheat near-isogenic lines: Impact on *Fusarium* mycotoxin levels in the grain

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Demand for hard white wheat (*Triticum aestivum* L.) has increased along with the demand for whole grain products. However, many white wheat varieties are susceptible to Fusarium head blight (FHB), caused by a fungal pathogen, *Fusarium graminearum* (teleomorph *Gibberella zeae*). Furthermore, the FHB mycotoxin, deoxynivalenol (DON), accumulates primarily in the bran layer of kernels. Consequently, whole grain products prepared from infected white wheat grain could pose a health risk. Near-isogenic lines (NILs) of red and white winter wheat were selected for use in this study to examine potential bran differences and identify the impact of any genetic differences on the accumulation of DON in bran. Parents, NILs, and control varieties were artificially infected with FHB, and samples were collected from both infected and uninfected plants. For DON content analyses, samples from infected plants were visually sorted into kernels without damage and into Fusarium-damaged kernels (FDKs). Mean DON content for samples was significantly different between red- and white-seeded parents, between NILs, and between red- and white-seeded FHB-susceptible and -resistant control varieties. The mean DON content of FDKs from the white-seeded parent was higher than for the red-seeded parent, but the mean DON content of the red NILs was higher than for the white NILs. The mean DON content of red-seeded FHB-resistant and -susceptible controls was higher than the mean DON content of the respective white-seeded resistant and susceptible controls. To compare accumulation of DON in the bran layer, the same samples will be pearl milled to produce bran and nonbran fractions. The DON content in bran and nonbran fractions will be analyzed, and the accumulation of DON in fractions derived from the white NILs will be compared with the accumulation in fractions derived from the red NILs.

Wheat arabinoxylans and arabinoxylan oligosaccharides show strongly different prebiotic and intestinal fermentation properties in rats

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Cereal Foods World 56:A18

The importance of structural features of wheat arabinoxylan (AX), one of the main dietary fibres in the human diet, for its prebiotic potential and intestinal fermentation properties was studied in a rat trial. Experimental diets based on pregelatinized starch were prepared. AXOS with an avDP of 5, water-extractable AX (WE-AX), water-unextractable AX (WU-AX), and combinations thereof were included in the reference diet at 5% AX. Animals received a specific diet for 2 weeks before being sacrificed. Cecum and colon samples were collected for metabolic activity and microbiological analyses. AXOS and WE-AX were intensively fermented in the cecum. Degradation of AXOS and WE-AX mainly stimulated the production of acetate and led to a significant drop in the pH of the cecum content and an effective suppression of markers of the proteolytic breakdown. Moreover, AXOS and WE-AX stimulated selectively the growth of bifidobacteria in the cecum and colon of rats. WE-AX had a more pronounced effect in the hindgut of the animals as completion of its fermentation occurred in the colon. The WU-AX fraction was far more resistant and lacked bifidogenic potential. Intake of WU-AX did result in an increased butyrate production. Combining WU-AX and AXOS caused a striking synergistic increase in butyrate levels in the cecum. WU-AX, WE-AX, and AXOS together combined a selective bifidogenic effect with elevated butyrate levels, a reduced pH, and suppressed proteolytic metabolites. In cereal foods, these combinations can be achieved by addition of AXOS as an ingredient or by enzymic modification of the native AX population.

Hyperspectral image analysis for soft wheat milling quality

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Cereal Foods World 56:A18

The combination of imaging and spectroscopy, or hyperspectral image analysis, offers a new approach to milling quality evaluation in its potential to simultaneously collect and determine kernel morphological properties and NIR spectral information that relates to underlying chemical and physical structure. The objective was to evaluate this technique on the evaluation of soft wheat milling quality. Pixel-by-pixel spectral analysis was evaluated on two 2010-harvest sets of SRW wheat that underwent pilot milling for softness, milling, and baking indices. Altogether, 164 genotypes were imaged, each consisting of 30 kernels selected at random. Image processing steps consisted of 1) masking all 144 wavelength bands (992–1681 nm range) using the reflectance image at 1001 nm to identify the background; 2) spatially compressing to reduce storage memory by 72%; 3) applying an SNV transformation to each pixel spectrum (to minimize the shadowing effects caused by surface curvature); and 4) calculating the mean and standard deviation spectra for each pixel in a kernel (~500 total) for systemic and textural characterization, respectively. Exhaustive searches were conducted of the best wavelength pairs of either means or standards, or of the best principal component scores, with either used in a pooled covariance linear discriminant analysis (LDA) model of better vs. poorer (2-group) quality grade (by separate trials of softness, milling, and baking grades). Results indicate that irrespective of the systemic or textural response, the best image-based models, when tested by leave-one-out cross-validation, were correct ~75% of the time. This is on par with similar LDA models developed using conventional NIR spectra of ground meal or bulk intact kernels. Interim conclusions emphasize the point that improvement in accuracies of hyperspectral models will occur with kernel subregion analysis.

The formation of glutenin macropolymer and large glutenin structures as induced by a dough mixing-heating cycle

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For standard dough mixing (30°C), a lot has been learned about the status of SDS insoluble glutenins. The glutenin particles are predominantly mechanically disrupted and dispersed. Mixing renders the glutenin macropolymer

(GMP) soluble in 1.5% SDS, and GMP re-assembles during rest. The effect of a combined dough mixing-heating cycle on gluten(in) is far from clear. In this study, we set out to improve our understanding of factors that affect gluten(in) aggregation. In order to explore the physicochemical effects of mixing-heating cycles, three wheat flour samples, low, medium, and high protein content, were selected for preparing processed dough samples on the Chopin Mixolab. To study the effects on GMP, the mixing procedure was stopped at eight different times. The times chosen represent a relevant change in the dough curve (Tq, T). After dough processing, part of the sample was immediately frozen in liquid nitrogen, another part was allowed to rest for 45' before freezing. The samples were freeze dried, followed by milling. Dough sample analyses were done using LM to visualize gluten(in) aggregate characteristics, water extractions, unreduced SDS extraction vs. reducing extraction, and identification of key proteins in forming insoluble fractions and aggregates. The results show that GMP wet weight in the three flour samples parallels dough peak time on the Mixolab: from 1' for the low to 5.5' for the high GMP-gel flour. The LM results indicate that initial aggregate formation starts at relatively low dough temperatures. At some stages, GMP of heat-treated dough was higher than the GMP in the respective flour. This may be due to heat-induced copolymerization of water/SDS-soluble proteins into the GMP fraction. Protein extraction/separation showed that GS are key in heat-induced aggregation, resulting in the large structures obeserved. The observations may help understand the effect of processing on gluten functionality.

Suitability of solvent retention capacity test methodologies for European wheat flours

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Cereal Foods World 56:A19

Solvent retention capacity (SRC) tests have been successful in evaluating the performance of mainly North American soft wheat flours. However, whether they are equally successful within a European context featuring harder wheat is not clear. The objective of our work was, therefore, to evaluate the contribution of specific flour constituents to the analytical readings in SRC tests and to study the suitability of SRC parameters as predictors for the quality of cookies and bread made from European wheat flours. Nineteen commercial European wheat flours with different functionality were characterized using classical methodologies. Their SRC profile, consisting of water retention capacity (WRC), 5.0% (w/w) sodium carbonate SRC (SCSRC), 50.0% (w/w) sucrose SRC (SuSRC), and 5.0% (w/w) lactic acid SRC (LASRC), was analyzed as well. We also modified specific flour samples by adding (ball-milled) wheat starch, arabinoxylan (AX), or specific enzymes. This clearly illustrated the contribution of proteins, damaged starch, and AX to all SRC values. Flour proteins, especially glutenins, mainly contributed to LASRC, while damaged starch largely impacted flour SCSRC. Water-extractable AX only contributed to the SuSRC values. In a second step, the suitability of SRC parameters as predictors for cookie and bread quality of the flours was studied and compared with the suitability of more conventional flour quality parameters. The WRC values were the best predictors for cookie diameter (r = –0.82). For bread volume, all parameters related to flour protein level and/or quality, including LASRC values (r = 0.69), were predictive. The SRC values are good, time efficient, and simple cookie and bread quality predictors for European commercial wheat flours.

Stress relaxation of wheat kernels and their relationship with milling, rheological, and bread quality of wheat

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Cereal Foods World 56:A19

The stress relaxation behaviors of 10 different commercial samples of soft and bread wheat type kernels were studied using the generalized Maxwell model with 4-exponential terms at 1200 s of relaxation. Tests were performed using the TA-XT2 with the probe TA-510 at 0.5 mm of deformation and loading rate of 0.1 mm/s. The objective was to compare the traditional quality data with the viscoelastic properties obtained using the stress relaxation with generalized Maxwell model to determine the parameters that would best differentiate the quality characteristics of wheat samples. The data suggested two fast phases at shorter times about 1.5 to 15 s ($\tau1$ and $\tau2$) and two slow phases with longer times of ≈ 85 to 750 s ($\tau3$ and $\tau4$). The shorter decay of $\sigma1$ can be explained by very weak forces due to hydrogen interactions that affect mainly rheological properties, while slow decay ($\sigma4$) located at longer relaxation times were due to strong forces may be due to ionic and hydrophobic interactions among proteins and other compounds. There were differences in springs and relaxation times of bread wheat compared to soft wheat type kernels. The stresses $\sigma1$ and $\sigma4$ were correlated with wheat kernel, flour, rheological, and breadmaking properties. The elasticity of the spring ($\sigma0$) was significantly correlated with all the properties, such as kernel (test weight, ash, protein, and falling number), flour (yield, sedimentation volume, and protein), rheological properties (water absorption, gluten content, arriving, developing time W, and P/L ratio) and bread volume among others, while $\sigma2$ and $\sigma3$ did not showed correlation at all. The relaxation times were high for bread wheat with high-quality breadmaking quality compared with soft wheat types. The stress relaxation test in wheat kernels is a fast and inexpensive tool for predicting rheological and breadmaking quality with potential as alternative test for the traditional methods.

A novel immature spike culture-derived variant creation strategy for mutation-mining in wheat (*Triticum aestivum* L.)

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The objective of this study was to generate mutations expeditiously in wheat using an immature spike culture-derived variant (SCDV) creation strategy. A SCDV population was created for a soft white spring wheat cv. AC Nanda. Immature spikes were cultured in liquid medium containing 5% (w/v) sucrose and 0.4% (w/v) L-glutamine prior to occurrence of anthesis. Ethyl methanesulfonate (EMS) was used at 0.1, 0.25, and 0.5% in the culture medium for three hours. Spikes were then transferred to medium without EMS and cultured to maturity for 30 days. Seeds (M_0) were advanced to M_2. M_1 plants exhibited a range of phenotypes from dwarf to late heading to extended heads. The SCDV creation strategy is simple, fast, requires minimum handling of EMS, and since EMS is supplied prior to anthesis, the chances of targeting mutations in the germ-line cells (ovules and microspores) are higher, which may lead to higher frequency of variants. The SCDV population was screened by a simple sequence repeat-high resolution melt curve (SSR-HRM) analysis to rapidly scan for mutations. Several of the variants showed different melting temperatures compared to the control, indicating occurrence of mutations. To test if the screening for variants could be expedited, RNA from leaf tissue of M_2 plants was used for expression analysis using quantitative real-time PCR for the starch biosynthetic genes, *SBEI*, *SBEIIa*, and *SSI*. A down-regulation of expression of these genes was observed compared to the control in three of the tested variants. High-resolution melt curve (HRM) analysis using primers specific for a fragment of the *SBEIIb* gene confirmed the existence mutations in four of 12 variants screened. Variant fragments are being sequenced for determination of mutation sites. Detailed analyses will be conducted to characterize these variants.

Creation and analysis of novel HMW-GS and puroindoline alleles

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The puroindolines and the high-molecular-weight glutenin subunits (HMW-GS) are major determinants of wheat flour functionality. The puroindoline genes puroindoline a and b together reside at the wheat *Hardness* locus and control whether wheat is soft or hard textured. Hexaploid wheat HMW-GS are encoded by the *Glu-A1*, *Glu-B1*, and *Glu-D1* loci. Our objective is to better understand the structure/function relationship between puroindolines, HMW-GS, and wheat end-product quality. To this end, we created an EMS mutagenized population using the soft spring wheat variety Alpowa. More than 100 new puroindoline and HMW-GS alleles were generated and analyzed after backcrossing to Alpowa. Seed quality was assessed by grain hardness tests, milling, and baking analyses as well as small-scale tests of wheat end-product functionality. The results indicate that the novel alleles may shed light on the structural regions of the puroindolines and HMW-GS that are most important to wheat end-product quality. The new alleles also may prove useful as a novel source of allelic variation for wheat breeding programs.

High-digestibility, high-lysine (HDHL) sorghum grain contains kafirins which participate in the protein network of composite dough and bread

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The storage protein of sorghum grain is kafirin which is confined in protein bodies and does not participate in dough formation. The aim of this study was to determine whether protein body-free kafirins in high-digestibility, high-lysine (HDHL) sorghum flour participate as viscoelastic proteins in wheat-sorghum composite dough and bread above their glass transition temperature (T_g). Functional tests on HDHL sorghum kafirins were performed using the following: dough extensibility (DE), extensional viscosity (EV), bread compressibility (BC), and bread specific volume (BSV) at room temperature

and at 35°C (above T_g). Sorghum flour additions were 30 and 60% flour weight basis for DE and EV, 30 and 42% for BC, and 20 to 60% at 2% increments for BSV. Maximum resistance to extension (gram) and time to dough breakage (sec) at 35°C for HDHL sorghum doughs were significantly greater ($p < 0.01$) than for normal sorghum, at both substitution levels. Significant differences were also observed between room temperature and 35°C for HDHL sorghum composite doughs, while normal sorghum displayed no difference, indicating functional changes in HDHL kafirin upon exceeding T_g. Changes in functional properties were also highlighted between HDHL and normal sorghum doughs through EV measurements, as HDHL sorghum displayed greater EV with increased strain while EV decreased in normal sorghum (60% substitution). BSV data revealed higher loaf volumes for HDHL sorghum compared to normal sorghum at substitution levels above 30% and up to 60%, with the highest difference at 42%. HDHL sorghum bread exhibited lower hardness values, lower gumminess, and higher springiness than normal sorghum bread. These results show clearly that liberated kafirin in HDHL sorghum flour contributes to the formation of a protein network which is necessary for superior quality of composite dough and bread.

Potential of alkylresorcinols in Canadian red hard and red soft wheat bran and their stability during baking

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Cereal Foods World 56:A20

Alkylresorcinols (ARs) are amphiphillic phenolic lipids and mostly found in cereal brans such as rye and wheat. ARs are 1,3-dihydroxy-5-alkylbenzene homologues with odd-numbered alkyl side in the range of 15–25 carbon atoms. Studies have shown that ARs can be used as biomarkers of whole grain consumption. In this study, ARs composition and content of Ontario (ON)-grown red hard wheat bran (RHWB), red soft wheat bran (RSWB), and bread samples were measured using GC-MS. All samples contained saturated and unsaturated ARs, and levels of saturated ARs were higher than unsaturated homologues. Total ARs content for RHWB was 255.76 mg/100 g before breadmaking and after baking, the amount was 194.44 mg/100 g. Before baking among ARs, C-21 was the most dominant homologue, followed by C19:0, C23:0, C25:0, and C17:0. After baking, the relative proportion of homologue C23:0 increases but C25:0 decreased. This result suggests that ARs have good stability (76%) during baking. This is the first report on ARs composition of wheat grown in Canada, especially in Ontarian wheat.

Interactions between cereal soluble dietary fibres and bile salts

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Cereal Foods World 56:A20

Soluble dietary fibres (SDF) can reduce plasma cholesterol in vivo, possibly by restricting both dietary cholesterol uptake and bile salt re-absorption, thereby leading to the recruitment of circulating cholesterol for synthesis of further bile. Underlying mechanisms remain obscure and have been addressed in this work by a combination of NMR spectroscopy, small angle X-ray scattering, viscosity measurement, and time-resolved dialysis. A range of cereal arabinoxylan and (1,3;1,4)–β–glucan samples all show at least one type of interaction with both monomolecular bile salt micelles and complete porcine bile. Evidence for direct molecular binding and/or network entrapment of bile salts by individual cereal SDFs is obtained. Both mechanisms are shown to lead to a retardation of bile salt diffusion under dialysis as a mimic of small intestinal re-absorption. Factors controlling the strength of interactions will be discussed as a potential means of tailoring cereal SDFs for enhanced nutritional value.

Developing barley-fortified wheat flour-based foods

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Cereal Foods World 56:A20

Americans are increasingly at risk of premature death from both cardiovascular disease and diabetes due to overweight, elevated cholesterol, high blood pressure, and abnormal blood sugars. These risk factors are partially contributed by a diet low in fiber and high in refined grains, sugars, and saturated fats. Barley is a rich source of soluble and insoluble fiber. β-glucan, a fraction of the soluble dietary fiber, is the primary component in barley that is responsible for lowering serum cholesterol and blood glucose. Barley can be part of the solution to the development of healthy foods in American diet. The main objective of this study was to develop wheat-based products with additional nutritional and health benefits fortified with high β-glucan barley flour. Each of hard red spring, hard red winter, and soft white flour was blended with 10, 20, and 30% of three types of barley flour, including waxy, hulless and hulled types. The varieties tested were Radiant, Salute, and Sustagrain. The results showed that up to 20% barley flour was acceptable in instant ramen noodles, bagels, and pan breads in terms of eating quality, while up to 30% barley flour was acceptable in flour tortillas and sugar-snap cookies. Nevertheless, some formulations and processing parameters had to be adjusted when barley flour was added. In conclusion, high β-glucan barley flour can be a good option to improve the nutritional and health benefits of wheat-based products. By incorporating barley flour into popularly consumed wheat-based products, it could help consumers improve their health.

Effects of LAB fermentation on physical properties of oat flour and its suitability for noodle making

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As a popular category of Asian noodles, starch noodles are a product of purified starch made from various plant sources. However, starch noodles produced from sweet potato, potato, corn starches, etc., are moderately elastic, dull, opaque, displaying high cooking loss or swelling during cooking. Fermentation may change the amorphous region of the starch granule as well as the chemical components and thereby modify both the physical properties of flour and the texture of the noodle. Oats have attracted considerable interest not only for high soluble and insoluble fiber content but also for high fermentability with lactic acid bacteria (LAB). The objectives of the present study was to study the effects of LAB fermentation on gel strength, pasting properties, and the amylose content of oat flour and determine the suitability of oat flour for noodle making by investigating the texture and cooking quality of the fermented oat noodles produced. The results showed that fermented samples had a significantly lower pH than control samples. Gel strength and amylose content initially increased and then decreased ($P < 0.05$) with fermentation time. The peak viscosity, breakdown, final viscosity, and setback value decreased with fermentation time. Fermented noodles showed a higher hardness and springiness. In particular, *Lactobacillus plantarum* (LP) induced the highest springiness, cohesiveness, gumminess, chewiness, and resilience over 12 h of fermentation. The cooking quality evaluation indicated that fermentation improved the quality of oat starch noodles. Fermented oats resulted in noodles with low cooking loss and higher cooking weight compared to noodles made from fresh flour. The use of LP for 12 h of fermentation time yielded noodles of the best quality. LAB fermentation may promote the nutritional value of oats, which represents a promising field for further study.

Comparison of glutenin subunit composition among North American hard wheat classes

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Cereal Foods World 56:A20

Glutenin subunit composition is one of the most important determinants for wheat end-use properties. We studied the glutenin composition among North American wheat classes (1CW, DNS, and HRW) exported to Japan. We analyzed individual seeds using protein and DNA analyses. For *Glu-1* locus, most of all cultivars composing 1CW, DNS, and HRW had *Glu-D1d*, but *Glu-B1i* was not found in those of 1CW. For *Glu-3* locus, we found a new *Glu-A3* allele in the one of cultivars of HRW. Most of cultivars of 1CW and DNS had *Glu-B3h*, but most of those of HRW had *Glu-B3b* or *Glu-B3g*. Since cultivars having the subunit combination of *Glu-D1d* and *Glu-B3b* or *Glu-B3g* show extra-strong dough properties. HRW is expected to have very different gluten properties from 1CW and DNS.

Quantification and modeling of dough microstructure by the use of image analysis

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For the validation of the dependency of wheat dough's rheological properties with its microstructure numerical values of the microstructure have to be available to execute correlation analysis. Furthermore, these values could be used to gain a model to explain changes in the microstructure in dependency of independent variables. Thus, the purpose of this study was to develop a method to quantify the microstructure of wheat dough proteins assessed by confocal laser scanning microscopy (CLSM). The often indicated relation between the microstructure and the process determining rheology of dough should be proofed and characterized. Target values of the image analysis (imageJ) were the area fraction, Feret's diameter, perimeter, circularity and branching index. Rheological properties were analyzed with fundamental and extensibility tests. After the establishment of the methodology, a response surface methodology with the independent values pH, water and sodium

chloride addition was performed. The combination of CLSM with an image processing tool enabled the quantification of the protein network microstructure. A variation of water addition based on flour showed high significant ($p < 0.01$) linear correlations, e.g., with the branching index ($r = –0.92$). The linear correlation of the branching index with the rheological measures exhibited high significant correlation coefficients ($r \geq \left| 0.78 \right|$) with the rheological properties. Furthermore it was possible to model the microstructural values as a function of the independent values with high correlation coefficients ($R^2 \geq 0.80$). In summary, the results submit a novel view on the microstructure of dough. The visual structure of the dough has proven to be a reliable and powerful tool for examining and quantifying dough protein microstructure. The high dependency of rheology from structural elements could be verified.

Whole grain gluten-free flat breads

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Cereal Foods World 56:A21

USDA food guide recommends that at least ½ of all the grains eaten should be whole grains. FDA allows label health claims for food containing 11 g and 51% whole grains. This is the only report demonstrating innovative whole grain products. Whole grain gluten-free flat breads were prepared with corn, millet, brown rice, and sorghum flour. In addition, whole grain chickpea flour was added to increase the protein content in some formulations. Dough formulations containing 1 g od salt and 20 mL od canola oil are given: whole grain flour, instant potato, chick-pea in grams and water in milliliters were 1) corn 200, 0, 0, and 260; 2) millet 150, 50, 0, and 216; 3) brown rice 150, 50, 0, and 210; 4) sorghum 150, 50, 0, and 225; 5) corn 150, 0, 50, and 200; 6) millet 100, 50, 50, and 205; 7) brown rice 100, 50, 50, and 200; and 8) sorghum 100, 50, 50, and 220 respectively. Each dough mixture resulted in five 15-cm round flat breads. Flat breads were made with moist hands on wax paper. Breads were cooked on a lightly oiled grill at 375°F for 6–8 minutes. Taste panels of local 35–46 volunteers resulted in 85, 50, 78, 74, 74, 54, 94, and 86% acceptance of the respective novel health-promoting gluten-free breads. Each bread contained 30–40 g of whole grains. The results offer consumers additional nutritious choices and would increase whole grain consumption.

Quantification of wheat pentosans using a phloroglucinol colorimetric assay

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Pentosans play a critical role in end-use quality and nutrition of wheat (*Triticum aestivum* L.). An efficient, accurate method of pentosan quantification facilitates the characterization of flours/mill streams, the selection of high or low pentosan varieties (and grain lots), and the study of solubility (extractable vs. unextractable fractions). The objective of this work was to evaluate the efficiency and accuracy of the standard phloroglucinol method of Douglas (Food Chem. 7:139-145, 1981) for quantification of wheat pentosans. The following parameters were examined. The stability of the phloroglucide product, which results from the reaction of pentoses with phloroglucinol, the optimal concentration of phloroglucinol, optimal hydrolysis time, and the pentose concentration—absorbance response curve. An improved method that included the elimination of glucose, a reduction in phloroglucinol, and a controlled post-reaction measurement regime was used to measure pure xylose standards and whole meal wheat samples. Results were compared against a baseline provided by GC-FID. The use of this more robust method can increase uniformity between operators and among replications and increase the accuracy of pentosan determinations in wheat.

Protein-based methods to quantify common wheat in spelt wheat

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For more than 10 years spelt has gained new popularity as an "ancient cereal" and is, therefore, increasingly cultivated. Consumers believe that spelt is of higher nutritional value than common wheat. Thus, spelt and spelt products yield a substantially higher price as compared to common wheat. On this background, it is of great interest whether commercial spelt products have been mixed with common wheat. German food guidelines allow 10% wheat in spelt wheat and products thereof. Therefore, the aim of this work was to develop a method to quantify portions of common wheat in spelt wheat below 10%. Omega-b-gliadins were found to be typical proteins for wheat, which are not present in spelt. This protein type was characterized by MALDI-TOF-MS and N-terminal sequence analysis. The analysis showed that omega-b-gliadins are similar to omega-5-gliadins, but due to a point mutation they contain a cysteine residue instead of a serine residue and are therefore bound to the glutenin polymer. To identify a wheat-specific amino acid sequence within omega-b-gliadins, they were isolated by semipreparative HPLC and partially hydrolysed with chymotrypsin. After selective enrichment of cysteine-containing peptides from the digest on thiopropylsepharose, amino acid sequences were determined. The amino acid sequence of one cysteine-peptide was completely determined by Edman-degradation and LC-MS-MS analysis. Unlabelled and stable isotope-labelled standards of this peptide were synthesized and a stable isotope dilution LC-MS-MS assay was developed. Calibration mixes with wheat-spiked spelt flours were analyzed to enable direct conversion of the results to wheat concentrations. The new method is suitable to quantify even small amounts of wheat (approximately 1%) in spelt flours and baked goods. In addition to model studies, commercial spelt flours were analyzed and 3 out of 20 samples contained more than 10% wheat.

Preliminary investigation of QTLs related to antioxidant activity and quality in a hard × soft cross

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Knowledge of the genetic control of micronutrient content in wheat could improve outcomes when breeding for enhanced nutritional quality. A recombinant inbred population was examined for phenotypes related to total antioxidant activity (TAA) as well as for conventional quality traits. The population was derived from Tubbs (U.S. Pacific Northwest soft white winter wheat) and NSA 98-0995 (French hard red winter wheat). A combination of diversity arrays technology and simple sequence repeat markers were used to construct genetic linkage maps. Quantitative trait loci (QTL) analysis was performed using composite interval mapping in WinQTL Cartographer v.2.5 with logarithm of odds threshold of 2.5. Transgressive segregation was observed for key quality traits as well as TAA. Significant QTL were observed for TAA on 7A and 5B coincident for QTL related to protein attributes. TAA was positively correlated with grain hardness ($p < 0.001$). Weak but significant correlations with starch damage ($p < 0.01$; positive), break flour yield ($p < 0.01$; negative), and polyphenol oxidase activity ($p < 0.05$; positive) were also observed. There was no significant difference in TAA between red and white lines in this population although the parents were significantly different.

Bread crust: An overview

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Crust is a very important feature of bread and in general of any bakery product. Besides, crust is a challenging concept and is difficult to define. Three domains may be considered in the bread structure: the outer and visible layer of the product, a transition zone, and then the crumb. The "functional" properties of the crust are somewhat related to physical properties (crispness, colour, water activity, moisture content, …) and sensorial properties (appearance, aroma, …). Other aspects may be considered such as possible presence of contaminants like acrylamide or exogenous contaminants (i.e., particles of antistick coating from the baking support). This presentation provides an overview on bread crust based on selected results from our group and from existing literature. The impact of processing conditions on crust quality will be presented with special emphasis on degree of fermentation, baking temperature, amount of steaming during baking, and baking time. Recent and original results on the impact of the amount of steam on crust crispness will be implemented to better understand the link between process parameters and crust structure. The use of different techniques (X-ray microtomography, 2D GC-GC MS TOF, …) will be presented for monitoring the impact of those process conditions. The impact of formulation in particular the use of fibres on the functional properties of both the crust and aroma of bread will be discussed. Outlook in terms of research will be proposed.

Small intestine mucosal α-glucosidases have a rate-limiting role in starch digestion

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Small intestine α-glucosidases are two membrane bound complexes that are comprised of maltase-glucoamylase (MGAM) and sucrase-isomaltase (SI),

each having N- and C-terminal subunits. In the past decades, gut α-glucosidases were not considered as rate limiting for starch digestion. They were assayed as maltase and conventionally thought to convert α-amylase hydrolysates to glucose without structural consideration. Accordingly, starch is nutritionally classified into rapidly, slow, and resistant starch based on α-amylase susceptibility only. Here, we investigated the digestion capability of individual subunits of mammalian recombinant α-glucosidases. Maize starch, including raw starch granules, gelatinized starch, and α-limit dextrin (LDx), were incubated with recombinant mammalian N- and C-terminal MGAM and SI at 37°C for various periods. We examined the glucogenesis by glucose oxidase and peroxidase (GOPOD) reaction and structural change by liquid chromatography. Individual subunits have different preference for linear oligomers and, notably, three subunits can nearly completely digest the branched fraction of α-LDx. The large molecular size of starch is not a barrier for small intestine α-glucosidases, and starch molecules were digested by gut α-glucosidases without the α-amylase's participation. One subunit, the C-terminal MGAM, showed strong digestion of gelatinized starch (nearly 50% in the first hour in our in vitro system). Different native starch structures and their resulting α-amylase hydrolyzed products were digested differently by the mucosal α-glucosidases. In thinking about slowly digestible starchy foods, structural aspects and linkages of α-glucan substrates should be considered. To manipulate starch digestion, dietary glucose production amount and rate, the complexity of digestion at the mucosal a-glucosidases level should be taken into account.

Alkylresorcinol metabolites as biomarkers for intake of whole grain wheat and rye

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Mounting evidence from epidemiology suggests inverse associations between whole grain (WG) consumption and risks of several chronic diseases (e.g., obesity, type 2 diabetes, and cardiovascular disease). Traditional dietary assessment methods are prone to measurement errors that may influence the observed diet-disease associations in any direction. A group of phenolic lipids, alkylresorcinols (AR), found in high amounts in the outer parts of wheat and rye kernels are biomarkers for whole grain products of these cereals. As such, AR help overcome some of the problems associated with the traditional methods, as the errors of the methods are independent from each other. Ingested AR are absorbed from the small intestine and disappear rather quickly from the systemic circulation, hence reflect mainly short- to medium-term intake. AR are subjected to hepatic metabolism, leading to the formation of two main metabolites, 3,5-dihydroxybenzoic acid and 3-(3,5-dihydroxyphenyl)-propanoic acid (DHPPA), which are excreted in urine and bile. A previous study observed longer apparent half-life of plasma AR metabolites compared to intact AR, thus indicating that AR metabolites could act as longer-term biomarkers. In Finnish women, urinary AR metabolites and plasma DHPPA correlated significantly with intake of rye and dietary fiber and an American study showed good correlations between WG intake and urinary excretion of DHPPA. In a recently conducted validation study on free-living Swedish participants, urinary AR metabolites were good reflectors of WG intake and the medium-term reproducibility of urinary AR metabolites was similar to plasma AR and self-reported WG intake. As a substitute or compliment to plasma AR, urinary AR metabolites could be used as biomarkers for intake of WG rye and wheat, especially when fasting plasma samples are absent.

A new method for assessing the effect of variable gastric conditions on cereal digestion in monogastric animals

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The effect of pH and incubation time on reducing sugar release and particle size reduction of maize grits was investigated. A sample of maize was ground through a 1-mm hammer mill screen. Xylanase was added at 0 or 16,000 BXU/kg and incubated with a water/pepsin (Sigma Aldrich, 2,000 U/kg) solution. Each sample was adjusted to a target pH of either 1, 2.5, or 3.5 through use of HCl. Samples were tumbled with ceramic beads at 42°C and aliquots removed at 0, 30, 60, and 120 min and immediately frozen for storage prior to analysis. The pH, particle size distribution, and total reducing sugars (TRS) of each of the samples were measured. Particle size was grouped by diameter and each group represented as a percent of the whole. Groups were as follows (µm), <10.39; 10.40–25.38; 25.69–53.51; 53.52–251.6; and 251–900. An initial ANOVA indicated that there was no significant effect of time on TRS, measured pH, or particle size volume in each group ($P > 0.05$ in all cases). This allowed subsequent ANOVA to test the effect of enzyme inclusion (+/–) and pH where the data were a pooled mean of the time points per pH (repeated measures). There was no significant effect of enzyme inclusion on any parameter ($P > 0.05$ in all cases). However, there was a significant effect of pH on TRS ($P = 0.014$) and three of the five particle size groups ($P = 0.010$, 0.011, 0.763, 0.032, and 0.167 for the above groups, respectively). At low pH, there was more reducing sugar released and generally a lower volume of smaller particles. The converse was true with higher pH. It was expected that particle size reduction would follow reducing sugar appearance. It is proposed that there may be two mechanisms acting within the system; enhanced acid hydrolysis to release reducing sugars and a decrease in pepsin activity that inhibited particle size breakdown at low pH.

The new cereal value chain: From seed to sewer

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Phil Williams Applied Research Award

The past two decades have seen remarkable advances in our ability to understand and manipulate the genetics of major cereal crops in ways that increase yields, provide resistance to pests and diseases, and increase the quality of cereal products. There has been a parallel expansion in our understanding of the overall nutritional benefits of cereals and the ways in which specific components of cereals underpin specific health benefits. While protein quality dominated cereal chemistry for many years, the past decade has seen carbohydrates take centre stage as a major linchpin between cereal composition and nutritional outcomes. By working at the interface between cereal genetics and human nutrition, it has been a privilege to participate in a range of projects that have tested our knowledge of relationships between cereal composition and human health outcomes and led to the development of cereal products that have hit the supermarket shelves. While much is yet to be done, this work demonstrates the potential of encouraging the collaboration between cereal scientists and nutritionists, delivering healthier options for consumers and the potential for healthier economic outcomes for the grains and food industries. A range of examples of genetic modifications of cereal grain using both GM and non-GM breeding technologies will be given.

Mechanically and thermally treated functional wheat flours

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There is an increasing customer demand for more natural or clean label products. To meet such growing expectations, new processing technologies are required to improve the performance of wheat flour systems with minimum or no addition of conditioners and other chemical ingredients. This study addresses development of thermal (dry and moist) and mechanical (shear and extrusion) treatment techniques to modify intrinsic properties of native wheat flours and low-quality mill fractions to improve their functionality. Dry and moist (20–25%) wheat kernels were exposed to microwave or infrared heat for 1.5 or 2.5 min in lots of 200 g. Treated kernels were tempered to 15.5% moisture and then milled on Brabender senior. In order to study the impact of heat treatment before and after milling, straight grade flours of untreated wheat samples were subjected to the same heat treatments as described above. All of the flour samples were then subjected to a set of physical (color, particle size), chemical (size exclusion-HPLC, composition, and solvent retention capacity) and rheological and pasting (Mixolab, Rapid Visco-analyser) tests. There was no significant difference in color of flours obtained from milled grain. However, flours hydrated to 25% and exposed for 2.5 min in microwave was darker than the rest. Flour and flour from grain exposed for 1.5 min of heating had higher dough stability than samples exposed for 2.5 min or control regardless of hydration moisture. Mixolab C1 time was higher for samples exposed for 1.5 than those exposed for 2.5 min and control. C1 torque for all samples decreased with exposure time regardless of hydration moisture. C3 torque increased with exposure time. In general, microwave had higher impact than infrared. Enhanced mixing and pasting properties, improved handling, and stability make heat-treated flours highly desirable as naturally functional ingredients.

The effect of lipid extraction on physical and material properties of gluten

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Flour lipids play an important role in determining the functional properties of gluten as evidenced by property differences after defatting. In order to identify underlying mechanisms, gluten was hand-washed from dough prepared from

both a baker's flour and a chloroform-defatted baker's flour (DFG). There was an 80% reduction in the level of free fatty acids (FFA) from DFG compared with the non-defatted gluten. Each of the gluten samples was freeze-dried and ground to a fine powder before being equilibrated to a range of differing moisture contents, ranging from 6 to 16% (w/w). Samples were characterised using NMR spectroscopy and small angle X-ray scattering (SAXS) to investigate changes in protein structures and properties caused by both defatting and changes in moisture content. Hydrated DFG samples were less cohesive than normal gluten, indicating a possible reduction in the noncovalent bonding between gluten proteins. Water absorbtion, under controlled humidity conditions, was not significantly affected by the presence or absence of lipids. SAXS results indicate an expansion of structure in the 10–20 nm range with increasing moisture, that was more pronounced in the DFG samples compared to normal gluten. Comparison of cross-polarisastion NMR spectra indicates a difference in the relative intensities of signals due to protein and starch. The spectrum of gluten shows greater intensity from protein than from starch whereas the DFG spectrum shows greater intensity from starch compared with protein. However, the amounts of starch and protein in the samples are very similar, this suggests that there is a major difference in the relative rigiidity of protein and/or starch between the lipid containing and the DFG samples.

Physicochemical properties of extruded washed wheat bran

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Wheat bran, a by-product of roller milling during the milling process of wheat, contains substantial amounts of residual starch that may interfere with the analysis of its physicochemical properties. Therefore, the specific objectives of the present study were to develop a method (washing) that removes most of the starch adherent to milled wheat bran and to investigate the effects extrusion processing variables have on the physicochemical properties (such as water binding capacity) and composition (including insoluble dietary fiber, soluble dietary fiber, total dietary fiber) of washed and nonwashed wheat bran. Washed and nonwashed wheat bran obtained from soft white wheat were ground to pass through 0.4- and 1.0-mm screens and extruded in duplicate on a corotating and intermeshing twin-screw extruder under conditions of varying screw configuration (low and high shear), feed moisture (25 and 35%), screw speed (100 and 400 rpm), and die temperature (100 and 150°C). Washing reduced starch adherent to wheat bran by 76%, increased insoluble dietary fiber from 38 to 69%, and decreased soluble fiber from 4.9 to 1.7%. Water-binding capacity was higher for washed bran and was not affected by particle size of the washed bran. Extrusion cooking increased soluble dietary fiber but decreased insoluble dietary fiber. It is possible that shear created during extrusion cooking causes mechanical rupture of the glycosidic bonds of insoluble dietary fiber, leading to an increase in soluble dietary fiber.

Wheat flour constituents, sugar and fat: An overview of their impact on sugar-snap-type cookie making

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Cookies contain high flour, sugar, and fat levels. Although their importance for cookie quality has been demonstrated, knowledge of the functionality of these ingredients in cookie making is limited. We studied the physicochemical transformations of major dough ingredients (wheat flour, sugar, and fat), as well as the interplay between these ingredients. This way, we provided a scientific basis for impacting baked product quality. Model cookie making with gluten-starch blends as flour models showed the gluten level to impact cookie (dough) properties. The extent of gluten cross-linking, determined by the reduction in sodium dodecyl sulfate (SDS)-extractable protein (EP) levels, was related to cookie spread. Cookie baking with milling fractions of different wheat cultivars yielded different spread rates and set times. The spread rate was dictated by the damaged starch level, whereas the set time depended on the flour SDS-EP level. Both glutenin and gliadin (subfractions) cross-linked during cookie baking. More pronounced cross-linking decreased the set time and, hence, cookie diameter, and, at the same time, increased resistance to structural collapse and, thus, cookie height. Increasing sugar (19.1 to 31.2%) and fat (8.7 to 15.8%) levels increased cookie diameter. Higher sugar levels increased spread rate and set time, the latter being related to postponed and slower gluten cross-linking. Onset and rate of gluten cross-linking both depended on the temperature difference between the temperature of reaction and the glass transition temperature. Increasing fat levels, on the other hand, increased spread rate but not set time. Fat physically interfered with the formation of some, but not all, gluten cross-links during baking. More gluten cross-linking increased cookie break strength.

Physicochemical properties and resistant starch formation of extrusion-cooked and drum-dried buckwheat and quinoa flours

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Buckwheat and quinoa produce starch-rich seeds, usable as cereal seeds. Buckwheat starch has high amylose content (appr. 30%), making it of interest for resistant starch (RS) formation. Quinoa starch has amylose content below 10% and is characterised by very small starch granules (appr. 1.5 µm), present as single granules and compound S granules (up to 14,000 granules bound together in polygonal complexes). Buckwheat and quinoa flours were extrusion-cooked and drum-dried and physicochemical properties of resulting flours determined. Extrusion cooking was performed by a pilot-scale conical counter-rotating twin-screw extruder. Different extrusion variables (screw configurations, barrel temperatures, feed moistures) were applied to obtain different shear stresses on the raw materials. Drum drying was carried out by a pilot-scale contact dryer (one steam-heated drum, four spreading drums). Physicochemical characteristics of heated flours were determined, including starch, amylose/amylopectin, dietary fibre, RS and crude fibre contents, pasting properties, water absorption index, water solubility index, swelling properties, freeze-thaw stability, emulsification properties, and molecular weight distribution. Extrusion cooking showed that both flours required high shear forces and low dough moisture contents to deliver fully expanded products. With low shear forces and high moisture contents, extrudates were not expanded but were still fully gelatinised. In buckwheat, the RS content was decreased by extrusion cooking from 0.7 g/100 g dm (raw material) to 0.1 g/100 g dm, while in quinoa it was increased from 0.2 g/100 g dm to 0.4 g/100 g dm. Drum-drying of buckwheat and quinoa flours did not result in fully gelatinised flours; however, increases in RS were observed again in quinoa (0.9 g/100g dm) but not in buckwheat (0.1 g/100 g dm), suggesting the compound S complexes could be exploited for RS production.

Image-based modelling of bread firmness

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The consumers' interpretation of bread quality is affected by sensory perception. Despite freshness, at the point of sale, the consumer perceives fresh bread as soft and stale bread as firm. Understanding what determines firmness is an important step toward meeting consumer expectations. The standard measure of bread firmness quantifies the response of the crumb to compression at a central position. This result is relied upon to estimate the firmness of the whole loaf. Firmness in bread is distributed unevenly, but the source of this distribution is unclear. The physical properties of moisture content, density, structure, and crystallinity are known to play roles in the firmness of bread. Their relative contributions to firmness can be gathered by eliminating bread age and hence the effect of crystallinity, thereby allowing the other important factors to be quantified by image analysis. Image-based techniques have been developed to determine the spatial distributions of moisture, density, and structure across a slice of bread. Optical density has been used to determine relative density calibrated against reference data for each type of bread. A near-infrared reflectance (NIR) calibration has been developed to determine moisture using a hyperspectral imaging system. The distribution of structure has been measured with a C-Cell instrument. The bread slice has been dissected and tested for firmness. The data points have been used to model the relationship between density, moisture, structure, and firmness. This new approach has been applied to test the hypothesis that the orientation of structure is important for firmness and to understand the scope of the model. Significantly, the results give us a better understanding of how firmness is derived and distributed within bread and hence improvements in product formulation, processing, and product perception can be measured.

Preparative methods to probe the DP4+ peak in ethanol fermentation samples

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HPLC is the analytical method most commonly used to monitor process efficiency in fuel ethanol production. Sugars left unutilized after fermentation are typically separated by an organic acid column into four peaks, the last being DP4+, which lumps all maltooligosaccharides bigger than maltotriose. This peak is routinely used to assess the completeness of enzyme hydrolysis, and thus estimate potential yield loss. However, it is known that DP4+ contains ions, proteins, dextrins, and other soluble compounds with low affinity for the stationary phase. We report the use of preparative methods,

using both ultrafiltration (3-kDa cutoff) and ion-exchange separation (quaternary ammonium stationary phase), to obtain increasingly accurate values of residual dextrins in industrial endpoint fermentation samples. We found that dextrins comprised only 10–20% of the total DP4+ peak area. The remainder 80–90% consisted mainly of inorganic ions and organic macromolecules, which contribute the highest and second highest to the peak area, respectively. These components can vary due to process changes; backset, chemical usage, and sample handling can affect DP4+ concentrations. Using robust chromatographic steps, such as reported here, will enable ethanol producers to interpret more accurately their HPLC data.

Response of wheat plants to stress as expressed by antioxidant levels in the grain

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Producers of whole wheat products are interested in marketing nutritional benefits in their products. Wheat containing high antioxidant levels could help them achieve this goal. Since wheat antioxidant levels are variable, they need assurance that they can access wheat with consistent, significant antioxidant levels. In order to produce wheat with consistent levels of antioxidants, the factors and mechanisms involved for their expression by plants must be understood. Research has emerged which shows that some antioxidants can perform as plant's defense response to stress. The objectives of this study were to 1) determine the effect of specific stress factors on plant expression of phenolic acids, and 2) optimize the expression level by determining the physiological stage where maximum expression is achieved. Sets of wheat plants (var. Karl 92) were exposed to the following stress factors: insect damage, fungi infestation, and heat. Antioxidants were extracted from the bran fraction of grains from these plants by acidified extraction, alkali hydrolysis, and liquid-liquid separations. The acid and base extracts were analyzed for total phenolics content (TPC) and antioxidant capacity (AC) by the Folin Ciocalteau and DPPH method, respectively. Extract from grains of plants stressed with insect, rust, and heat had 1.02, 0.83, and 0.6 mg FAE/g bran. The AC of these extracts was 15.57, 10.48, and 7.42%, respectively. The TPC of insect- and rust-stressed plants was 24 and 3.5% higher than the control, while heat reduced the expression levels by 26%. Insect damage was the most effective stress factor for increasing the accumulation of phenolics in the grain.

Assessment of DNA extraction methods for PCR testing of discontinued or unapproved biotech events in single seeds of canola, flax, and soybean

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When low level presence of biotech seed or grain is detected in nonbiotech grain, there could be a need to test the single seeds for presence of unapproved or discontinued biotech event(s). The suitability of three DNA extraction methods (SDS-based, fast ID, and relatively high-throughput methods) was assessed for single seeds (kernels) of canola, flax, and broken seeds of soybean. The extracted DNA was used for real-time qualitative PCR detection of OXY235 canola event (discontinued event), FP967 flax event (discontinued event), and DP305423 soybean event (new event—regulatory approval received in some countries). Higher amount of DNA was obtained with the SDS and relatively high-throughput methods compared with the fast ID method. There was high variability among single seeds in terms of weight vs. DNA yield. Statistical analysis was carried out to compare the results. Abs260/280 ratio of ≥1.8 was obtained for DNA extracted with fast ID and SDS-based methods. The DNA of all three extraction methods had low Abs260/230 ratios, indicating the presence of contaminating substances that absorb at 230 nm. Consistent and repeatable PCR results were achieved for DNA extracted with the fast ID and SDS-based extraction methods. Inhibition of real-time qualitative PCR was observed for soybean DNA extracted using relatively high-throughput method; however, repeatable PCR results were obtained by reduction of the amount of soybean DNA in the PCR. Overall, the DNA extraction methods can be used for rapid DNA-based detection of discontinued or unapproved biotech events in single seeds of canola, flax, and broken seeds of soybean.

Heat-induced polymerization reactions of wheat gluten proteins

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Protein Division Walter Bushuk Award

Heat-induced network formation of wheat gluten is essential for many wheat-based applications. It is mainly ascribed to disulfide (SS) cross-links, but the occurrence of nonreducible cross-links has also been suggested. The objectives of the present study were to investigate the impact of reaction conditions during heating on the extent and type of cross-links formed in gluten model systems and wheat-based applications. In a first part, an accurate method was developed for wheat gluten amino acid analysis, which requires neither derivatization nor oxidation. In a second part, gluten or it fractions were heated under different time, temperature, pH, and moisture content (mc) conditions and network formation was evaluated based on extractability in sodium dodecyl sulfate-containing buffer and levels of reagents, intermediates. and end products of cross-linking reactions. For one, heat/alkali treatment (pH 6.0–11.0, 50–130°C, 0–120 min) of gluten induced b-elimination of SS, which released thiol groups (SH) and dehydroalanine (DHA) and further led to (i) SS cross-links by SH-SS interchange and SH oxidation, and (ii) the DHA derived cross-links lanthionine (LAN) and lysinoalanine (LAL). In general, longer heating time, higher temperature, and more alkaline pH resulted in greater extractability loss but prolonged heating (e.g., pH 7.0, 90°C, >30 min) led to protein degradation. For another, heating gluten at low mc induced nonreducible cross-links without involvement of SS or SH. Further research suggested the formation of isopeptide cross-links, which have been identified using MS/MS in heated gluten model peptides. In a third part, LAN and—to a lesser extent—LAL levels have been found to increase during the alkaline dip and the subsequent baking of wheat-based pretzel snacks.

Product qualities of Korean puffed rice snack (Yukwa) by using vacuum puffing machine

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Cereal Foods World 56:A24

Yukwa is a favorite Korean traditional oil puffed rice snack made from waxy rice. The shelf life of commercial deep-fried Yukwa depends upon the rate at which oxidation of lipids results in rancidity and off-flavor of the product. The objective of this study was to explore the possibilities of using vacuum puffing machine to produce oil-free Yukwa products. Response surface methodology was used to evaluate the effect of vacuum puffing conditions, including heating temperature (100–160°C), preheating time (0–8 min), and vacuum puffing time (5–20 min) on physical characteristics of the vacuum-puffed Yukwa compared to the deep-fried Yukwa. Increasing preheating time and vacuum puffing time caused an increase in lightness and a decrease in yellowness. All of vacuum-puffed Yukwa products had lower expansion ratio than those of deep-fried Yukwa. Vacuum-puffed Yukwa at 100°C heating temperature, 6 min o fpreheating time and 10 min of puffing time had highest value in volumetric expansion ratio (10.04) and lowest value in bulk density (0.15 g/cm^3). The microstructure of vacuum-puffed Yukwa exhibited smaller pore size and more uniform cell structure. Moreover, the oxidative stability (acid and peroxide values) of puffed Yukwa from optimize vacuum puffing condition and deep-fried Yukwa was studied at different moisture content (17 and 25%) of waxy rice pellet. The fried Yukwa from 25% moisture content of waxy rice pellet showed highest in both acid and peroxide values, while the peroxide value of puffed Yukwa had less than 9 meq/kg even after 15 days of storage at 60°C. Increasing the moisture content of waxy rice pellet resulted in higher vacuum-puffed Yukwa equilibrium moisture content obtained by using static-gravimetric method. Sensory analysis was carried out in final product for appearance, color, flavor, crispness, hardness, and overall acceptability.

Characterization of carbohydrate DP profiles of ethanol-water soluble fraction by using maltodextrins as a model system

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This study focused on characterizing the molecular weight distribution and degree of polymerization (DP) profiles of carbohydrates in the 4:1 volume ratio of ethanol-water solution, which is used to precipitate dietary fibers in the current enzymatic-gravimetric AOAC methods. Solutions of maltodextrin and resistant maltodextrin were used to examine the effects of ethanol concentration and carbohydrate concentration on the DP distribution in the aqueous ethanol solution and in the precipitate. High-performance anion exchange chromatography-pulsed amperometirc detection (HPAE-PAD), size exclusion chromatography (SEC), and HPLC with an ion exchange column were used to compare the DP profiles and quantify the amount of each DP fraction. The oligosaccharides (DP 3–9) were confirmed to be totally soluble in the aqueous ethanol solution. The polysaccharides (DP >9), however, were found to be present in both solution and precipitate. The ethanol-water soluble fraction had DPs as high as 20. Several grain and food samples were also analyzed for their DP distribution in the aqueous ethanol fraction. The results in this study suggest that the ethanol-water soluble carbohydrate fraction contains DP 3–9 oligosaccharides as well as fractions of DP >9. Such

fractions from the fiber analysis process, therefore, should be included in the total dietary fiber results.

Effects of glycerol on water properties and steaming performance of prefermented frozen dough

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Cereal Foods World 56:A25

Prefermented frozen dough has been emerging in the bakery chains and traditional food chain stores in China market. Prefermented frozen dough showed some advantages, including a reduced need for yeast viability after frozen storage, less time-consuming production after freezing, and cheaper bake-off stations. Addition of glycerol resulted in improved dough leavening capacity, reduced proof time after initial freezing and thawing, and improved freeze-thaw stress tolerance. The objective of this study was to investigate the influence of glycerol on the water properties of prefermented frozen steamed bread dough (PFD) and on the quality of steamed bread. The amount of ice in both unfrozen steamed bread dough (UFD) and PFD with and without glycerol was investigated by differential scanning calorimetry (DSC). The quality of unfrozen steamed bread (UFB)/prefermented frozen dough steamed bread (PFB) was also evaluated. Frozen stability and steaming performance of prefermented frozen dough were negatively correlated with ice crystal growth. Glycerol effectively prevented the formation of ice crystals during freezing and frozen storage, maintaining the quality of steamed bread from prefermented frozen dough even over a period of 30 days. The best steamed bread performance was observed with the dough containing 2% of glycerol (flour weight basis) addition. Prefermenting conditions significantly affected the quality of UFB/PFB. The highest quality scores of steamed bread from prefermented frozen dough were obtained from 32°C and 85% rh for 40 min. The effect of glycerol on the flavor compounds of steamed bread remains a promising area for ongoing and further studies.

Viscoelastic characteristics of pig digesta are influenced by wheat arabinoxylan

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Cereal Foods World 56:A25

The presence of soluble dietary fibre (SDF) increases the viscosity of digesta which may restrict peristaltic mixing and influence the transit time. The increase in viscosity of digesta is thought to be one of the major factors responsible for beneficial effects, such as reduced blood cholesterol through reduction in absorption of cholesterol and bile salts. A detailed study of the viscoelastic characteristics of digesta would enhance understanding of the role of viscosity and its correlation with health biomarkers. The present study investigates the effect of SDF on viscoelastic characteristics of digesta. A set of 40 healthy pigs were fed four different diets with and without added SDF (soluble wheat arabinoxylan). These pigs were anaesthetised and digesta samples were collected from the small intestine (SI). The SI was divided into four different parts denoted SI1 (first metre), SI2, SI3, and SI4 (last metre). These digesta samples were subjected to steady state and dynamic rheological measurements. The elastic modulus (G') is higher than the viscous modulus (G'') for all digesta samples showing weak gel characteristics. All the samples show typical pseudoplastic behaviour. The power law indices describing the large deformation flow (shear) viscosity dependence on shear rate, and the small deformation complex (dynamic) viscosity dependence on oscillatory frequency are given in equations (1) and (2). $\eta = K\gamma^{n-1}$--(1); $\eta^* = K\omega^{n-1}$--(2) where η = flow (shear) viscosity, η^*= complex (dynamic) viscosity, K = consistency constant, γ = shear rate, ω = frequency, and n = power law index. The power law index for both flow viscosity and complex viscosity is greater for pigs fed the SDF-enriched diet, indicating less shear thinning characteristics. Interestingly, the power law index increases from SI2 to SI3 to SI4 for large steady shear deformations (flow viscosity) and decreases for small deformations (complex viscosity). This difference in power law indices may be related to the different behaviours of particulate and continuous phases in the digesta as they respond to the continuous digestion processes taking place along the SI. The increased viscosity of digesta in the presence of SDF may influence absorption of nutrients, digestive enzyme and/or bile diffusion, and transit time, each potentially imparting positive effects on health biomarkers.

Generation of high-amylose wheat lines through TILLING

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Cereal Foods World 56:A25

With the rise in human health concerns such as obesity and diabetes, there has been increasing interest in altering starch composition in cereal grains to increase the proportion of resistant starch. Resistant starch is defined as starch that escapes digestion in the small intestine and is considered a form of dietary fiber with beneficial health properties due to the slower release of glucose upon digestion and fermentation of the starch in the intestine. Modification of traits in wheat can be complicated by the size and functional redundancy of the polyploid wheat genome, increasing the difficulty of breeding new traits especially those due to a reduction of gene function. TILLING (Targeting Induced Local Lesions in Genomes) is a means to identify novel genetic variation without the need for direct selection of phenotypes. This method allows the identification of new alleles whose properties can be evaluated after combining by conventional breeding. Using TILLING, we have identified novel mutations in starch-branching enzyme IIa (*SbeIIa*) genes in tetraploid and hexaploid wheat. By combining these mutations in the A and B genomes in tetraploid wheat and the A, B, and D genomes in hexaploid wheat through breeding, we have developed wheat lines with increased amylose content. These new wheat lines also have elevated levels of resistant starch.

Antioxidant assay development to guide the development of high-antioxidant wheat

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Cereal Foods World 56:A25

As the food industry moves to accommodate health conscious consumers, demand for food products with functional phytochemical properties will increase. Availability of wheat with consistently high antioxidant (AOX) activity is of interest to several consumer product companies. The wheat processing industry has shown interest in functional, preservative capabilities of natural antioxidants in an effort to simplify food labels. A reduction in use of additives such as BHA, BHT, and TBHQ by enhancement of natural AOX levels in wheat is a recognized benefit. However, there are many types of AOX compounds found in wheat that can be differentiated for their biological and preservative activities. Our research has shown that wheat antioxidants can suppress cancer in model animal systems as a valued biological benefit. This research uses tissue culture assays to assess biologically relevant wheat AOX activities. An extraction method using an acidified methanol, acetone, water solvent, and subsequent liquid-liquid extraction with ethyl ether/ethyl acetate has been developed by our research group. Caco-2 cancer cells cultured and treated with AOX extracts from wheat samples may elucidate antiproliferative effects attributed to the extracted AOXs. Results will be compared with those of the cellular antioxidant activity assay, as described by Wolfe and Hai Liu, 2007. All extracts will also undergo HPLC, DPPH, TPC, and FRAP analysis to provide a broad profile of AOX components found in wheat. The end goal of this research is to identify desirable AOX compounds and link them to their primary biological or preservative functions to help guide wheat breeders to produce wheat with desired AOX activities.

Expression profiling of endosperm metabolic proteins during whole wheat kernel development

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Cereal Foods World 56:A25

Hexaploid wheat is one of the most important cereals for human nutrition. Wheat endosperm is the topic of interest for researchers particularly storage proteins, but albumins globulins are still needed to be studied for improvement of grain quality. In the present study, wheat endosperm proteins particularly albumins-globulins were focused. Molecular understanding of the biology of developing grain tissues will assist the improvement of quality traits and yield as well. Grains of hexaploid wheat, *Triticum aestivum* (cv. Récital), were collected from fertilization to maturity at 21 stages of development. Endosperm was separated by manual dissection and albumins-globulins were extracted. Six replicates of 2D electrophoresis at each stage of development under a pH gradient 3–11, IPG (24 cm) × SDS-PAGE were performed. Gels were stained with Coomassie blue and 1780 spots were detected by Nonlinear SameSpots image analysis software. Hierarchical clustering analysis (HCA) revealed principally nine evolutionary protein profiles and mainly four developmental phases were recognized over grain development. Spots including proteins from each profile were identified by LC-MS/MS. 73% of proteins picked were identified and then were classified using KEGG pathway classification and Gene-ontology in 17 different biochemical processes. Major functions were carbohydrate metabolism (26%), followed by protein synthesis and transcription/translation (15% each). High diversity of protein functions was found not only related to the accumulation of the major grain component starch and storage protein. Expression patterns of endosperm storage proteins (gliadins and glutenins) were also revealed on the same biological material. This study would help in the development of proteome reference maps for the developing endosperm (albumins/globulins).

A polymeric perspective on mechanism of effect of acid hydrolysis on gelatinization of pea starch: Does gelatinization really happen?

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Cereal Foods World 56:A26

The effect of acid hydrolysis on gelatinization behaviour of starch, which is of high relevance to food industry, has been extensively studied by differential scanning calorimetry (DSC). However, many inconsistent results have been reported and interpreted from different perspectives, which are based on the assumption that gelatinization of starch still occurs even after extensive hydrolysis. The objective of the research was to challenge this assumption and provide new insight in terms of polymer dissolution. In this study, a novel concept of "semipreparative" DSC was applied, which involves the thermal transition of starch and subsequent morphological characterization by scanning electron microscopy (SEM). The characteristic, well-defined endotherm was observed in the DSC traces for native starch and starch after one day of hydrolysis, but after two days of hydrolysis, the endotherm became broad and undefined. After DSC heating, native starch was observed visually and with SEM to have formed a gel, whereas starch granules hydrolysed for one day appeared to have undergone only limited swelling and coalescence. Starch that had been hydrolysed for two or more days appeared powdery and SEM images revealed that the granules had undergone very little swelling. After one day of hydrolysis, the broadening of endothermic transition with a shift to higher temperature of the endothermic peak is proposed to be due to the major swelling and minor dissolution of multiple polymer chains. Based on these results, we conclude that for native starch and acid-treated starch for one day, the well-defined endotherm was predominantly attributed to the swelling behaviour of relatively intact starch chains and that, after two days of hydrolysis, the broad and undefined endotherm was increasingly due to the dissolution of damaged starch chains.

Structural evidence for the slowly fermented property of corn arabinoxylans at the human colonic *Bacteroides* level

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Cereal Foods World 56:A26

Corn bran arabinoxylans (AX) was found to be fermented slowly compared with AXs extracted from other cereal brans, such as rice and sorghum. Elucidating the structural basis for the slowly fermented property and in consideration of its bacterial digestion assembly, the xylan utilization system (XUS) is a step toward understanding the manipulation of human colonic microbiota rationally by providing appropriate substrates. In this study, corn AX was treated by three AX-degrading enzymes in different combinations to produce a series of AX molecules differing in their fine structures. The enzymes used were an endoxylanase and two arabinofuranosidases with distinct specificity. Finally, 14 samples were obtained including native corn AX. Molecular weight was analyzed by HPSEC with pullulan standards; monosaccharide composition was determined by GC and linkage profiles were analyzed by methylation-GC-MS. Utilization of these structurally different AX molecules by human colonic pure strains of *Bacteroides* was studied. Based on their structural information and bacterial growth results, five of the fourteen samples were chosen to do in vitro fermentation by human fecal microflora. FOS was used as the fast-fermented control. The structural information indicated that multiple enzymatic hydrolyses retained certain linkages that are responsible for slow fermentation. Pure-culture and human fecal fermentation results confirmed these hypotheses and led to the conclusion that terminal xylosyl, linked arabinosyl, and disubstituted xylosyl residues are responsible for complex branching patterns that are related to their initial slow fermentation properties. A novel hydrolyzed small AX structure was found to have an ideal fermentation profile for colon health with slow initial gas production and highest bacterial growth yield.

Identification of protein associated with corn fiber gum and its importance to emulsification

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Cereal Foods World 56:A26

Corn fiber gum (CFG), an alkaline hydrogen peroxide extract of the corn kernel wet milling by-product "corn fiber" is a protein-containing arabinoxylan with a protein content ranging from ca. 2–9% by weight. Several studies have suggested that this protein is covalently linked to CFG and that it plays a significant role in its excellent emulsifying properties in oil-in-water emulsion systems. Nevertheless, the identity and structure of this protein has remained unknown until now. CFG was deglycosylated by treating with trifluoromethanesulfonic acid (TFMS) and the resulting free proteins were purified by using a C18 solid-phase extraction cartridge. The proteins were then separated for identification by SDS-PAGE. The main protein band recovered from the gel was treated with a proteolytic enzyme, chymotrypsin, and the resulting peptides were purified using C18 ZipTip pipette tips and analyzed using matrix-assisted laser desorption/ionization with automated tandem time-of-flight (MALDI-TOF/TOF) mass spectrometry. The partial sequences derived from the mass spectrometric analyses of the resulting chymotryptic peptides were found to be consistent with corn z1A alpha zein protein (major storage protein in corn endosperm) as queried against the primary sequences from the National Center for Biotechnology Information (NCBI) database. The hydrophobic protein rich components present on CFG contributes significantly towards its emulsifying properties.

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Abstracts of Poster Presentations

Abstracts submitted for poster presentations at the 2011 annual meeting in Palm Springs, California, October 16–19. The abstracts are listed in alphabetical order by first author's last name. Abstracts are published as submitted. They were formatted but not edited at the AACC International headquarters office.

Effect of salts on starch pasting properties in semolina and pasta and on pasta processing and cooking parameters

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Cereal Foods World 56:A27

Salts are intentionally added to bread and pasta products or unintentionally added as innate dissolved salts in water. An experiment was conducted to determine the effects of salt and salt concentration on rheological parameters of semolina and on pasta processing and cooking qualities. Salts evaluated were: magnesium chloride, magnesium sulfate, sodium chloride, disodium phosphate, and sodium bicarbonate. Pasting properties were evaluated with concentrations of salts with semolina and grounded spaghetti. $MgSO_4$ (0.5%) had lowest pasting viscosity difference (3.67%) in semolina and grounded spaghetti 175.8 and 172.13% respectively, compared to other salts. Lowest value for breakdown viscosity indicated from $MgCl_2$ (8.29%) in grounded spaghetti which was significantly low compared to semolina with same salt. Mixograph data showed that $MgSO_4$ 1% and Na_2PO_4 1% strengthened dough properties, whereas $MgCl_2$ weaken dough properties. Specific mechanical energy (SME) had significant difference between salt concentration and the extrusion parameters. Salts which promoted strong dough properties had high specific mechanical energy, while salts that promoted weak dough properties which had low SME values. There were significant differences of cooking loss in $MgSO_4$ and NaCl salts, which also related to strong dough properties in mixograph. NaCl had a high cooking loss and relatively low peak viscosity. A low trough viscosity and low final peak viscosity with high cooking loss occurred with semolina and spaghetti that contained $NaHCO_3$ 5%. Lowest SME was recorded when extruding semolina containing Na_2PO_4 1% or NaCl 1%. The resulting spaghetti had moderate cooking loss results. All of these results show that concentration levels of salts in semolina may affect the rheological, cooking, and extrusion parameters.

Vitreous and floury maize kernels: Physicals characteristics and starch biosynthesis

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Cereal Foods World 56:A27

The hardness of the corn kernel is very important to determine its use in the food industry; the hardness depends on the endosperm type, which can be vitreous or floury. Starch is the main component of the maize endosperm. Previous studies of maize with vitreous (VE) and floury (FE) endosperm showed differences in the amylose/amylopectin ratio, granule size, and physicochemical properties, hypothesizing that the starch biosynthesis mechanisms are different in each endosperm type. The aim of this work was to carry out the morphological, physicochemical, and structural characterization of maize with different endosperm type and related to the starch biosynthesis enzymes. The maize with floury endosperm had larger grains and higher values of thousand-kernel weight and floating index. Differences in the starch accumulation and granule size distribution at 20 days after pollination (DAP) between the two endosperm types were found; however, at 50 DAP both VE and FE presented similar values (starch content 76%, and average granule size 15 µm). The amylose accumulation was more evident in VE to 20–50 DAP (7–27%), than FE (17–23%). The crystallinity percentage and gelatinization enthalpy presented a decrease to 20–50 DAP in both endosperm types, which is related to the amylopectin level present in each developmental stage. SSI, SBEIIb, and GBSSI enzymes were identified; the GBSSI was more abundant in all samples. The differences at 20 DAP suggest that kernel of VE has a slower development than FE. However, the same starch biosynthesis enzymes were detected in both samples.

Antioxidant capacity of tortilla elaborated from extruded Mexican pigmented maize flour

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Cereal Foods World 56:A27

The effects of extrusion cooking on total phenolics, anthocyanins, and oxygen radical absorbance capacity (ORAC) of Mexican pigmented maize processed into tortillas were investigated. Tortillas prepared from extruded flours retained between 68.8–80.9% and 69.9–81.1% of total phenolics (TF) and total antioxidant capacity, respectively. Approximately 77–84% of TF in raw kernels was in its bound form. The retention of TF and total antioxidant capacity in extruded flours was higher compared to tortillas from nixtamalized flours. Blue maize lost 65% of the anthocyanin content when it was processed into extruded tortillas. Approximately 65–73% of the ORAC associated with raw kernels or their tortillas was due to bound compounds. Extruded tortillas lost 18.9–30.1% of the total ORAC associated with raw grains. Results clearly indicate that the proposed lime-cooking extrusion strategy was instrumental in retaining higher levels of phytochemicals, particularly TF, and antioxidants in all tortillas.

Influence of lysophosphatidylcholine (LPC) on the gelation and functional properties of diluted wheat starch suspension

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Cereal Foods World 56:A28

Starch is the most common storage carbohydrate in plants and also the largest source of carbohydrates in human food. Starch is a key component of staple foods like wheat, rice, and potato. In addition, starch has been widely used in food products not only as a main component but also to modify texture, improve moisture retention, control water mobility, and maintain overall product quality during storage. The starch in staple foods has been implicated in the complications related to obesity, type II diabetes, etc. Enzymatic degradation of starch results in glucose and its rate is considerably important. A slow rate is considered positive since this leads to lower metabolic stress. Because wheat starch is a basic ingredient of so many foods, it formed the core of the present work. For this we studied the starch-LPC interaction in great detail. The effect of LPC on thermal properties and viscosity behavior of starch suspensions were studied using DSC and RVA, respectively. Furthermore, the influence on granular shape was observed by light microscopy and the swelling power and solubility indices were established. Depending on LPC concentration, behavior of starch granules, such as viscosity, granular shape, and thermal properties while heating, differs. LPC at high concentration blocks functional properties of starch. RVA profiles demonstrated no viscosity increase at high LPC concentration which is due to intact granules at processing temperatures as observed by light microscopy. LPC at low concentrations postponed pasting times and altered peak and end viscosities. In addition, swelling and solubility were hindered by LPC due to less water ingression by starch granules, which signifies less starch accessibility to enzymatic degradation. DSC results imply inclusion complex formation of LPC into amylose.

In vivo digestibility of amylose-stearic acid complex in rats

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Cereal Foods World 56:A28

High-amylose corn starch-stearic acid complex (HASA) that has a resistant starch content of 74.8% has recently been developed. Compared with cooked normal corn starch (NC) and high-amylose corn starch VII (HA7), the cooked HASA has demonstrated effective inhibition of the development of preneoplastic lesions (precursors of cancer) in rat colon induced by azoxymethane. To understand the mechanism of the inhibitory effect of HASA, we conducted this study to compare in vivo digestibility of the NC, HA7, and HASA. Each of the cooked starches (55%, db) was mixed with other ingredients to prepare the NC, HA7, and HASA diets. The resistant starch content of the diet was 2.5, 12.5, and 30.1%, respectively. Three groups of 7-week-old male Fisher-344 rats (5/group) were fed with respective diets for 9 weeks. During the feeding period, no significant differences were found in the rat body weight and the weight of daily food-disappearance between different groups. However, the daily feces weight and contents of starch and lipid of the feces from the HASA-fed group were significantly larger than those of the other two groups. Additionally, the starch content of the feces from the HASA-fed group decreased from 42.7% in week 1 to 14.8% in week 9, indicating that more starch was utilized by the rats as well as their gut microflora. But the lipid content of the feces from the HASA-fed group increased steadily from 26.6% in week 1 to 52.6% in week 9, of which the free stearic acid content ranged from 62.1 to 73.7%, suggesting that most stearic acid was not utilized. Compared with NC and HA7, HASA was highly resistant to enzymatic digestion both in vivo and in vitro. With a longer feeding period, a greater proportion of starch in the HASA diet was digested and fermented, whereas most of the stearic acid remained not absorbed and was discharged in the feces.

Validating the health benefits of barley foods: Effect of processing on physiological properties of beta-glucan in test foods

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Cereal Foods World 56:A28

Approved health claims in several countries suggest that consumption of at least 3 g/day of oat or barley beta-glucan (BG) soluble fibre will help reduce cholesterol levels and lower the risk of heart disease. These physiological benefits have been attributed to extractability and molecular weight (MW) properties of BG which varies depending on the characteristics of the source plant material and the final food microstructure after processing. Although BG viscosity is often cited as the property of physiological importance, few clinical trials report details on the physicochemical properties of BG, nor do studies control variables that may affect the physiological functionality of this bioactive component during feeding. To address these issues, a prefeeding study and clinical trial was designed to 1) characterize the range of effects processing has on the viscose properties of BG in various food matrices; 2) establish standardized food processing/preparation methods to create a series of whole barley products and formulations with a defined and reproducible food matrix for inclusion in feeding studies; and 3) determine realistic MW and viscosity ranges for treatment effects. Grain/food processing techniques (e.g., heat/moisture, enzyme, and chemical treatments) were used to evaluate the effect of processing and food matrix on BG properties. An in vitro digestion method was used to obtain BG extracts, which were then used to determine BG solubility, MW, and viscosity. Food processing methods were optimized to consistently achieve single serving test foods with 3 or 5 g BG with MW <250,000 and >1,000,000 g/Mol. Results of this study indicate that BG MW and viscosity is significantly affected by food matrix, storage, and processing techniques. Processing methods can be used to design whole barley test foods which possess low or high BG viscosity, solubility, and MW to obtain valid data for a clinical trial.

Utilization of high-fibre barley fractions in tortillas to reduce glycemic response and lipogenesis

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Cereal Foods World 56:A28

It is important for nutrition research trials to test barley cultivars and milling fractions that are suitable for human food use, to ensure that results are relevant to potential consumer diets. Therefore, the objectives of this research were to determine the effects of high-fibre barley ingredients on glycemic response in humans and animal models. A wide variety of germplasm has been valuable in raw material selection and has facilitated the development of a number of barley products such as tortillas. Detailed compositional analysis and characterization of barley foods, which is lacking in many published nutritional studies, will allow for a better understanding of the observed health effects. Barley test food tortilla products were developed containing specific levels of soluble, insoluble, and total dietary fibre. These test products were then used to study glycemic response and lipogenesis in concurrently run human and animal trials. All barley test meals produced a more stabilized glycemic response over time in human subjects compared to the glucose control. In the rat model, the high-amylose barley treatment resulted in significantly lower serum glucose levels compared to the low-amylose treatment. Results suggest that beta-glucan may play a positive role in human glycemic response, and that the type of dietary fibre present in barley flour may cause differences in postprandial lipogenesis.

Microstructure and protein composition of marama bean

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Cereal Foods World 56:A28

Marama bean, *Tylosema* species, is an underutilised indigenous Southern African protein-rich oilseed legume. Knowledge of the physicochemical characteristics of marama protein is important to determine its use as a functional ingredient in food systems. In this study, the microstructure of protein bodies in marama and protein composition were determined. Soya bean was used as a reference. Marama parenchyma cells contained spherical protein bodies (4 ± 2 µm) surrounded by a network of lipid bodies, similar to those of soya. SDS-PAGE of marama protein showed three major protein bands and was different from soya. The patterns of these protein bands in marama under nonreducing and reducing conditions were similar, suggesting a lack of disulfide bonds. Only a major basic legumin (11S) (20 kDa), medium- (63 kDa), and high-molecular-weight protein (HMW) (148 kDa) bands were separated. The vicilin (7S) and acidic 11S subunits seemed to be absent in marama protein. The HWM proteins in marama are most likely stabilised by tyrosine crosslinked since marama protein contains about 9% tyrosine, which is almost three times that of soya. The pIs of most polypeptides in the marama proteome map were between 6 and 10, indicating that marama protein is a more basic protein than soya protein. The absence of vicilin (7S) in marama protein makes it unique compared to other legume proteins.

In vitro starch digestibility of kodo millet (*Paspalum scrobiculatum*) as affected by protein-starch-lipid interactions

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Millet starch is known to have low digestibility than most other starches, although they have numerous pores on their granule surfaces. The pores are

expected to increase the starch digestibility of millets, but this is however not the case. This study therefore investigated the effect of starch-lipids-protein interactions on the digestibility of millet starch. Fifty (50) mg of whole millet flour and defatted millet flour were cooked with 4 ml of distilled water. Proteins were removed from both cooked whole and defatted flour by the addition of pepsin from porcine pancrease and the kinetics of their in vitro starch digestibility determined for 3 hours. Results indicate that there was a significant increase in the rapidly digestible starch (RDS) component when the both proteins and lipids were removed compared to the other samples. The RDS of the whole flour, defatted flour, whole flour, and defatted flour without proteins were 23.5, 27.2, 10.3, and 41.75%, respectively. In general, the rate of starch hydrolysis of the flour with both proteins and fat removed was higher than for the defatted flour, then whole millet flour and finally millet flour without proteins. It can be concluded that the interaction between starch proteins and lipids significantly affected the in vitro digestibility of the starch. This result indicates processes that are likely to reduce the protein and/or fat contents of millet flour, for example decortication, are likely to significantly increase its starch digestibility.

Starch damage influence on the production of corn flour measured by an amperometric method

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The main component of the corn kernel is starch (about 70%); therefore, the quality of flour, masa, and tortillas is determined mainly by the starch behavior during the flour production. In this study, it was measured the starch damage of the corn by conductivity which claims to be easier and faster than the current methods. Starch damage was evaluated using different variables such as corn type: Pionner30G54 and Pionner30P16; two degrees of nixtamal cooking: precooked and cooked; and two types of grinding: blade grinders and hammers. Results were obtained as iodine absorption (Ai) for each sample: during nixtamalization, masa, flour, and milling. The starch damage increased along the stages of flour production, the damage was caused by mechanical (milling) and physicochemical effects such as cooking. The grinding type didn't has a significant effect on damage starch but the cooking method showed a great impact, precooked samples have less damage starch than cooked samples. The evaluation of the corn type shows no significant differences because the selected corns are from the same variety. The analysis of the data showed a repeatability value of $R^2 = 0.95$. This method proved to be useful and reliable to measure the starch damage of corn flours.

Features of spaghetti pasta, made with wheat semolina and banana flour

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The spaghetti, an Italian cuisine dish, is a type of dried pasta in the shape of long thin strings of circular section, consumed throughout the world. They are made with wheat semolina, eggs, and other ingredients. In this work, we tested mixtures of wheat semolina (WS) and banana flour (BF). The spaghetti was handmade, dehydrated, and stored. The follow mixtures, 100/0/0, 85/15, 70/30, and 55/45 of WS/BF, were evaluated. The properties determined were: the water absorption index (WAI) and solubility (WSI), color, protein, fat, maximum viscosity (Vm), enthalpy (ΔHgel), and gelatinization temperature (Tgel) in flour, adhesion and cohesion in dough, color, moisture, and Vm of raw and cooked spaghetti. The BF showed the highest values of WAI (2.36 vs. 1.93) compared with WS and they were significantly different compared with the others treatment. This same behavior was for the WSI, but the proteins and lipids content was lowest (3.21 and 0.8%). The BF developed more Vm (3111cp) than the WS (1257cp). The ΔHgel was higher from BF than WS. The Tgel of BF was higher (77°C) than WS (63°C). Dough of the mixtures were less adhesive but more compact than the dough of WS. The color of dehydrated raw spaghetti was darker by increasing the amount of BF in the evaluated mixtures. The proteins and fats also increased due to eggs added. The Vm increased with increasing proportion of BF and declined sharply in the cooked spaghetti due to a high degree of gelatinization of starch during the elaboration process. The greater tensile strength of cooked spaghetti was to treatment 100/0, while all other treatments showed good consistency. Based on the characteristics, treatment 70/30 was selected as the best and performed a sensory test (level of acceptance, 7-point hedonic scale) compared to commercial spaghetti. Spaghetti evaluated (70/30) were rated as similar to the commercial.

Properties of pasta for noodles, made with wheat semolina and taro flour

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The noodle is a type of dried pasta shaped like a smooth strip, narrow and long. They are a typical Italian food, consumed throughout the world. They are made with wheat semolina, water, and eggs. In this work, we prepared noodles with mixtures of wheat semolina (WS) and taro flour (TF). The noodles were handmade, dehydrated, and stored. The tested mixtures were 100/0/0, 70/30, 60/40, and 50/50 WS/TF. The properties determined were the water absorption index (WAI) and solubility (WSI), color, protein, fat, maximum viscosity (Vm), enthalpy (ΔHgel), and gelatinization temperature (Tgel) in flour, adhesion and cohesion in dough, color, moisture, and Vm of raw and cooked noodles. The TF showed high values of WAI, significantly different (2.6 vs. 1.93) compared with WS. The WAI showed similar behavior. The protein and lipid content were lower from TF (1.71 and 0.28%) than the WS. The Vm of TF (1676cp) was greater than WS (1257.7cp). The TF had higher ΔHgel than WS. The Tgel of TF was higher (82–83°C) than ST (62–63°C). The dough of all mixtures were more adhesive and more compact than the dough of WS. The color of dehydrated uncooked noodle was darker by increasing the TF in the mixtures. Proteins and fats increased due to eggs added during processing. By increasing the proportion of TF, the Vm increased in direct proportion to the flour used (between 1257 and 1676cp). This same viscosity decreased rapidly in the cooked noodles because, during the process, the starch had a high degree of gelatinization. The tensile strength of cooked noodles was higher than the treatment 70/30, although all treatments showed good consistency. Based on results, the 70/30 treatment was selected like the best, due to its characteristics showed. This treatment was tasted by a sensorial test (7-point hedonic scale), comparing against commercial noodles. Noodles selected and tested were rated as very good (rating = 6), similar to the commercial noodles.

Evaluation of organic wheat bread quality

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This study involves physical and chemical characterization of different wheat classes based on endosperm texture (hard versus semihard) and bran color (red versus white), as well as the milling techniques used (roller mills versus stone mills) and farming system (organic versus conventional for hard red wheat). Ten wheat flour samples were obtained from the Karahan Milling Company, Turkey, in 2008. Ash, protein, and gluten index values of samples were in the range of 1.24–1.92% d.b., 11.56–13.12% d.b., and 75.17–96.84, respectively. The falling number and sedimentation value changed between 312–402, 8–32 ml. It was found that farinogram values were 62.03–73.57% for water absorption, 4.40–6.03 min for mixing time, respectively. Furthermore, according to 135-min extensogram, extensibility was 82.67–112 mm, Rmax was 257.67–429 B.U., and area was 33.5–56 cm^2. Volume ranged in 854.58–1015.83 cm^3. Structograph hardness value was determined as 613.33–858.33 B.U. The data for crumb color was 43.06–53.57 for L, 3.67–5.72 for a, and 11.36–15.13 for b parameters. It was found that especially the milling technique affected the flour, dough, and bread quality significantly ($p < 0.05$). Ash, protein, gluten index, and structograph hardness values of stone-milled samples were higher than those of roller-milled ones. On the other hand, sedimentation value, extensibility, and bread volume of stone-milled samples were lower than those of roller-milled ones. Also, different wheat classes and wheat produced by using different farming system have different product properties. The scientific research about organic bread is still mostly limited, therefore investigation of the organic bread quality is very important to enhance the available literature and to produce healthy and qualified products.

Mixing and pasting characteristics of flaxseed meal-wheat flour mixture

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Flaxseed is an important raw material for food applications within the emerging concept of functional foods due to their increasing popularity among health-conscious consumers. It is abundant in many nutrients, such as polyunsaturated fatty acid, protein, and lignans. It reduces the risk of many chronic diseases, including hormone-based cancers, cardiovascular diseases, and adult diabetes. Knowledge about the effect of supplementation of wheat

flour with flaxseed meal on the rheological properties of dough characteristics is limited. The aim of this study was to determine mixing and pasting characteristics of flaxseed meal (0, 10, 20%) – wheat flour (weak and strong) mixture using Mixolab (Chopin Technologies, France). Tests were carried out at the constant water absorption and mixing speed (80 rpm). Mixing and pasting behavior was studied Chopin + protocol: initial equilibrium at 30°C for 8 min, heating to 90°C over 15 min (4°C/min), holding at 90°C for 7 min, cooling to 50°C over 10 min, and holding at 50°C for 5 min. Water absorption (C1), mixing stability, protein weakening (C2), starch gelatinization (C3), amylasic activity (C4), and starch gelling (C5) were determined. Mixolab data of flaxseed meal (0, 10, 20%) – weak wheat flour mixture were found to be in the range of 0.76–0.84 Nm for C1, 0.25–0.39 Nm for C2, 1.88–2.19 Nm for C3, 1.22–1.76 Nm for C4, and 2.44–3.26 Nm for C5. Whereas, the data of flaxseed meal (0, 10, 20%) – strong wheat flour mixture changed between 1.42–1.62 Nm for C1, 0.66–0.67 Nm for C2, 1.74–2.20 Nm for C3, 1.70–2.30 Nm for C4, and 2.64–3.51 Nm for C5, respectively.

Formation of amylose-lipid complex in starches treated with isoamylase and beta-amylase

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Amylose is known to form inclusion complexes with a large number of polar and nonpolar compounds including fatty acids. Amylose-inclusion complexes have been proposed to function as carriers for delivering and protecting functional ingredients. The objective of this study was to enhance the formation of amylose-lipid complex by debranching starch with isoamylase and then treating with or without an additional beta-amylase treatment. High-amylose corn (Hylon VII), common corn, and potato starches were included in this study. Immediately after the enzymatic treatment, 5–10% (w/w starch basis) stearic acid in hot 95% ethanol was added to the suspension gradually, and this mixture was incubated at 80°C for 30 min and then at 45°C overnight. The treated starch was evaluated for thermal transition by differential scanning calorimetry, X-ray diffraction pattern, and apparent amylose content by iodine affinity. All treated starches displayed the V-type pattern with three peaks at 13, 17, and 20°, and the beta-amylase treatment further increased their peak intensities. Similarly, the melting enthalpy of amylose-stearic acid complex was increased with the beta-amylase treatment for all treated starch samples with a shift to higher peak temperatures. The iodine affinity of starch increased after the isoamylase treatment and further increased with the beta-amylase treatment, but decreased after the stearic acid treatment. The results demonstrate that an additional beta-amylase treatment after the isoamylase treatment increased the formation of amylose-lipid complexes in amylose-containing starches. The present study shows the potential of incorporating beta-amylase treatment in starch modification to enhance the formation of complexes between amylose and other bioactive compounds.

Isolation, characterization, and identification of ligninolytic bacterial strains

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The objective of this research was characterize and identify bacterial strains with ligninolytic activity. 150 different strains were isolated from compost, cow dung, and straw; they were grown on selective media containing commercial fiber, straw, or commercial lignin. Enzymatic extracts were obtained from bacterial strains. Qualitative colorimetric assays (Guaiacol, ABTS, methylene blue, galid acid, diaminoflourene) were carried out to evaluate ligninolytic activity. 80 strains showed ligninolytic activity. Enzymatic extracts showed a positive correlation between ligninolytic indicators (oxidation of aromatic compounds, phenolic and no phenolic) and REDOX mediators (veratryl alcohol, ABTS, Mn2+) specifics for enzymes with activity laccase, Mn peroxidase, and lignin peroxidase type. These enzymes were identified and quantified in 17 the bacterial extracts evaluated at pH 4.5 (LiP = veratryl alcohol-guaiacol; MnP = lactate-guaiacol-Mn+2; laccase = ABTS-catalase). From these, three strains (34, 40, and 30) showed the most activity for Li peroxidase (0.001–0.017, 0.0036–0.015, and 0.009–0.014 U/mL, respectively); strains 34, 40, and 30 also had the greater activity for Mn peroxidase (0.002–0.011, 0.005–0.011, and 0.007–0.012 U/mL, respectively) and laccase (0.014–1.01, 0.483–1.24, and 0.123–1.25 U/mL, respectively) compared commercial fungal ligninase (LiP = 0.018 U/mL; MnP = 0.0015 U/mL; and laccase = 1.67 U/mL). These activities values were obtained in a 10 days incubation and evaluated each day. Maximum and minimum values represents best-worst day for enzymatic activity, respectively. Morphological, biochemical, and DNA analysis indicate that at least two of the best ligninolytic strains are *Bacillus* spp.

Effect of sorghum phenolic extracts on starch pasting, thermal, and digestive properties

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Ingredients/technologies that promote slow digestion of carbohydrates are needed to manage diabetes and obesity. This study investigated how type and concentration of sorghum phenolic extracts influence starch functional and digestive properties. Freeze-dried phenolic extracts obtained from white, black, and high-tannin sorghum brans and normal corn starch were used for pasting and thermal tests. The concentrations of freeze-dried phenolic extracts used were 5 and 10% w/w. Starch-phenol extracts were cooked in a rapid visco analyzer (RVA) using a standard 2 profile. At the end of cooking, the material was immediately frozen using liquid nitrogen, freeze dried, and stored. The freeze-dried cooked material was used for in vitro digestibility tests. The % hydrolyzed starch after 16 h of digestion was determined for all treatments. White, black, and high-tannin freeze-dried extracts had yields of 3, 10, and 8.5%, respectively, based on bran amount. RVA peak viscosity was significantly higher in both 10% black and 10% high-tannin freeze-dried extract treatments compared to control. Time to peak viscosity was shifted from 8.1 min (control) to 8.7 min (10% black extract). White sorghum extracts did not differ from control. The DSC showed that starch gelatinization onset and peak temperatures (°C) increased in the presence of phenolic extracts. Control To and Tp were 67.1 and 71.5°C, respectively, whereas the treatments had a range of 68–68.8 and 72.3–73°C. Starch was less digestible in the presence of high-tannin and black sorghum extracts compared to control. The highest reduction in starch digestibility (18%) occurred in the 10% high-tannin phenolic extracts-starch treatments. There was no significant difference in digestibility between 5% white sorghum extracts and control. Thus, sorghum phenolic extracts significantly changed starch functional and digestive properties.

Influence of fat content and maltogenic amylase addition on pound cake specific volume, firmness, and porosity parameters

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Fat is known to have an effect on cake volume and texture and maltogenic amylase has an antistaling effect. Crumb structure is related to appearance, volume, and texture and can be evaluated through image analysis. It is desirable that cakes present many fine and uniformly distributed alveoli. Pound cakes were produced using balanced formulations, with fat contents of 20, 40, and 60% (flour basis). Cakes were prepared with and without the enzyme maltogenic amylase (1000 mg/kg, flour basis). Control samples were those without enzyme. Specific volume was determined by seed displacement. Firmness was measured on days 1, 7, 14, and 21, using a TA-XT2 texture analyzer. Porosity was evaluated using a Panasonic DMC-LZ8 camera and the freeware Scion Image for Windows. The parameters evaluated were area, perimeter, and maximum and minimum diameters of alveoli. The results showed that the cakes with the highest specific volumes were those with 20% fat and maltogenic amylase (2.87 cm^3/g) and they were also those with the lowest firmness during all the storage period (637, 907, 931, and 988 gf on days 1, 7, 14, and 21, respectively, compared to 1293, 1390, 1470, and 1741 without enzyme). With respect to porosity, the quantity of alveoli identified was higher for the formulation with 20% fat without enzyme (1415) and lower for the formulation with 60% fat without enzyme (489). Values for area, perimeter, and maximum and minimum diameters for cakes with 20, 40, and 60% without maltogenic amylase were 0.114, 0.080, and 0.144 mm^2; 1.057, 0.863, and 1.204 mm^2; 0.335, 0.285, and 0.392 mm^2; 0.196, 0.169, and 0.214 mm^2, respectively. In general, the alveolar parameters of the cakes with 20, 40, and 60% fat and maltogenic amylase did not differ from those of their respective control samples. Cakes with lower fat contents (20%) can have their quality parameters improved (increase in volume, reduction in firmness, and similar alveolar characteristics) with the use of maltogenic amylase.

Novel process based on partial germination to enhance milling yield and nutritional properties of pulses

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Pulses are one of the staple foods in the Indian diet, they are an excellent source of proteins and are rich in essential micronutrients such as iron and

fibres and at the same time are low in fat. A new industrial process of partial germination has been developed that improves the nutritional value of pulses, and its effect on milling, cooking, and sensory properties was studied on brown chickpeas at laboratory scale. The pulses were partially germinated, stabilized through a gentle drying, and then processed through a laboratory-scale grain testing mill. The mill outcome was divided into six different fractions: daal (dehusked splitted grains), gota (dehusked unsplitted grains), un-dehusked grains, brokens, husks, and powder and the daal yield was calculated on weight basis. Daal were then evaluated in terms of aspect, colour, hardness, and cooking properties and tested from a trained panel for their sensory properties after cooking. It was found that partial germination improves the milling properties of brown chickpeas, since the daal yield increases from 75.8% (untreated-raw brown chickpeas) up to 81.8%, and the milling efficiency increases from 75.8% up to 93.8%. Partially germinated samples are more yellow in colour than raw, while hardness is lower and shape also becomes slightly curved. With respect with the cooking properties, partial germination increases the cooking time and decreases the quantity of dispersed solids. The sensory assessment showed that the partially germinated daal were sweeter than the nongerminated daal and slightly more pale in colour. This study shows that partial germination of pulses, which is proved to improve the nutritional value, has also the effect of enhancing the milling properties without affecting in a prohibitive way the cooking and the sensory properties of the final product.

Chemical composition and antioxidant capacity of tortilla made with the blend quality protein maize and black bean

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Tortilla and beans are the basic components in the diet of people in the urban and rural areas of Mexico. Quality protein maize is suggests for tortilla preparation due to that presents an increase in lysine and tryptophan levels. Beans contain important amount of dietary fiber that produce digestibility characteristics to starch and protein constituents. Additionally, beans contain polyphenols, reporting an inverse association between polyphenols intake and risk of coronary disease and cancer. The objective of this study was prepare tortilla, blending quality protein maize (70% w/w, dry matter) and black bean (30% w/w, dry matter), and the chemical composition and antioxidant capacity were assessed. Tortilla with bean had higher protein, ash, and dietary fiber content and lower fat amount than control tortilla (12.0 and 8.8%; 2.6 and 1.7%; 14.7 and 9.4%, 3.9 and 4.4%, respectively). Extractable polyphenols (EP) and condensed tannins (CT) levels were higher in the tortilla with bean than control tortilla (1.99 and 0.96 mg/g of EP; 8.7 mg/g of CT, CT was not detected, respectively). This pattern produced higher antioxidant capacity in tortilla with bean than control tortilla (12.6 and 7.0 µmol Trolox eq/g of EP; 3.6 µmol Trolox eq/g of CT, CT was not detected, respectively). The addition of bean to tortilla modified the antioxidant capacity of corn tortilla, obtaining a nutraceutical product.

Relationship between the number of channels in starch granules and their derivatization using rapidly reacting reagents

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Because it had been previously determined that a highly reactive reagent, viz., phosphoryl chloride, reacted primarily at starch granule surfaces, including channel surfaces, the hypothesis that the number of channels in starch granules would affect the nature of the modified starch product was formulated and tested. Starch was isolated from five inbred lines of corn/maize with previously determined relative average degrees of channelization (RADC), viz., B73 (1.0), W22 (1.0), Mo17 (1.7), W23 (14.9), and Oh43 (15.2), and dervatized with highly reactive reagents that were likely to react at channel surfaces. Because the native starches had different characteristics, values of various parameters given by them were subtracted from those obtained for the derivatized starches and the differences were compared. No correlations were found between RADC and DS values or any DSC parameters. Partial correlations were found for RADC and final RVA viscosities of products of reaction with phosphoryl chloride, adipic acetic mixed anhydride, acetic anhydride (AA), and octenylsuccinic anhydride (OSA). Because it had also previously been determined that removal of the protein lining the channels affected derivatization with phosphoryl chloride, the starches were treated with a protease to remove surface protein. After this treatment, partial correlations were found for RADC and RVA final viscosities for products of reaction with AA and OSA only. The conclusions are that there are differences between the starches of these five inbred lines other than RADC and that the differences other than RADC had the greater influence on modification.

Phenolic levels and oxygen radical scavenging capacity of hybrid black rice samples

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Advanced inbred lines, made from the cross between the black (Yunanheixiannuo) and white (Xieqingzao B) rice as parents, were collected with the three color shades conveniently divided into black, brownish purple, and white (unpolished grain). The aim of the present study was to evaluate phenolic levels and free radical scavenging capacity among the hybrid samples. Supernatants of 80% methanolic extracts of rice samples were used to measure free phenolic contents. Significantly higher levels of free phenolics ranging from 11.19 to 16.74 mg ferulic acid equivalent/g rice were found in black rice compared to brownish purple (<6.00 mg/g) and white (<4.30 mg/g) rice samples ($p < 0.05$) using Duncan's multiple range test. Bound phenolic acids, obtained by alkaline hydrolysis of the residue remaining after methanol extraction, ranged from 0.75 to 4.79 mg/g when measured using the Folin-Ciocalteu assay. All black rice samples including parent and offspring had significantly higher oxygen radical scavenging capacity (37.77 to 60.18 µmol TE/g) compared to brownish purple (<29.00 µmol TE/g) and white (<24.00 µmol TE/g) samples ($p < 0.05$). Individual phenolic compounds responsible for grain pigmentation and antioxidant capacity were characterized using LC-MS/MS. The results of this study provide new opportunities for rice breeders and, eventually, commercial rice growers to promote the production of pigmented rice, particularly black rice, with enhanced phytochemical content and antioxidant capacity.

Solubilization of hydrophobic compounds in a soft nanocomplex from starch, protein, and lipid

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A soluble, nanoscale, ternary complex from starch, protein, and lipid self-assembles under specific heating and agitation conditions. It has a molecular weight and radius of gyration between 6–8 million Da and 20–70 nm, respectively. Investigation of its iodine binding has shown its potential to incorporate small hydrophobic compounds. The ability of the ternary nanocomplex to incorporate and/or solubilize different valuable hydrophobic compounds (1-naphthol, peppermint oil, thymol, and 5-fluorouracil) was investigated. The ternary complex was prepared in a diluted system by mixing supernatant from high-amylose corn starch, ß-lactoglobulin, and linoleic acid in a 20:2:1 ratio (w/w). Different concentrations of various hydrophobic compounds were then incorporated into the ternary complex. Iodine binding ability and turbidity were used to confirm incorporation of the fourth component. Evidence supports the presence of hydrophobic components in available sites of the amylose helices indicated by decrease in iodine binding. Results showed that the binding efficiency of ternary complex is a function of the nature of fourth component. In case of chemotherapeutic drug, 5-fluorouracil, the nanocomplex can accommodate around 1 mM of the compound without any change in turbidity, whereas in case of 1-naphthol, the ternary complex was able to bind as high as 3.5 mM without noticeable increase in the turbidity. The results show the potential of this soft soluble nanocomplex to carry and solubilize small hydrophobic bioactive nutrients, drugs, or flavors for delivery in a hydrophilic system.

Thermomechanical properties of flour doughs affected by protein composition and mixing conditions

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Dough mixing is one of the most important ways to characterize the quality of wheat flour. Mixing process transforms the combination of flour and water into a viscoelastic mass, develops the dough, and helps the air occlusion. The physical and chemical reactions occurring during dough development are related to complex mechanisms involving the wheat proteins. Proper dough development is also affected by mixing intensity (kneading speed) and work imparted to the dough. The objective of this research was to study impact of gluten fractions, namely glutenin and gliadin, mixing speed, and temperature on thermomechanical properties of synthetic wheat flours using Mixolab (Chopin Instruments). Synthetic wheat flours containing 85% wheat starch, and 15% of gliadin-glutenin mixture were prepared. Glutenin:gliadin mixture was added in 0:15, 5:10, 7.5:7.5, 10:5, and 15:0 percent proportions. Tests were carried out at the constant water absorption (98% db) and varying mixing speed (60–120 rpm) and temperatures (30–50°C). The resulting mixing and pasting curves were analyzed using standard Chopin+ protocol to determine water absorption (C1), mixing stability, protein weakening (C2), starch gelatinization (C3), amylase activity (C4), and starch gelling (C5).

Synthetic dough only with gliadin formed extensible, stretchy dough with minimum mixing, as expected. C1 time values for glutenin-rich doughs were typically high. Increase in mixing speed resulted in increase higher dough consistency independent from the mixing temperature. Mixing temperature was observed to have higher impact on dough consistency and stability than mixing speed. Softening effect of temperature was more significant at low mixing speeds. Synthetic doughs with varying ratios glutenin:gliadin mixtures displayed different degree of sensitivity to varying mixing speeds and temperatures.

Effect of the degree of milling on the energy required to cook rice

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Energy requirements for cooking rice are directly related to the cooking duration. The rate at which rice absorbs water during the cooking process determines the cooking duration. It is expected that rice with high surface lipid content (SLC) (low degree of milling) absorbs water more slowly than rice with low SLC (high degree of milling). The objective of this study was to determine the energy required for cooking rice with different degrees of milling. Long-grain, parboiled, and nonparboiled rice with degrees of milling ranging from 0.3% SLC to brown rice (2.3% total lipid content) were cooked in an automatic rice cooker using water to rice ratios from 1.5 to 2.5. Energy usage of the rice cooker was recorded over time using a Watt meter that was connected to the rice cooker. Degree of cooking was assessed using Ranghino test and moisture content of the cooked rice. Energy requirements showed a positive linear trend with cooking duration. The differences among cooking durations for rice with SLCs from 0.3 to 0.8% were not significant for nonparboiled as well as for parboiled rice for a given water-to-rice ratio. Cooking duration for brown rice was significantly greater than those of the milled samples for a given water-to-rice ratio for nonparboiled and parboiled rice samples. Energy requirements increased linearly as the water-to-rice ratio increased. Parboiled rice required more energy for cooking than nonparboiled rice at all degrees of milling.

"New cereals" and pseudo-cereals: Rheological properties investigations

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During the last decade, "new cereals" and pseudocereals were introduced in cereal industries processes to improve nutritional quality of traditional wheat food. Mixed with wheat (*Triticum aestivum*), we can find these new grains in breads and cookies recipes. The objective of this study is to evaluate with the CHOPIN Mixolab the rheological properties (dough development, starch gelatinization, and retrogradation) of three "news cereals" or pseudocereals and mixed cereals-wheat dough. Flours from three different type of grain (buckwheat, spelt, and kamut) were analyzed with the CHOPIN Mixolab (Chopin+ protocol). Tests was first made with pure flours, then with different cereal-wheat mixes (5/95, 10/90, 20/80, and 50/50 cereal/wheat ratio). Obtained results show it exist significant differences between pure buckwheat flour, spelt flour, and kamut flour. These differences appear at constant hydration both on the protein part (buckwheat and spelt stability is around 11 min against 5 min for kamut) and on starch part (C3 – C2 difference is around 1.5 Nm for spelt, against only 1.3 Nm for buckwheat). Furthermore, cereals addition on wheat flour alters dough rheological behavior. These alterations change according cereals proportion in the mix. Spelt and kamut flour introduction in wheat flour mainly modify protein part (C1, C2. and development time). Buckwheat influences both protein part and starch part. The results showed high variability due to the type of cereals or pseudocereals used and proportion of flour introduce in mixes with wheat flour. These results suggest that Mixolab could be efficiency use to determine pure and mixed with wheat flour quality for such type of product.

The occurrence of ochratoxin A in soy protein infant formulas and protein powders

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Ochratoxin A is a nephrotoxic and a nephrocarcinogenic mycotoxin produced by the *Aspergillus* and *Pennicillium* species. This mycotoxin in regulated by many countries throughout the world. For example, the European regulation for ochratoxin A in baby food is 0.5 ppb (parts per billion) and 3 ppb for processed cereals and cereal products. The United States currently has no regulations for this mycotoxin. A limited survey of soy protein infant formulas and protein powders purchased from retail stores in seven different states in the United States was conducted and the samples were analyzed for ochratoxin A at a detection limit of 0.05 ppb. Ochratoxin A was analyzed in 27 soy protein infant formula samples and 51.8% were positive (greater than 0.05 ppb), with two of the samples found to be over the European regulation of 0.5 ppb. The highest concentration of ochratoxin A found in infant formulas was 1.9 ppb. 11 soy protein powders were analyzed for ochratoxin A with 72.7% of the samples positive (over 0.05 ppb) and one sample result (3.5 ppb) was over 3.0 ppb the European regulation for processed cereals and cereal products. This data suggests that ochratoxin A is a potential contaminant in soy-based products, including infant formulas and protein powders, in the United States.

Determination of deoxynivalenol and zearalenone in single kernels from a highly contaminated corn sample

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Corn, when exposed to wet growing conditions in the presence of the *Fusarium* mold species, can be contaminated with the deoxynivalenol and zearalenone mycotoxins. A corn sample highly contaminated with both deoxynivalenol (15.9 ppm) and zearalenone (1.5 ppm) was found in Ontario during 2006. Individual kernels were analyzed separately to determine the distribution of both deoxynivalenol and zearalenone. A single kernel of corn was crushed, extracted with acetonitrile/water, and purified with a solid-phase cleanup column. The purified extract was divided into two portions. One portion was analyzed for zearalenone by HPLC using fluorescence detection and the other portion, after additional purification, was analyzed for deoxynivlaneol by HPLC using UV detection. Approximately 100 kernels were selected for analysis and separated into three groups based on appearance; normal kernels, slightly damaged kernels, and highly damaged kernels. On average, the individual kernel weights decreased while the deoxynivalenol and zearalenone contamination increased with the amount of damage observed. For the normal kernel group, 34% were positive for deoxynivalenol (range from 0.1 to 7.0 ppm) and 6% were positive for zearalenone (range from 0.1 to 0.9 ppm). For the slightly damaged kernels, the number of positives for deoxynivalenol and zearalenone was 91% (range from 0.4 to 424.1 ppm) and 76% (range from 0.1 to 102.1 ppm), respectively. For the highly damaged kernels, the number of positives for deoxynivalenol and zearalenone was 94% (range from 0.2 to 699.0 ppm) and 96% (range from 0.1 to 221.5 ppm), respectively. The number of kernels contaminated for both deoxynivalenol and zearalenone greater than 0.1 ppm each for the normal, slightly damaged, and highly damaged kernel groups were 0, 69, and 89%, respectively. There was no correlation in the concentration of deoxynivalenol and zearalenone in the single kernels for either groups.

Effect of sorghum bran particle size in gluten-free muffins

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Gluten-free snack products lack fiber and have poor textural qualities. Sorghum bran is currently not utilized as a fiber additive in gluten-free snacks and would be ideal to improve fiber content. The objective of this study was to test Sumac sorghum bran in gluten-free muffins and to determine if bran particle size is critical to product quality. Larger (>120 sieve) and smaller (<120 sieve) particle size brans were substituted at 5, 10, 15, and 20% levels into the flour blend of a muffin formulation that consisted of 80% decorticated white sorghum flour and 20% tapioca flour. This addition added 0.5 to 2 grams of dietary fiber per serving. Specific volume, color, and texture profile analysis were performed on sample replications. Color was significantly affected by particle size. Large bran particles created a speckled color. Specific volume significantly decreased at the 20% substitution level of large-particle-size bran. Increased levels of large-particle-size bran decreased springiness and cohesiveness in muffins. Results indicated that large bran should not be substituted at levels above 10% of the flour blend without additional modifications to improve cohesiveness in the formulation. Small-particle-sized bran created a cohesive crumb, consistent color, and did not reduce specific volume at any level of substitution and is recommended for future use in gluten-free snack products.

Properties of wheat gluten as affected by high-pressure-induced deamidation

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During the production of wheat starch, gluten is isolated as the main by-product merchandized as so-called vital gluten. It is commonly used in the baking industry as part of flour improvers but the demand for this application is smaller than the amount of isolated gluten. Therefore, modifying the technological properties of gluten could lead to new products and would enlarge the range of applications. The deamidation of glutamine residues is a

suitable method to functionalize gluten proteins and leads to an improvement of the emulsifying and foaming properties. High-pressure treatment is another way to modify the technological properties of gluten. In this study, results are presented obtained from the combination of both methods. First, the influence of high hydrostatic pressure on the deamidation of the amino acid glutamine was determined by model experiments using the tripeptide PQL. The conditions were 200–600 MPa, 40–80°C, pH 1–7 (HCl). From these experiments it was concluded that deamidation of PQL was mainly affected by pH value and temperature followed by pressure. In the case of gluten, the degree of deamidation was much lower compared to PQL under the same conditions. The reason was that due to the buffering effect of the gluten proteins the HCl yielded higher pH values as compared to the model experiments. Nevertheless, the degree of deamidation was high enough to improve the foaming properties at certain conditions, e.g., after treatment at 200 MPa, 80°C for 10 min the foamability increased by 21% compared to untreated gluten and the generated foam was stable. From the determination of the ethanol extractable protein fractions it was concluded that low pH values inhibited the pressure-induced polymerization of the proteins which would impair the foaming properties. Thus, a gluten product with new technological properties had been produced.

Wheat flour tortillas prepared with a zero trans fat, based in palm stearin and high-oleic safflower oil

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Flour tortillas are usually made with hydrogenated fat containing 12–30% of trans fatty acids, being this trans fatty acids related to cardiovascular diseases. Wheat flour tortillas were prepared using a zero trans fat (grasaslab), based on palm stearin and high-oleic safflower oil. Concentration of palm stearin was 65:35-oleic safflower oil. Tortillas were also prepared with shortening as a control. The study of X-ray diffraction of grasaslab indicated the presence of the polymorphic form β and that of the hydrogenated shortening, the β' polymorphic form. The fatty acids profile showed that grasaslab had high proportion of palmitic and oleic acids, without the presence of trans fatty acids. Tortillas were prepared by hot-pressing. Firmness and rolability were measured at different storage times (2, 24, and 48 h), and physical properties (weight, diameter, thickness) and moisture content were also measured. The sensory acceptability test was performed. The fat had a significant effect ($p < 0.05$) in the firmness of the tortillas, observing lower firmness values in tortillas containing grasaslab that those made with hydrogenated shortening. The grasaslab affected positively the quality of tortilla, assessed as diameter, rolability, texture, and sensory acceptance; showing this grasaslab a potential as an alternative to commercial shortenings to reduce trans fats.

Nutritional and textural properties of amaranthus-enriched rice-based pasta

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A broad variety of gluten-free (GF) cereal-based products are available for celiac people. Unfortunately, most of them are of very poor quality, particularly when compared with goods from wheat, suggesting that more attention should be paid to the nutritional and sensory quality of GF products. In this context, the addition of amaranthus (25%) to heat-treated rice flour offers good opportunities for GF pasta production. Amaranthus flour not only is free of any toxic prolamin, but also it has interesting nutritional features, such as a high content in minerals (in mg/kg: Fe, 69; Ca, 271; Zn, 28), and fiber (4.9% db). The addition of amaranthus flour decreases the pasting temperature of rice starch from 80 to 70°C and improves the starch swelling capacity, increasing the hot viscosity from 120 to 190 BU in the MVAG test. Starting from a mixture of heat-treated rice flour and amarathus flour (75:25), a pasta sample (Pasta 1) was prepared in a pilot-scale conventional plant, as done for a reference pasta (Pasta 2) made from 100% rice flour. The dough was shaped into macaroni and dried using a low-temperature drying cycle (50°C for 14 hours). As expected, the pasta enriched with amaranthus showed an higher mineral content (in mg/kg: Fe, 98; Ca, 346; Zn, 32) than Pasta 2 (in mg/kg: Fe, 16; Ca, 37; Zn, 7) and, despite its higher fiber content (4.5 vs. 3.2% db), the presence of amaranthus flour did not increase leaching into cooking water at optimal cooking time but assured a higher water absorption during cooking than Pasta 2. This trend could assess the lower firmness of Pasta 1, as shown by sensory analysis. Evidence for a role of amaranth proteins in formation of mixed polymers with rice proteins will be discussed.
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Macromolecular and rheological properties of Italian waxy wheat

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Starch retrogradation is the major cause of breadcrumb firming, and amylose is assumed to be mainly responsible for bread staling, making the food industry interested in using waxy (amylose-free) cereals and/or starches in bakery products. Waxy wheat lines have been produced in Japan and in other countries, but showed poor adaptability to the Italian agronomic conditions. A breeding program set up at CRA-SCV starting from partial-waxy cultivars identified in Italian bread wheat germplasm led to the release of about 20 waxy hexaploid wheat lines (WHW, *Triticum aestivum* L.). Aim of the present work is the study of the properties of these lines and of the role of the waxy trait in bread texture. Eighteen WHW were selected and characterized by chemical and physical small-scale analyses, and the pasting and rheological properties of flours were evaluated. Results were compared with those obtained from two commercial nonwaxy cultivars, used as controls. Amylose content of WHW was typical of waxy lines (on average, 1.4%), with protein content ranging from 12.3 to 17.2%. In four WHW, the high protein content was associated to high gluten quality, evaluated by gluten index and SDS sedimentation volume. RVA test indicated a lower retrogradation tendency in WHW than in controls (setback values: 329 vs 931 cP). From a rheological standpoint, WHW showed high farinograph water absorption (70.3 ÷ 78.7%), but very low stability values. Baking tests indicate a good breadmaking quality of the Italian WHW, although starch-protein and protein-protein interactions in these systems deserve further investigation.
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Impact of functional native starch characteristics on storage stability of formulated food products

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This study provides insight into the impact of starch base, handling, and other parameters on the textural stability of "clean label" creamy soups/ sauces, fruit preparations, and gravies for packaged meals under ambient, refrigerated, and frozen conditions. Instability leads to degradation of food texture over time with negative impact on consumer perception. The performance of waxy rice and different varieties of waxy maize-based functional native starches (FNS) was tested vs. native and modified food starches (MFS). FNS are physically processed starches that label as native starches on ingredient statements but show the characteristics of MFS. Formulations were evaluated using descriptive sensory analysis, microscopy, rheology, and application tests to assess and make recommendations on how to achieve texture stability over shelf life for "clean label" products that are free from chemically modified additives. Waxy rice-based FNS showed stability and sensory/rheology texture characteristics comparable to MFS and were significantly superior to native starches. Freeze-thaw cycling showed both waxy rice FNS and selected MFS survived the required criteria for stability (1 year ambient, 20 weeks refrigerated, 18 cycles freeze-thaw for different foods) whereas native starches and other MFS failed earlier than desired for the target products. Microscopy and sensory observations provided evidence of the physical phenomena behind instability including granule damage and leaching of soluble starch into solution over storage time. Lower pH (<4) accelerated this effect. Higher temperature (>220°F such as used in retorted foods) accelerated granular damage and instability upon extended storage for foods that appeared stable when first produced. The results presented can be used to detect early signs of instability and to formulate "clean label" food products with desired shelf life and stability.

Processing attributes of oat flour and white salted noodle quality

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Western Australian oats has a reputation as the best in the world with its bright colour, plump grain, and low levels of admixture. Nutritionists worldwide recommend an increased consumption of whole grain products and dietary fibre. Evaluating the potential of oat varieties being included as a proportion of wheat flour, in production of number of products such as Asian noodles, pan bread, flat breads, and/or pasta products could potentially result in higher demand for this type of grain to health-conscience markets. The main objective of this study was to investigate processing attributes of oat flour and its use in white salted noodle (WSN) manufacture. In addition to two commercially available oat flours (from Blue Lake Milling pty. ltd. Australia), five WA-grown varieties including Carrolup, Yallara, Kojonup, Mitika and SV97181-8

were also evaluated. Different ratios of wheat to oat flour were used for noodle making. Up to 30% addition of oat flour to wheat flour was possible to process noodle sheet without formulation adjustment. The FSV values were moderately high to high, ranging from approximately 18 to 24 mL/g. The protein range of oat varieties was in the range of 13.1 to 16.2% on dry basis. Noodle quality was assessed in terms of raw and boiled noodle colour, colour stability, and boiled noodle texture. Raw noodle sheet and boiled noodle colour changes significantly ($P < 0.05$) with oaten flour incorporation and resulted in lower brightness and lower yellowness/creaminess when compared to the control (100% wheat flour WSN). Noodle firmness decreased with increased percentage of oaten flour in the formulation. Varietal differences were also seen in the textural properties of noodles as meausred using the TA-XT2.

Phenolic acids and sensory properties of whole grain products

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Phenolic acids have demonstrated antioxidant activity and are thought to contribute to the positive health outcomes observed with whole grain consumption. However, phenolic acids have been reported to elicit unacceptable flavours within food products. Little research regarding the effect of phenolic acids and the sensory properties within whole grain wheat products has been investigated. The objective of this study was to investigate the relationship between phenolic acids, total phenolic content (TPC), and the sensory properties of whole grain products using partial least squares (PLS) mapping. Two different moisture products (bread and crackers) were manufactured from red and white whole grain wheat, as well as two particle sizes (fine and coarse). TPC content was similar between the red and white wheat despite having different phenolic acid profiles. Differences in the relationship between phenolic acids and sensory properties were observed between the two moisture products. Within the bread crumb, the free and bound phenolic acids provided the best predictive scores; whereas the bound phenolic acids provided the highest predictive scores within the crackers. This research demonstrates a link between sensory characteristics associated with whole grain products and phenolic acids. As TPC test measures total phenols, the strong association between TPC and whole grain characteristics suggests that there are phenolic compounds other than phenolic acids contributing to sensory properties of whole grain products.

Investigating the impact of enzymes and heat treatments on quantification of folate in fortified wheat flour

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Australian mandatory fortification program requires addition of 200–300 µg of folic acid (FA) to 100 g of breadmaking wheat flour. This study investigated folate extraction methods prior to analysis of FA and 5-methyl tetrahydrofolate (5-MTHF) using ultra-performance liquid chromatography-tandem mass spectrometry. Commercial white and wholemeal flour samples were extracted using heat and with or without enzymes then purified using solid-phase extraction. Also, the same samples were simply extracted into phosphate buffer without both enzymes and heat. There are no significant differences in the measured FA between treatments of α-amylase only, rat serum only, both, and no enzymes ($P > 0.05$), whereas there was a significant difference in 5-MTHF levels ($P < 0.05$). Fortified white flour treated with no enzymes and heat had 115.8 µg FA/100 g and 17.1 µg 5-MTHF/100 g flour and there are no differences ($P > 0.05$) to treatments with both enzymes. Similarly, no significant difference in FA levels was found in wholemeal flour ($P > 0.05$) but 5-MTHF level of 17.8 µg/100 g was significantly higher ($P < 0.05$). The experimental data suggests that quantitative analysis of FA and 5-MTHF can be performed accurately by mixing of samples in a rotary shaker and centrifugation without enzymes and heat. This extraction method is simple and less time consuming which otherwise is tedious, thus could be appropriate for assessing compliance of the FA fortification program. A higher 5-MTHF level was determined in wholemeal flour without heat treatment indicating less degradation of 5-MTHF. The results found FA ranged 62.1–115.8 µg/100 g in fortified white and wholemeal flour, indicating underfortified FA levels in Australian flour.

Determination of folic acid & 5-methyl tetrahydrofolate in whole meal flours using ultra-performance liquid chromatography-tandem mass spectrometry

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In Australia, wholemeal flour is made up by adding back the wheat bran and wheat germ to white flour containing mostly starch after initial milling. The aim of this study was to examine any correlation between addition of bran mix and levels of folic acid (FA) and 5-methyl tetrahydrofolate (5-MTHF) in wholemeal flour. The bran flour mixtures were placed in a rotary shaker for 20 hours to acquire homogenous premix. Extraction of samples involved treatments with α-amylase and rat serum before solid-phase extraction using styrene dibenzene sorbents and ultra-centrifugation. The results revealed that concentrations of FA ($P = 0.05$) and 5-MTHF ($P > 0.05$) between samples were not different. Multiple extraction and analysis of commercial wholemeal flour showed consistently a wider FA range of 62.6–320 µg/100 g compared to laboratory premix. The level of 5-MTHF in commercial wholemeal flour is 14.8 µg/100 g, similar to laboratory premix ($P > 0.05$). BCR 121 of wholemeal flour analysed along with samples had 2.6 µg 5-MTHF/100 g, which is lower than (3.82 µg/100 g) the level presented by Pawlosky et al (2003). Adding 5, 10, 15, or 20% bran mix to flour may not have an effect on folate extraction, as there was no significant difference in measured FA and 5-MTHF levels, even though bran had 19.3 µg 5-MTHF/100 g. FA range in wholemeal flour samples suggests an inhomogenity indicating that flours may have varying fortified levels of FA. The results revealed a noncompliance with the fortified level because of lower FA levels in commercial fortified white (62.1 µg FA/100 g) and wholemeal flours.

Use of tropical maize for bioethanol production

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Tropical maize is an alternative energy crop for bioethanol production. It is comprised of sugar, starch, and cellulosic biomass, components that can be used for bioethanol production. Tropical maize requires few crop inputs, such as nitrogen fertilizer, and can be grown in Midwestern and North Central states, where large numbers of ethanol-producing facilities are located. The tropical maize syrup was fermented at four initial sugar concentrations, 6, 9, 12, and 15% (w/v). Sugar concentrations were calculated based on glucose, maltose, fructose, and maltotriose concentrations analyzed by HPLC. The different sugars in syrup were maintained at constant ratio on dry basis. Fermentation, for 72 h, was conducted at 32°C, pH 4, using urea, glucoamylase, and ethanol red yeast inoculation. Among four sugar concentrations, final ethanol concentrations were the highest for 15% initial sugar concentration. Maximum glucose concentrations during SSF were 8.2% (w/v) at 12 h for 15% treatment. All glucose was consumed within 24 h, except for 15% treatment which had 0.5% residual glucose at 72 h. Fermentation rates increased with increase in initial sugar concentration from 6 to 12%, but decreased at 15%. In another study, conversion of tropical maize bagasse resulted in 8.15% (w/w) glucose through autohydrolysis process conducted at 160°C for 10 min. This additional glucose will increase further total ethanol yield from tropical maize.

Relationships between simple grain quality parameters for the estimation of sorghum and maize hardness

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Grain hardness affects sorghum and maize processing properties especially for dry milling. A wide variety of simple grain quality tests were applied to 17 sorghum and 35 white maize cultivars grown in six and four locations, respectively. The purpose was to compare tests that could be used to distinguish hardness among sorghum and maize cultivars. There is need to verify the quality tests that apply to sorghum grain quality evaluation and those suitable for maize. There is currently no specific criterion for sorghum and maize grain hardness. The grains were characterized by test weight (TW), thousand kernel weight (TKW), decortication using the tangential abrasive dehulling device (TADD), and kernel size (KS). Maize was further characterized for susceptibility to breakage (SB), stress cracking (SC), and milling index using near-infrared transmittance (NIT) calibrated against a pilot three break roller milling system. There were significant ($p < 0.001$) negative correlations between TADD with TW ($r = –0.673$), TKW ($r = –0.757$), and KS > 3.35 mm ($r = –0.560$) of sorghums. In maize, NIT milling index and TADD were significantly correlated ($r = –0.659$, $p < 0.001$) as was TW with NIT milling index ($r = 0.540$) and TADD ($r = –0.636$). TKW, KS, BS, and stress cracking measurements were not significant and did not seem to be related to maize grain hardness. For sorghums, TADD, TW, TKW, and kernel size >3.35 mm can be used together to evaluate sorghum hardness. NIT milling index, TADD, and TW are useful for maize quality evaluation.

A comparison of the literature on the association between intakes of bran, cereal fiber, and whole grains and risk of adiposity measures

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Definitions of whole grains vary depending on context and purpose, creating a gap between the findings of nutrition science and the dietary guidance consumers receive. A review of the scientific literature was conducted to evaluate the impact of these grain components on adiposity measures. MEDLINE was used to search the scientific literature for relevant studies. Additional studies were identified by bibliographic searches for relevant articles. Editorials, reviews, and studies published in languages other than English were excluded. Intakes of cereal fiber, bran, mixtures of whole grain and bran, and whole grains were generally inversely associated with adiposity measures; cereal fiber intake had the most consistent associations. The association between whole grains and weight gain reduction was attenuated after adjustments for fiber and micronutrients. Most whole grain analyses included over 25% bran in the whole grains food category. Thus, most studies reported as providing evidence on whole grains were substantially confounded by including bran containing foods. The small number of studies that reported effects from whole grain foods alone showed inconsistent effects on body weight measures. The data suggest that bran and cereal fiber are active components of whole grains.

A comparison of the literature on the association between intakes of bran, cereal fiber, and whole grains and risk and biomarkers of heart disease

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A literature review was conducted on the association between intakes of cereal fiber, bran, and whole grains and risk reduction of heart disease. The purpose of this review was to compare health-related benefits from bran/cereal fiber and whole grains from observational studies. MEDLINE was used to search the scientific literature for relevant studies. Other studies were identified by bibliographic searches for relevant articles. Intakes of cereal fiber, bran, mixtures of whole grains and bran, and whole grains are inversely associated with risk of heart disease and/or heart disease biomarkers. A majority of prospective studies comparing bran/cereal fiber and whole grains for risk of heart disease showed that bran or cereal fiber intake was more protective than whole grain intake. Most studies included cereals containing at least 25% of whole grain or bran content by weight in the whole grain food category. In the scientific literature, whole grain effects have been confounded with those from bran. Limited studies investigated the association between whole grain as defined by FDA (excludes over 25% bran and bran cereals) and heart disease risk and/or biomarkers of heart disease. The data indicate that bran and cereal fiber play a role in the health benefits gained from whole grains. Implications of these findings will be discussed.

Development of drug delivery system (DDS) and nutrient delivery system (NDS) using starch

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Starch is a GRAS (generally recognized as safe) food in the world for a long time. It is known that most of currently used DDS and NDS are using nanotechnology and liposome. They have many side effects and they are very expensive. Therefore, it is important to develop new DDS and NDS with no side effect and low cost. The objective of this study was to develop new DDS and NDS with starch as a carrier material using infusion technology and to characterize the physicochemical properties of developed DDS and NDS. Corn, waxy rice, nonwaxy rice, and potato starch were used as carrier materials. Fluorescein was used as an infusion material for easy detection. Each starch suspension with fluorescein was reacted in water bath at 40, 50, and 60°C for 30 min. After reaction, sample was centrifugated at 3000 rpm for 15 min. Fluorescein concentration of supernatant was measured for quantitative analysis using fluorescent detector. Precipitated starch was observed using fluorescent microscopy. After reaction, fluorescein did not infuse in various starches at all temperature except waxy rice and corn starches at 60°C. Concentration of fluorescein in supernatant of corn and waxy rice starches at 60°C was decreased about 70%, suggesting that 70% of fluorescein infused in those two starches at 60°C. Also, those two starch granules are luminous by green light when exposed to fluorescent detector. Therefore, we found that flourescein can be used as an infusion material and corn and waxy rice starches can be used as carrier materials for DDS and NDS.

Significance of flour particle size on sponge cake quality of soft white wheat

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Sponge cake is a popular product of soft white wheat in Asian countries and a good indicator for evaluating the comprehensive quality of soft wheat. Soft wheat flour of low protein and fine particle size is believed to be suitable for making sponge cake, while the significance of flour particle size and its independent role on sponge cake quality has not been well established. We evaluated the significance of flour particle size on sponge cake baking quality with minimum interference from other flour characteristics. Two different sets of flours, including flour fractions of different particle size separated by sieving and flours of reduced particle size obtained by additional pin milling, were tested for batter properties and sponge cake baking quality. The flour sets consisted of three soft white, one club, and two hard wheat varieties. Volumes of sponge cake baked from small (<55 μm), medium (55–88 μm), and large (>88 μm) particle fractions of soft and club wheat were 1353–1450, 1040–1195, and 955–1130 mL, respectively. The small particle fractions in soft and club wheat exhibited lower flour-water batter density (102.6–105.9 g/100 mL) than those of large particle and medium particle fractions (105.2–108.2 g/100 mL). The small particle fractions, however, indicated longest flour-water batter flow distance (15.8–23.9 cm) in a Bostwick consistometer, followed by medium particle (7.0–10.5 cm) and large particle (4.8–9.1 cm) fractions. With additional pin milling, the proportion of small particle flour (<55 μm) increased by 11.6–26.9% and the volumes of sponge cake increased by 0.8–15.0% in soft and club wheat. The density and Bostwick consistometer flow distance of the flour-water batter decreased by additional milling. The decrease in Bostwick flow distance is possibly due to increase in starch damage. Additional pin milling induced increase in starch damage and sodium carbonate retention capacity of flour by 0.1–0.2 and 4.8–13.9%, respectively.

Molecular characterisation of gluten development during dough development: Comparison of laboratory and pilot-scale processes

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We have applied food proteomics techniques to characterise the changes in flour proteins during dough development. We have used a range of techniques based on electrophoresis and liquid chromatography and have prepared dough using small-scale laboratory dough rheology equipment and commercially representative pilot-scale methods. We have compared the effect of native, denaturing, reducing, and oxidising treatments to systematically probe the role of inter- and intramolecular interactions during dough development and characterise the impact of different processes. Reproducible and predictable changes in the gluten protein complement as a result of processing are seen. These changes which correlate well with the performance of flours from different wheat varieties in the baking process. This comprehensive approach builds on previous knowledge and yields new insights into the behaviour of individual gluten components through processing. It also provides a comparison between different dough development methods. The significance of these findings for studying flour functionality will be discussed in relation to ingredient specification and process management for end-product quality.

Bioconversion of insect (*Sitophilus zeamais*), mold (*Aspergillus flavus*), and sprouted damaged maize (*Z. mays*) and sorghum (*S. bicolor* (L.) Moench) into bioethanol

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Sound, insect (*Sitophilus zeamais*), mold (*Aspergillus flavus*), and sprouted-damaged maize and sorghum kernels were bioconverted into fuel ethanol. The purposely damaged kernels were obtained and stored under controlled conditions of temperature and air relative humidity. According to physical characteristics, the three types of damages caused a detrimental effect on physical and chemical properties. Insect-damaged maize and sorghum had 20 and 10% less bulk densities compared to the respective sound kernels. The flotation index augmented from 85 to 100% in maize and from 17.5 to 63.3% in sorghum. Protein content was similar in all treatments (8–9% in maize and 11% in sorghum); however, the free amino nitrogen (FAN) concentration in maize and sorghum (110 and 81 mg/L, respectively) increased significantly in sprouted- and insect-damaged maize (250 mg/L) and mold-infested sorghum (389 mg/L). The change can be attributed to protein hydrolysis due to enzymes generated during sprouting or produced by *A. flavus*. Likewise, the reducing sugars were higher in sprouted-damaged maize (11 g/L) compared to the sound kernel (1 g/L). After treatment with *alpha*-amylase, all hydrolyzates contained 110–120 g/L reducing sugars, except sprouted sorghum with 149

g/L. Crude fiber and fat contents were higher for insect-damaged kernels, indicating the *S. zeamais* had preference for the starchy endosperm. For both types of grains, insect- and mold-damaged kernels yielded less ethanol after simultaneous saccharification and yeast fermentation. In terms of ethanol production, sorghum was the least affected with a reduction of 8 and 11% for mold- and insect-damaged kernels compared to the 9 and 15% for maize. This research clearly demonstrates that insect and mold infestations reduce starch and thus ethanol yields and that the use of sprouted kernels is a good alternative for ethanol biorefineries.

Development and quality evaluation of whole wheat saltine crackers

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Whole grain foods contain many positive qualities such as being rich in dietary fiber, resistant starch, oligosaccharides, phytosterols, vitamins, minerals, and protective antioxidants. Whole wheat can promote intestinal peristalsis, prevent colon cancer, provide benefits for patients with type II diabetes by reducing insulin sensitivity, and reduce the risk of cardiovascular diseases. The main focus of this research was to develop whole wheat saltine crackers. Each sample of soft white wheat (SW) flour was blended with 25, 50, 75, and 100% of ultrafine soft white whole wheat (SWW) flour. The physical characteristics of saltine crackers made from the different flour blends were compared with those of the crackers made from 100% SW flour. Optimized formulation and processing parameters of whole wheat crackers were developed to enhance product quality. Physical analysis of the baked saltine crackers showed as the SWW flour was increased from 0 to 100% in the formula, both the cracker bending force and thickness decreased, while the cracker expansion (height/weight ratio) increased, and the diameter and baking loss did not show significant changes. Sensory evaluation of the crackers were conducted and will be presented in addition to physical testing results.

Effects of processing on material properties of gluten-free cakes

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The goal of this study is to determine the quantifiable material properties that make a great cake and to use that information to develop a superior and accessible gluten-free substitute for wheat flour in cake. Currently, approximately 1% of the U.S. population suffers from celiac disease, an autoimmune disorder triggered by the consumption of gluten. Gluten is a protein found in many grains and plays an important role in the texture, taste, and color of wheat-based baked goods, like cake. The absence of gluten gives the cake a crumbly texture and poor color, as well as poor crust. In this study, rice flour is the gluten-free flour used to replace wheat flour in a recipe for vanilla cupcakes on a weight basis. The choice of rice flour over other gluten-free flours was based on its success in previous experiments. A pycnometer was used to measure several variables, including porosity, bulk density, and matrix density of the resulting cakes. A texture analyzer was also used to measure force vs. distance, which was then used to calculate cohesiveness, hardness, springiness, and chewiness. The density and porosity information was compared to the texture values to look for correlations. These variables were compared to the measured values for the cakes made with wheat flour. In addition, the white rice flour was preheated for ten minutes at several temperatures (250, 300, 350°F) and then substituted into the recipe. Cakes made with the white rice flour preheated at 250°F were found to have properties closest to the wheat flour cakes. The differences found in the cakes made with preheated flour may be simply due to moisture losses but future work will include an analysis of the proteins in each of the preheated and nonpreheated rice flour to look for possible changes, as well as a comparison of the density and texture results to a taste test of each of the rice flour cakes.

Structure design of maize endosperm tissue and starch by hydrothermal and thermomechanical processing for tailored end-product properties

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Maize is the basis for products such as gruels, baked products, or thickeners where starch acts as macronutrient and texture agent. Traditional maize processing requires long cooking times at excess water conditions to achieve tissue softening and starch gelatinization. There is a demand for processing maize in an efficient way into dry intermediate products with tailored functionality in terms of cooking behavior and texture. At the same time, sustainable processing calls for processes with minimal water, moderate temperatures, and utilization of maize endosperm tissue rather than starch only. A process for maize processing based on steam cooking and flaking at limited moisture (20–30% wb) followed by drying has been investigated at pilot scale. Maize was processed into flakes and intensity of steaming, flaking, and drying was varied. Milled flakes were characterized at different levels of structure. Macroscopic properties were analyzed with RVA (rapid viscoanalyzer) and gel compression tests. The microstructure was assessed by light microscopy. Melting of starch crystals was measured by DSC (differential scanning calorimetry). A state diagram of raw maize with glass transition and starch melting as a function of moisture content was established based on DSC. A broad range of tissue disintegration and starch gelatinization could be generated by adjusting the moisture level, steaming time, and flake thickness. Dyrying conditions were found to be crucial for adjusting cooking behaviour and texture. A drying concept was developed where the flakes were rapidly dried in the glassy state. The temperature was controlled to keep the flakes below the glass transition curve during drying. This procedure led to instant-type maize products with rapid viscosity development during cooking and good gel formation upon cooling.

Physicochemical properties of native and heat-moisture-treated potato and amaranth starch mixtures

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There is great interest in production of natural (not chemically modified) starches with extended ranges of functionality. Mixtures of two or more native starches or physically modified starches may exhibit nonadditive physical properties, such as pasting viscosity parameters. Our hypothesis was that the extreme difference in granule size between potato and amaranth would result in novel properties on mixing. Gelatinizing, pasting, and gelling properties of different combinations of native and heat-moisture-treated potato and amaranth starch mixtures were studied. Two peaks were observed in pasting curves when large differences of swelling factor and amylose-leaching existed between individual components in the mixture. The mixtures showed higher hot paste stability, at least more than the less stable component in the mixture. Mixtures of HMT potato and native amaranth showed nonadditive pasting behavior. Mixing 10% of native amaranth to HMT potato starch caused large reduction of peak viscosity and cold paste viscosity, resulting in a very soft gel. Each component of a mixture gelatinized independently showing two peaks corresponding to the individual components, indicating gelatinization in the mixture behaved as the sum of the individual components. When transition parameters of both components were similar in the DSC, a single endotherm resulted. Dramatic changes of pasting and subsequent gel properties resulted when thermal transition of two components occurs in the same temperature range. Retrogradation enthalpies as measured by DSC were between the two individual components in all the mixtures.

Evaluation of whey protein and fiber on the physical properties of high-ratio cakes

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High-ratio cakes traditionally contain increased levels of fat and sugar making them nutritionally undesirable. One way to combat this issue is by replacing the sugar and fat with alternatives such as whey protein and fiber to maintain the structural properties while providing additional health benefits. The objective was to determine the physical and structural characteristics of high-ratio cakes substituted with whey protein and fiber. Two levels of fiber (resistant wheat starch), 12 and 20% (w/w), and one level of protein, 7% (w/w), were substituted for a portion of the sugar and shortening. The batter was evaluated for specific gravity and viscosity; the cakes were tested for texture (texture profile analysis), color, and microstructure (x-ray microtomography, XMT). No significant differences ($p > 0.05$) for batter viscosity were seen across treatments, but the cakes containing the highest level of fiber (20%) were found to have greater specific gravity (0.97) compared to the control (0.92). Cakes consisting of 20% fiber inclusion were wider in diameter and lower in height compared to the control. Crumb L, a, and b color values were found to be significantly different for all three cake treatments. Cake moisture measurements showed little differences, but hardness values (50% compression) from texture analysis varied across all cake treatments with 12% (1.90 kg) and 20% fiber (2.92 kg) being higher than the control (0.93 kg). XMT imaging of the air cell structure showed minimal differences in the air cell size, but the cell wall thickness was significantly different between all three treatments indicating a variation between the distributions of the air cells. These results illustrate that replacing a portion of sugar and fat with fiber and whey protein influences the structural properties of the high-ratio cakes which may affect the overall quality.

Fermentation of distillers dried grains with solubles by microorganisms and cellulase production

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The high fiber content of distillers dried grains with solubles (DDGS) limits its inclusion in animal feed; ruminant diet could contain DDGS up to 25–30% w/w, whereas for nonruminant diet contains up to 15% of diet. The nonruminant digestive system lacks enzymes needed for fiber digestion. The objective of this work was to evaluate growth of yeast and bacteria on DDGS during fermentation and production of microbial cellulase by them. Cultures of *Lactobacillus caseii*, *Lactobacillus plantarum*, *Pediococcus acidilactici*, *Saccharomyces boulardii*, and *Saccharomyces cerevisiae* were inoculated into sterilized DDGS medium (100 g DDGS in 80 mL distiller water) for solid-state fermentation. The microbial cultures were grown on and allowed to ferment DDGS at 33°C for 96 hours and enumerated periodically. The periodic samples and fermented solids were freeze-dried. Cellulase production during fermentation was measured by reacting a buffered extract of DDGS on carboxymethyl cellulose. The glucose released was measured by reducing sugar assay. Results indicate that DDGS supported healthy growth of the microorganisms (2–3 order of magnitude up from 108 cells inoculation) and followed typical microbial growth kinetics. Both lactobacilli demonstrated early growth and peaked between 48 and 60 h. Yeast were slower to grow, peaking at 72 h. However, enzyme cellulase production was higher by yeasts—19.1 IU/g DDGS by *S. boulardii*, and 11.1 IU/g by *S. cerevisiae*. Bacteria produced only 1 IU/g or less cellulase under the conditions studied. Research showed that yeasts were better microorganisms for cellulase production on DDGS fermentation. Implication of the research is that inclusion of yeasts on DDGS supplemented nonruminant diet could be helpful to enhance DDGS inclusion limits.

Mycotoxin test kit validation for high-aflatoxin samples

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Five commercial mycotoxin test kits were validated, including Aflatest from Vicam, Romer kit from the Romer Lab, Charm kit from Charm, Neogen Veratox, and Neogen Veratox AST. Three chemists evaluated three reference samples of naturally occurring aflatoxin contaminated ground corn. Each chemist analyzed seven samples per mycotoxin test kit for each of the three reference samples. The reference samples were also subject to HPLC analysis methodology (21 times per reference sample), yielding official results of 59, 306, and 901 ppb. The data were analyzed using SAS general linear model (GLM) procedures to explore whether significant differences were observed between test kits and chemists for the three aflatoxin levels. The percent relative difference for each aflatoxin measurement was calculated by subtracting the official (HPLC) value from the test kit value, dividing the difference by the average official value. All test kits met the GIPSA acceptable limits, which allow the maximum relative standard deviation (RSD) for the 100-ppb sample to be 16%. There was no observed significant main effect for chemist; however, a significant three-way interaction and two-way interactions were observed for test kit, aflatoxin level, and chemist ($P < 0.01$). The Romer and Neogen AST displayed no significant difference with HPLC results in percent relative difference at the three aflatoxin levels while the Charm and Aflatest results for the highest level (901 ppb) of aflatoxin were significantly different from HPLC results. Ideally, all test kits, with the proper dilution procedure, should give consistent results for different aflatoxin levels. However, it is tricky to figure out which step is critical for each individual kit. As the validation was done in a well-controlled laboratory environment, bigger variations would be expected in the real field practice.

Identification of extensibility parameters influencing dough strain hardening index and extensional stiffness

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A fundamental understanding of dough behavior is helpful to our knowledge of breadmaking technology. Extensibility tests were performed on HWW dough mixed to target consistency using the Mixolab. The Kieffer rig, fitted on a Texture Analyzer TA.XT.*plus*, was used to collect force-distance data from samples from 31 breeding lines grown over 3 years in South Dakota. Data acquired from tensile tests was derivatized to obtain a stress-strain curve. The curve was fitted using an exponential equation to extract two parameters: dough extensional stiffness (ES) and strain hardening index (SHI). A set of extensibility parameters was collected. Stepwise regression was used to determine which of these parameters influenced ES and SHI. Regression models were developed using data from 333 tests. Dough strength (R_{max}), initial slope of test (E_i), and difference between extensibility at R_{max} and dough maximum extensibility (E_{diff}) were the parameters that explained SHI. The model had an R^2 of 83.7. E_i and E_{diff} were the parameters explaining the variations in ES values (R^2 = 93.2. A validation sample set consisting of samples from 25 lines grown in Selby in 2009 (N = 225) was used to determine the efficacy of the predictive models. Extensibility parameters were collected and used in the models. ES and SHI were collected using curve fitting. Highly significant correlations between actual and predicted values of SHI (r = 0.774) and ES (r = 0.842) proved the validity of our regression equations. SHI is a key property of dough that allows gas cells to inflate at larger volume. It was correlated with loaf volume and overall quality of bread. The parameters identified in this study may be key parameters for screening among breeding lines and predicting end-product quality.

Parameters that affect pasta cooking

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Three different experiments were conducted to measure the influence of cooking surface temperature, cooking water/pasta ratio, and cooking vessel material on the final quality of cooked pasta. In experiment 1, pasta samples were cooked in 400 mL of water at four different surface temperatures (250, 300, 350, and 400°C). In experiment 2, pasta was cooked at a surface temperature of 400°C in four volumes of water (400, 500, 600 and 700 mL). In experiment 3, the effect of cooking pasta in a glass and in a stainless steel vessel was recorded. In all the experiments, the same five different amounts of pasta (13, 20, 27, 33, and 48 g) were cooked. All pasta samples were cooked till their optimum cooking time (OCT). Cooking loss, cooking weight, and cooked firmness were measured to determine the final quality of the cooked pasta. A data logger (DL) was used to record the drop of temperature produced after the pasta addition and the time required by the water to recover its cooking temperature. OCT was greater when cooked at 250 than 400°C; with 48 than 13 g pasta; and with a glass than with a stainless steel vessel. Cooking loss, cooking weight, and cooked firmness were greater when cooked at 400 than 250°C; with 13 than 48 g; with a stainless steel than with a glass vessel. Cooking water volume 400 to 700 mL did not affect cooking loss, weight or cooked firmness. Drop in temperature and recovery time of temperature of the cooking water were greater at 250 than 400°C; 48 than 13 g pasta; and with 400 than 700 mL cooking water. Regarding pasta quality and optimization of the cooking process, the results showed that the best cooking parameter combination from significant point of view was to cook a pasta/water ratio of 13 g/400 mL at a surface temperature of 400°C in a stainless steel vessel.

Rheological properties of sorghum protein concentrates produced by extrusion-enzyme liquefaction

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Small amplitude dynamic oscillatory properties of two sorghum protein concentrates produced by extrusion-enzyme liquefaction at low (17% db) and high (32% db) in-barrel moisture contents were evaluated. The protein content of these concentrates were 74 and 72% db, respectively; and in vitro protein digestibility values were 76 and 56%, respectively. Sorghum protein concentrate (0, 5, 10% based on starch) was added to potato starch and two levels of moisture content were used (55 and 65% db) to simulate dough and batter systems. Amplitude and frequency sweep were conducted using a strain-controlled rheometer. In both dough and batter systems, the sorghum protein concentrate extruded at 17% in-barrel moisture consistently had higher G' and G" values than the concentrate extruded at 32% in-barrel moisture, regardless of addition level. The dough system exhibited higher elastic (G') and viscous (G") moduli than the batter system, as expected. At low moisture content, pure potato starch and the dough containing 10% of sorghum protein concentrate extruded at 32% in-barrel moisture had similar G' (8.0×10^3 to 8.5×10^4 Pa) and G" (3×10^3 to 4×10^4 Pa). In the batter system, potato starch exhibited significantly higher G' (1351–3193 Pa) and G" (285–706 Pa) than any of the batters with sorghum protein concentrate (G' 10–565 Pa; G" 4–224 Pa) from 0.01 to 20 Hz. Beyond 20 Hz, G' and G" values of all batters converged toward a common value. At high moisture content, protein concentrate produced at 17% in-barrel moisture was more stable than the concentrate produced at 32% in-barrel moisture at higher frequencies. The addition of sorghum protein concentrate to gluten-free bread can improve its nutritional value without possibly sacrificing quality provided that sufficiently high viscosity is maintained. The quality of gluten-free bread containing sorghum protein concentrates was also evaluated in this work.

Dietary fiber-updating the AACC Official Methods in line with CODEX Alimentarius definition adoption

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Cereal Foods World 56:A38

Nutritionally, dietary fiber is unique in that its nutrition benefits relate to its resistance to digestion, as opposed to most nutrients which depend upon bodily absorption for their benefits. Consequently, dietary fiber consists of a digestion resistant complex mixture (mostly carbohydrate) of components that vary by source, preparation, and processing. Serious research on dietary fiber in the 1950s and 1960s resulted in a definition by Trowell et al in 1976. Beginning in 1980, AACC International validated Approved Methods 32-05, 32-06, 32-07, 32-20, 32-21, and 32-25 to match that definition. Scientific advances in the subsequent two decades resulted in the physiologically based conclusion that additional components, e.g., resistant starch and nondigestible oligosaccharides are validly included in the Trowell et al definition; therefore, AACC Approved Methods 32-23, 32-28, 32-31, 32-32, 32-33, 32-40, and 32-41 for these components have been validated. Recently, the CODEX Alimentarius Commission adopted a clarifying definition of dietary fiber (ALINORM 09/32/REP, 09/32/26) recommended by the Committee on Nutrition and Foods for Special Dietary Uses that reflects the scientific findings of the past 5 plus decades in a single, concise definition. CODEX further updated the method with editorial clarifications in 2010 (ALINORM 10/33/REP, 10/33/26) AOAC International scientists validated an all-inclusive method (Official Method of Analysis 2009.01) commensurate with this definition. AACC has now completed the collaborative study for validating methodology for the insoluble and soluble fractions of dietary fiber per the CODEX definition and expects to have an Approved Method shortly.

Characterizing the phytochemical contents and volatile profiles of some selected Ontario red and white wheat varieties

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Cereal Foods World 56:A38

In Ontario, there has been a shift from the production of white wheat to red as is it more conductive to the growing conditions, is more resistant to diseases, and yields a greater amount for processing. The demand for healthful whole grain products that taste good is rapidly increasing and the off-flavors which are more noticeable in red wheat products have presented a great challenge to the food processors. Wheat grain and its fractions contains various classes of phytochemicals, such as phenolic acids, polyphenols (lignans and flavonoids), carotenoids, alk(en)ylresorcinols, tocopherols/tocotrienols, and phytosterols/phytostanols. In this study, 25 varieties of red and white wheat were characterized for their phytochemical contents and a few varieties were selected based on these contents to analyse for their volatile profiles. The phytochemical contents of the wheat flours were analysed using high-performance liquid chromatography (HPLC) and the volatile profiles were obtained by heating the flours at 200°C, trapping the volatiles using a carboxen/polydimethylsiloxane (PDMS) solid-phase microextraction (SPME) fibre, and analysed using gas chromatography-mass spectrometry (GC-MS). The total phenolic content which contains mainly phenolic acids and polyphenols ranged between 2058–2700 µg/g ferulic acid equivalents and the total flavonoid content ranged between 245–520 µg/g catechin equivalents, accounting for 10–20% of the total phenols present in the whole grain. Various classes of volatile compounds, including alcohols, aldehydes, esters, and furans, were found to exist in varying combinations and concentrations in the red and white wheat flours. It has been speculated that the phenolic composition of wheat grain has an influence on the flavor of whole grain products and the findings of this research will be useful in determining the source of these flavor compounds.

Improved wheat grain color classification based on detailed spectral analysis

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Color determines the preference and choices made by consumers, who over the years have been observed to express likeability toward products made from white wheat rather than red whole grain. Kernel color is also speculated to have a relationship with the phytochemical content, especially phenolic compounds which are present in higher amounts in the bran fraction. Therefore, the flavor profile of wheat and the products made therefrom is related to the color and in turn its phytochemical content. Hence, color is an important parameter for the selection of wheat varieties used in processing of food products. Previous studies on genetic analysis of wheat have shown that the color gene (*R*) is located on chromosome number 3. The use of the genetic markers would be the most accurate way to differentiate between the red and white grain color based on the genotype of *R* gene. But until enough research is done to characterize the markers for the thousands of wheat varieties, the NaOH test is the best option to quickly and qualitatively distinguish between the red and white wheat varieties. Over the years, L*a*b* values have been reported and used to qualitatively differentiate between the colors but have been found to be very conservative. Upon detailed spectral analysis, we found the parameter of hue to be a better descriptor that can be used to differentiate not just between red and white wheat varieties but also the varying shades of red. These shades of red can possibly be related to and determined by the number of dominant alleles and can be reported as light (Rrr), medium (RRr), and dark red (RRR). Phenotypic relationships based on color as determined by principal component analysis (PCA) clearly showed a significant differentiation between the white and light, medium and dark red colored wheat varieties.

Diffusion of alpha-amylase in starch granules

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The diffusivity of alpha-amylase within starch granules was calculated from the digestion kinetics of size-fractionated maize and potato starch granules and correlated with the diffusion of enzyme-sized fluorescent FITC-dextran probes within granules, measured using fluorescence recovery after photobleaching (FRAP) on a confocal microscope. Digestion of all size ranges of maize and potato starch granules followed first-order kinetics, consistent with enzyme-substrate complex formation being rate limiting. The apparent amylase diffusion coefficient was calculated from the relationship between granule size and digestion rate and was 7.40E-10 cm^2 sec^{-1} for maize starch, five to six times higher than for potato starch, presumably due to the numerous pores and channels available at the surface of maize starch granules giving easy access to amylase for hydrolytic action. For FRAP measurements, maize granules, raw (undigested), or pre-incubated with alpha amylase for 30 seconds were suspended in FITC-dextran solution, allowing passage of the probe into the granules through numerous pores and channels. It was clear from the FRAP experiments that for maize starch diffusion was dependent on pore size and number of channels available for the probe to diffuse. On the other hand, 70 kDa FITC-dextran was unable to diffuse inside potato starch granules due to the absence of pores and channels. Further, FRAP experiments will allow a quantitative analysis of the diffusion of dextran probes varying in molecular size, both before and after alpha-amylase treatment.

Changes in durum wheat kernel composition and appearance during grain filling

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Researchers have shown that genotype and environment can affect the final carotenoid pigment content of durum wheat. Limited research has been conducted on deposition of carotenoid pigments during kernel development. An experiment was conducted to determine the effect of kernel development on the carotenoid pigment concentration in durum wheat kernels. Spikes were collected from durum grown in field plots established in Prosper, ND. Changes in kernel morphology associated with grain filling were examined by scanning electron microscopy and by dissecting scope. In a second experiment, grain samples collected during the annual durum crop survey from 2008, 2009, and 2010 were used to determine carotenoid pigment content of semolina and the loss of pigment during pasta processing. Only samples where the cultivar was identified were used. Carotenoid pigment content was determined using Approved Method 14-50 (AACC International 2000). As grain development progressed from early post-anthesis to physiological maturity, protein content, kernel size, and kernel weight increased, while the concentration of carotenoid pigments per kernel declined. Carotenoid pigment concentration per kernel was greater for large than for small kernels. Conversely, pigment content was greater in meal from ground small kernels than from ground large kernels, which reflects the dilution of pigment by starch and protein in large kernels. Pigment loss during processing varied with cultivar and was greater from semolina derived from grain grown in 2008 and 2009 than in 2010, indicating an effect of environment.

An investigation into the use of millet, sorghum, maize, and wheat in development of muesli with higher dietary fibre content

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This study considered whether less common whole grains such as millet (M), sorghum (S), maize (A), and wheat (W) could be successfully incorporated into muesli products in order to improve its dietary fibre level. Four different formulations were developed, (1) 25%M, 25%S, 30%A, & 20%W; (2) 50%M,

10%S, 20%A, &20%W; (3) 40%M, 15%S, 35%A, &10%W; and (4) 30%M, 45%S, 10%A, & 15%W, and extruded using a Werner and Pfleiderer extruder. The process conditions were set at screw speed 250 rpm, water feed 13%, feed rate 20%, and barrel temperature for 120°C at die exit and 80°C at feed entry. Torque, material temperature, and pressure were recorded during extrusion run. A number of nutritional and textural properties in extrudates including soluble and insoluble fibre, protein content, bulk density, hardness, slice area, slice brightness, cell contrast, and number of cells were measured. The extrudates were palletized, then 33% from each sample were mixed with 17% dried banana, 13% dried pineapple, 10% coconut, 13% dried peanuts, 7% sunflower, and 7% pumpkin seed. Netwisp program was used to calculate nutritional properties of the final product. Sensory evaluation including flavour, overall texture, crunchiness, aftertaste, and overall liking were assessed. A commercial sample was used for comparison. The protein level in extrudates varied from 9.64 to 11.29%, insoluble fibre from 6.11 to 7.61%, and soluble fibre from 0.92 to 1.21%. A significant ($P < 0.05$) difference between in terms of hardness, bulk density, and number of cells was detected while no difference was found in terms of slice brightness and cell contrast. The total dietary fibre of the finished product varied from 10.4 to 12% and depended on formulation. Sensory evaluation results showed that all the samples were comparable to the commercial one in terms of aroma, overall texture, crunchiness, and aftertaste.

Folate content of commercially produced corn and wheat tortillas purchased from retail outlets in the western United States

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Unfortified corn and enriched wheat flour tortillas, procured from retail outlets in the western United States were analyzed for total folate content using a modified tri-enzyme extraction method with rat plasma, followed by the standard microbial assay with *Lactobacillus casei*. Two to three lots of each brand and type of tortilla were evaluated. Ingredient declarations indicated all wheat flour tortillas were produced using white enriched flour, fortified to deliver 0.7 mg folate per pound of flour, per FDA regulations. Total folate in wheat flour tortillas ranged from 142 to 238 µg/100 g dwb. This agrees with the expected level (157.4 µg/100 g), based on calculations using the standard folate levels for enriched wheat flour. Folate content of unfortified corn tortillas was significantly lower (17.6–28.5 µg/100 g). Results showed the total folate of corn tortillas to be higher than the concentration reported in the USDA nutrient database (9.2 µg/100 g dwb). Analysis of variance showed that lot-to-lot and brand-to-brand folate variation in enriched wheat flour tortillas was large compared to variation in unfortified corn tortillas. There was no significant difference ($p < 0.05$) between corn tortillas based on brand or lot. Enriched product folate variation could be attributed to manufacturer differences in overages and fortification levels for enriched wheat flour. Batch-to-batch fortification inconsistencies probably contributed to variation as well. The significant difference in folate content between unfortified corn tortillas and tortillas made from enriched wheat flour illustrates the need for fortification of corn masa flour in the United States. Fortification of corn masa flour with folic acid has the potential to significantly increase the consumption of folate in Hispanic women of childbearing age, since tortillas are a staple in the diet of large segments of the U.S. Hispanic population.

Improvement of physical and mechanical properties of durum wheat (*T. durum*) starch films through hydrolysis and cross-linking

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Recently, the use of wheat starch in the development of biomaterials has increased. However, the application of native starch is still limited, due to the deficient barrier properties, moisture sensitivity, and poor mechanical properties. To obtain optimal functional properties, the starch needs to be modified. Native starch was hydrolyzed with HCl in the presence of methanol for 1 hour at 70°C, and after that, it was cross-linked using sodium trimetaphosphate. The films were prepared by the casting method, using glycerol as plasticizer. Starch and a small amount (up to 5%) of modified starch were used. The films were analyzed by atomic force microscopy (AFM), also the mechanical properties, elongation at break (E), elastic modulus (EM), and the stress maximum (TS) were evaluated, films solubility was measured and X-ray diffraction studies (XRD) were made to the films. Films were transparent, flexible, and homogeneous, according to AFM. The solubility was low compared with other studies, and according to XRD the films showed a semicrystalline structure. The mechanical properties improved, decreasing the elongation at break and increasing the maximum stress of tension. The addition of starch modified by hydrolysis and cross-linking has great influence on the physicochemical properties of durum wheat starch films.

Development of a highly nutritional and nutraceutical product from an optimized mixture of extruded maize and bean flours

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The combination of cereals and legumes compliments the levels of essential amino acids and phytochemicals, improving the quality of the protein and consumer health. The aim of this research was to determine the best combination of extrusion process variables for the production of extruded flours from maize (EMF) and bean (EBF) to prepare a mixture (60% EMF + 40% EBF) suitable to elaborate a nutraceutical food product of high acceptability and nutritional quality. Maize and bean kernels were broken to obtain grits (1–2 mm), which were added with a mixture of distilled water [60% (v/v)] + edible oil [(39.8% (v/v)] + lecithin [(0.2% (v/v)] to reach a moisture content of 28% [previously, maize grits were mixed with lime (0.21 g lime/100 g grits)]. Extruder operation conditions were selected from a factorial combination of process variables: extrusion temperature (ET, 120–170°C) and screw velocity (SV, 120–200 rpm). A central composite experimental design with five variation levels generated 30 assays. RSM was applied over two response variables: antioxidant capacity (AC) and acceptability (A). Mixtures from each assay were evaluated for AC and used to prepare 30 food products [25% mixture + 75% distilled water] that were evaluated for A. Predictive models for response variables were developed. An optimum value for the two responses variables was obtained using the desirability method. The best combinations of extrusion process variables for EMF and EBF were ET = 99°C/SV = 162 rpm and ET = 172°C/SV = 94 rpm, respectively. The optimized mixture had a global desirability of 1.00; it contained 12.73% proteins (DM). The AC of 100 g of food prepared from the optimized mixture was 3,074 µmol TE. The acceptability of the food product was between "I like it" and "I like it extremely". This nutraceutical new food product could be used as an alternative to those with low nutritional value.

Dietary fiber improvement of pasta products using dehydrated *Opuntia* flour

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The development of low-calorie and high-fiber foods has been a great priority for the food industry in recent years. This is due mainly to the growing consumer interest for a healthier and nutritive diet. Dehydrated *Opuntia* flour has a high dietary fiber content, which makes it an alternative for the enrichment of food products deficient in dietary fiber. This research was designed for the preparation of durum wheat flour-based pasta enriched with dehydrated *Opuntia* flour. Dietary fiber contents (total, soluble, and insoluble DF fractions) and consumer acceptability in the enriched pasta products were evaluated in an attempt to select the highest dietary fiber product and also with the highest preference from the consumers. Three flour blends were investigated: 95:5, 90:10, and 85:15 (wheat flour:dehydrated *Opuntia* flour, respectively). A commercial pasta-making machine was used. Fresh pasta was dried in an air tunnel drier at 60°C. Fresh pasta was analyzed for their chemical composition and total, soluble, and insoluble dietary fiber contents. Pasta products were cooked for 9.5 min in boiling water, previous to consumer preference trials. Sensory evaluation of enriched pasta products was performed using a hedonic scale, showing that the 85:15-enriched pasta was the most accepted one. This enrichment level (85:15%) had the following chemical composition: improved total protein content (11.0%), a low fat content (1.07%), and relatively high total dietary fieber content (13.7%). Based on these results, the addition of 15% dehydrated *Opuntia* flour to durum wheat flour-based pasta formulation increases the dietary fiber content significantly and the enriched pasta was quite acceptable for the consumers.

Comparison of microwave processing and excess steam jet cooking for spherulite production from starch:palmitic acid inclusion complexes

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It was previously shown that toroidal and spherical/lobed spherulites were formed upon slow cooling of aqueous dispersions of high-amylose corn starch

and palmitic acid after passing through an excess steam jet cooker. In order to determine whether excess steam jet cooking is essential for spherulite formation, or if spherulites with different morphology or size could be formed by other methods, microwave processing was examined. This alternative method can provide rapid heating to 140°C (as is typical for jet cooking), but with minimal shear. High amylose starch was combined with palmitic acid (5% based on apparent amylose) at a solids content of 3.5%, similar to the conditions used for spherulite production with jet cooking. After treatment at 140°C for 10 min with magnetic stirring in a closed microwave reactor, the dispersion was stirred while cooling to 120°C, then transferred to a water bath and cooled for 22 h from 95 to 40°C without stirring. Spherulites were formed with size and morphology similar to those obtained by steam jet cooking, suggesting that the shear-induced reduction in amylose molecular weight associated with jet cooking is not essential for spherulite formation. Spherulite yield was 56.8% based on apparent amylose, as opposed to 86% yield obtained with jet cooking. However, the presence of retrograded amylose gel fragments and palmitic acid crystals indicated that the extent of complex formation was lower, possibly due to inadequate mixing. The effects of temperature, stirring, and cooling rate on spherulite formation, yield, and purity will be described. Even though spherulites in gram quantities are obtainable with microwave processing, excess steam jet cooking may be the most efficient approach for large-scale spherulite production because of its ability to provide sufficient heat and shear in a single step.

Interaction of rising CO_2 and soil water availability on wheat grain quality: Results from a 3-year free air CO_2 enrichment experiment

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Wheat (*Triticum aestivum* L. cv. Yitpi and cv. Janz) were grown under field conditions in the Australian Grains Free-Air Carbon dioxide (CO_2) Enrichment (AGFACE) facility for three consecutive years. Current ambient CO_2 (384 µmol mol^{-1}) and elevated CO_2 (550 µmol mol^{-1}) were combined with two water levels (rain-fed and irrigated), two different times of sowing to provide temperature differences during grain filling to investigate effect of rising CO_2, water availability, and grain filling temperature on grain quality. Grain yield, physical properties, mineral composition, grain protein, and flour rheological properties of wheat were investigated. Grain yield was increased by 31% when plants were grown under elevated CO_2 across all the treatments. Hardness index of the grain was increased by 3.5% at elevated CO_2, while grain protein concentration was significantly decreased. Overall, the reduction of grain protein concentration was 5.3% at elevated CO_2. Grain mineral concentration of Fe (39 mg kg^{-1}, 8%), Zn (27 mg kg^{-1}, 27%), S (1845 mg kg^{-1}, 6%), Ca (501 mg kg^{-1}, 6%), Mg (1403 mg kg^{-1}, 8%), and P (3988 mg kg^{-1}, 5%) were significantly declined at elevated CO_2 in 2009 growing season, while grain K, B, Mn, and Al concentrations were not changed. Similar changes in mineral composition were observed in 2007 and 2008 growing seasons at elevated CO_2. Most of the rheological characteristics of the flour of both cultivars were negatively affected by elevated CO_2, this may be due to reduction in protein concentration and/or modification of the protein composition. Overall, these data suggest that rising atmospheric CO_2 is likely to have negative impact on grain quality and these responses are depend on the combination of thermal and hydrological conditions during crop growth and grain formation.

Near infrared refectance spectroscopy in the prediction of chemical characteristics of Brazilian soybean

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Near-infrared spectroscopy (NIR) is a rapid nondestructive technique that is able to measure organic substances within minutes. This method has had great impact on the industry and agriculture for its nondestructive continuous measurement of physic-chemical properties. However, the use of near-infrared reflectance spectroscopy must be associated with chemometrics tools to predict parameters as moisture, lipids, and proteins. The partial least squares (PLS) algorithm is used to build the calibration model by regressing the deconvolved spectra against the concentration. The objective of this study was to develop NIR calibration using spectra and reference data and to compare the moisture, protein, and lipid content calibration to the regression analysis of combinations of NIR. Hundred soybean samples donated from The Brazilian Agricultural Research Corporation's (Embrapa) were used in this study. Validation was carried out both by means of cross-validation and test set validation. Various spectral treatments were employed to avoid baseline shifts arising from scattering: constant offset elimination, second derivate, standard normal variate (SNV), and straight line subtraction. To assess the model, the calibration standard error (SEC), prediction error (SEP), and determination coefficient (R2) were calculated. The PLS model developed for quantifying moisture, lipids, and proteins in soybean showed that there is a good agreement between the real and predicted concentrations with coefficient of correlation near 0.76 and SEP and SEC around 0.52 and 0.23%, respectively. Therefore, it can be concluded that the NIR procedure is potentially useful as a nondestructive analysis method for rapid and simple measurements of noisture, lipids, and proteins to evaluate the quality in soybean.

Development of a textured extruded product using soy protein isolate and whole grain quinoa (*Chenopodium quinoa* Willd.) flour

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Extrusion is an important process in the utilization of cereals and grains in the food industry, as it increases the digestibility of proteins. Among the grains used in this process, there is a special interest in soy due to its protein content and significant production in Brazil. Quinoa is a pseudocereal from the Andes with superior nutritional quality compared to cereals, especially considering the quality of its proteins, lipids, vitamins, and minerals and, as soy, is gluten-free. Given the advantages of the extrusion process and the strong interest in the development of new products with quinoa, the objective of this research was to obtain a textured soy protein product, to be used as protein source for meal and food products, from soy protein isolate and whole grain quinoa flour. The influence of extrusion parameters (moisture content and quinoa ratio) for obtaining the extruded product were evaluated using an experimental design. A twin-screw extruder was used with a rotation speed of 350 rpm and die temperature of 120°C. The dependent variables of the design were: expansion ratio, water and oil absorption, loss of solids, hardness (dry and hydrated), and density. The response surfaces showed that 15% moisture and 7.5% quinoa resulted in high rates of radial expansion (R^2 = 0.94) and reduced loss of solids (R^2 = 0.95). The water absorption and hardness values were higher when the content of quinoa was increased, probably because of its starch content. The study showed that it is possible to obtain a textured soy protein product with added whole grain quinoa flour with high protein content, gluten-free, and satisfactory technological characteristics (integrity and reduced loss of solids).

Comparison of the secondary structural changes in zein and gliadin with addition of high-molecular-weight subunits of glutenin (HMW-GS)

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Wheat gluten (WG) is recognized as the only cereal protein to have the unique ability to form a viscoelastic dough upon hydration and mixing. Gluten proteins are composed of gliadins and glutenins. The high-molecular-weight subunits of glutenin (HMW-GS) have been accepted as the main determinant of dough elasticity. Their contribution to elasticity was proposed to be through transition from β-turn to β-sheet structure. The main protein component of the corn kernel is zein. Unlike WG, zein is not able to form viscoelastic dough at room temperature. Zein is an aqueous alcohol-soluble protein analogous in a number of respects behaving similar to gliadin in WG and lacks HMW-GS which are assumed to be responsible for gluten elasticity. It is hypothesized that addition of a coprotein, such as HMW-GS in WG, may change the secondary structure of zein and cause an improvement due to β-structure formation. The objectives of this study were to investigate the secondary structural changes in prolamin protein (zein, gliadin) at the dough state produced by HMW-GS addition and compare the effects of HMW-GS on zein and gliadin. Secondary structures of proteins in the dough state were determined by using Fourier transform infrared (FTIR) spectrometry. Fourier self deconvolution (FSD) and spectra second derivative techniques were used to discriminate and assign the overlapped bands in the Amide I (1700–1600 cm^{-1}) region. The raw spectra were curve-fitted to calculate the relative areas under the assigned peaks to quantitatively evaluate specific secondary structural conformations. HMW-GS addition caused marked changes in second derivative spectra of zein. However, zein and zein+HMW-GS samples were found to have a higher random and α-helix structure than gluten, gliadin, and gliadin+HMW-GS samples, which might be the result of conformational differences between zein and gliadin.

Influence of glutenins on stress relaxation of wheat kernels and the relation to sedimentation and rheological properties

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Stress relaxation was evaluated for the first time in HMW-GS and LMW-GS directly from intact wheat kernels. Mechanical properties of wheat kernels, glutenin subunits composition, and dough rheology of 36 bread wheat kernels were studied. Sodium dodecyl sulfate-polyacrylaminde gel electrophoresis was used to determine HMW-GS and LMW-GS composition. Stress relaxation of wheat kernels tests was conducted using a texture analyzer TA-XT2 with stainless steel probe TA-510 (10 mm dia.) at 0.5 mm of deformation loading rate of 0.1 mm/s and 600 s of relaxation time; data were analyzed by means of the generalized Maxwell model with four-exponential terms. The stresses were mainly correlated with kernel mechanical properties. There were differences in springs and stress elements of Glu-A1 null compared to Glu-A1 1 and 2*. The Glu-B1 and Glu-D1 showed differences in the stresses. Glu-A3 only affected kernel mechanical properties, while Glu-B3 showed differences in both quality parameters and mechanical properties. The relaxation time of third Maxwell element (τ3) was high for genotypes with high SDS-sedimentation volume and long mixing time. Genotypes with 45 to 60 s of τ3 usually had good HMW-GS background and LMW allelic combination generally associated with good breadmaking quality. As expected, genotypes with short relaxation and mixing times and poor sedimentation volume were samples with Glu-A1 null, Glu-B3 j 1B/1R, and with Glu-A3 e (null). Differences in stress relaxation were found among HMW-GS and LMW-GS alleles specially Glu-3 loci and the differences were related to SDS-sedimentation, mixing, and alveograph data.

Establishing a cause-and-effect relationship between wheat protein functionality, wheat variety, and protein extraction process

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Wheat gluten is widely used for strengthening of poor wheat flour by flour mills, baking industry like pastries, biscuits, bread, ... Gluten functionality is known to be dependent on different factors like wheat variety, gluten extraction process, and gluten drying process. Next to that, gluten performance is also dependant both on the formulation and the preparation method of the dough. By just considering bread recipes, already a large variety of formulations and preparation procedures are being applied by different customers in different countries. For lack of an analytical method, very often application testing is used as a release control before delivering wheat gluten. Consequently, finding a clear relation between the basic gluten analytical results in the laboratory and the performance of the protein in the final application remains a big hurdle for the industry and makes the selection of the correct gluten quality for the different applications very difficult. In this work, a range of gluten samples produced in different plants using different wheat qualities were analysed by different analytical methods. Finally, two different alveo-graph protocols were selected. In a first protocol, the analysis is performed on a model system by blending wheat gluten and starch at a fixed ratio. In a second protocol, wheat gluten is added at different dosages to flour and the difference calculated versus a reference flour is used as a measure of gluten performance. Breadmaking was selected as a model application as it is one of the main applications of wheat gluten. Wheat gluten were selected based on the alveograph results and tested in breadmaking so as to correlate alveograph results to breadmaking performance of commercial wheat gluten in order to have a fast and economic selection method at the level of quality control checking.

Suitability of pulse flours in extruded products

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The addition of fiber and protein rich pulse flours to wheat-based extruded foods is an excellent way of incorporating the nutritional benefits of pulses into the human diet. The objectives of this study were to examine the suitability of adding pulse flours to pasta and extruded puffed snacks and to determine if the flours improved protein and dietary fiber levels while maintaining acceptable quality characteristics in the products. Dehulled and split yellow peas, kabuli chickpeas, and green and red lentils were processed into flour using a hammer mill. Pulse flours were added to durum semolina at inclusion levels of 10, 20, and 30% and extruded into spaghetti. Puffed snacks were prepared with 100% pulse flours using a twin-screw extruder. Protein and dietary fiber levels were significantly improved in the spaghetti and extruded snack treatments by the addition of pulse flours. Cooking times remained similar among all treatments. Cooked spaghetti made with pulse flour was firmer than the control samples. A trained sensory panel could not detect differences in flavour intensity among the three inclusion levels with the exception of red lentil flour. No differences were found in overall quality between spaghetti made with pulse flours and whole grain durum semolina. Extruded puffed snacks made from yellow pea flour had the closest expansion ratio and bulk density to the control product made with 100% corn flour. The trained sensory panelists found significant differences ($p < 0.05$) in hardness and crunchiness among the various extruded snacks. No differences were found in flavor acceptability between extruded snacks made with pulse flour and whole wheat flour. This research indicates that pulse flours can be successfully incorporated into spaghetti and extruded puffed snacks and can be used to formulate healthier products with acceptable quality characteristics.

Determination of pigment degradation power in durum wheat semolina: A simple colorimetric method

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While the importance of lipoxygenase (LOX) in pasta colour is well recognized, the difficulty and cost associated with the measurement of LOX restricts its use as a selection tool for color loss in most durum breeding programs. Thus there is a need to develop a rapid, cost-effective, high-throughput method for routine measurement of pasta color loss. This study developed a method to quantify pigment loss due to enzymatic degradation in semolina. The contacts among LOX, free fatty acids, pigments, and the incorporation of oxygen are required for pigment degradation by oxidation. Homogenization of semolina and water in a microcentrifuge tube can simulate the mixing and kneading process during pasta extrusion process. Semolina (200 mg) was mixed with water (0.15 ml) in a tissue homogenizer and allowed to rest overnight. Pigments were then extracted by adding 0.85 ml of 1-butanol followed by homogenization and centrifugation. Absorption at 435 nm were recorded and converted to yellow pigment concentration as specified by AACC method. This measurement can be conducted in parallel with routine semolina pigment content assay with water saturated 1-butanol extraction. The pigment degradation power (PDP) was calculated as a percentage of pigment loss after oxidation and was found to be genotype dependent. Durum genotypes with low PDP (2–7%) were characterized by the absence of a LOX gene duplication at the Lpx-B1 locus, which has been shown previously to be associated with a strong reduction in LOX activity in semolina. The PDP was significantly higher (12–28%) for genotypes carrying the LOX gene duplication. There were significant correlations ($r = –0.84$, $p < 0.0001$) between PDP and yellowness (b*) of spaghetti dried at 70 and 90°C, suggesting that this rapid method could be used in breeding programs as a tool to select for reduced color loss due to LOX activity.

Encapsulation and release properties of rice proteins

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Microencapsulation behavior of rice proteins was studied. The microsphere samples were prepared by microemulsion technique using sonication. Rice protein (70%) was suspended in water (1 g/100 ml) at various pHs (5.0, 6.0, and 7.0) and was sonicated (0.5" probe for 5 minutes) in the presence of 10% (w/v) peanut oil-vitamin E (0.5 or 1.0 ml) forming an oil-water emulsion. The solution was observed microscopically to select proper conditions of sonication time, power, and volume. The results were very similar under most of the conditions, except 1.0 ml oil provided more number of microspheres, which was used for all further experiment. The samples were freeze-dried (FD) and were analyzed for the release of vitamin E in water/hexane system. Samples (40 mg) were suspended in water (10 ml) at various pHs (3, 4, and 7) and were analyzed for the release of vitamin E in hexane layer at 305 nm using a UV-visible spectrophotometer. The changes were followed every 4–5 hours for the first day and then once a day up to 12 days. All microspheres sample were found to have the maximum release point for vitamin E on ninth day. However, samples prepared at pH 7.0 had the highest release of vitamin E by ninth day and lowest for the samples made at pH 5.

Associating *Vigna unguiculata* phenotypes with composition of bioactive compounds

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Sixty diverse *Vigna unguiculata* (cowpea) varieties were screened for polyphenols, tannins, flavonoid composition, and antioxidant activity to associate these beneficial attributes with seed phenotypic traits (seed coat color, texture, and plant maturity). Significant diversity was observed in the amount of polyphenols (2.05 to 13.8 mg gallic acid equivalents/g) and condensed tannin (0.2 to 10.8 catechin equivalents/g). Antioxidant activity values range from 25 to 85 Trolox equivalents, TE/g (oxygen radical absorbance capacity, ORAC), and 5 to 143 TE/g (Trolox equivalent antioxidant capacity, TEAC). Highest levels of phenols, condensed tannins, and antioxidant activity were observed in light brown phenotypes followed by black and red seed color phenotypes. White phenotypes had the lowest levels of these compounds. Seeds with a smooth seed coat showed higher amount of polyphenols and antioxidants than seeds with a rough seed coat. Midmaturing plants had higher antioxidant activity and polyphenols than early-maturing varieties. Only black and red phenotypes had detectable anthocyanins. Significant quantities of kaempferol, myricetin, and the isoflavone, diadzein, were detected in all nonwhite varieties. To study inheritance of these compounds, with color as an observable trait, crosses were made between white (black eye or light brown eye) and red varieties. All F1 seeds were similar to the female parents. From F2 seeds, the results so far indicate that white and red are recessive to light brown and black color. F3 seeds will be used to determine segregation ratio. In general, a phenotype with light brown seed, smooth seed coat, and of medium maturity is likely to have the highest amount of bioactive compounds.

Inulin and rice starch technology in reduced-fat laminated dough

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The high rate of obesity in the United States have positioned healthier food choices front and center in our national consciousness. Consumers are demanding healthier and lower-caloric options for the foods they consume, while maintaining the same quality, texture, and taste. Laminated doughs, the classic backbone of croissant and Danish pastry, typically contain greater than 25% total fat. In this study, synergies between long-chain inulin and rice starch(s) were explored with the goal of reducing the fat in a laminated dough systems by 30%. Shearing long-chain inulin in water provides a network of submicron inulin particles, whose particle size is similar to that of fat after homogenization. Rice starches provide structure, creamy mouthfeel, and freeze-thaw stability. Several combinations of inulin and rice starch were trialed and the optimum of these ingredients yielded a dough similar to the control in crispiness, flakiness, and height, with 30% less fat. Insulin and rice starch technology can be utilized to develop a reduced-fat and low-caloric pastry that meets today's consumer healthy diet trends.

Evaluation of refrigerated and frozen pasta made from freshly extruded macaroni and from dried macaroni

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Although dry pasta is commonly available, refrigerated and frozen pasta are a convenient option to consumers in the market as they usually take less time to cook than dry pasta. An experiment was conducted to compare the cooking quality of refrigerated and frozen pasta made from freshly extruded macaroni and from ultra-high-temperature (UHT) dried macaroni. Samples were subjected to 7 day storage at 4°C (refrigeration) and –12°C (frozen) conditions in a conventional household fashion. Dry macaroni was hydrated by cooking 1.5 minutes before storage. Partially cooked and fresh macaroni samples had an optimum cooking time of 2.5 and 1.5 minutes, respectively. Measurements for texture, cooked texture, cooking loss, cooking weight, cooked pasta color (Hunter L, a, b), and moisture were taken at days 1, 3, and 7 with a control as day 0. The results indicate no significant difference between macaroni stored at 4 or –12°C ($P > 0.05$). However, significant differences were seen between the UHT-drying processed samples and the fresh processed samples ($P < 0.05$), the latter resulting in a higher cooking loss (44.6%), lower cooked texture (51%), and higher cooked weight (10.85%). A dull color was visually perceived on refrigerated samples after the first day of storage, not so on frozen samples. Significant differences ($P < 0.5$) were encountered for brightness (Hunter L value) between cooked and uncooked (or part-cooked) samples, being the cooked samples brighter (7.74%). These results confirm that the UHT drying process helps determine for better cooking quality macaroni.

Pasta products supplemented with raw and fermented-cooked flours of *Vigna sinensis* and *Phaseolus vulgaris*

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Semolina pasta is one of the most consumed foods for low incoming population and it is the main caloric source. However, wheat protein is of low nutritive value because it is deficient in lysine. The aim of this work was to supplement pasta products with 5, 10, and 12% of raw and fermented-cooked *Vigna sinensis* (cowpeas) and *Phaseolus vulgaris* (white beans) flours in order to improve their nutritional quality. Although cooking parameters of pasta products with legume flours showed an increase in cooking time, weight, cooking losses, and soluble protein losses compared to semolina pasta, these values were within the acceptable range of good-quality pasta. Sensory test showed that pasta products with 5–10% legume supplementation were the most accepted. Compositional analysis revealed higher contents in protein and ash (up to 25 and 223%, respectively), B vitamins (up to 46% for B1 and 40% for B2), and inositol phosphates (up 131%) and also higher PER and true digestibility values than control pasta. Fermentation and posterior cooking positively affected protein quality of pasta products. It was concluded that it is feasible to make nutritive and well-accepted enriched pasta products with raw and fermented-cooked cowpea and beans flours.

Effect of the addition of fiber of seeds of guava (*Psidium guajava*) in doughs of wheat flour

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The addition of soluble fiber in breads improve its properties, the fiber of guava seed (*Psidium guajava*) is consider a remainder of the agro-industry. The objective of this work was characteritazion the doughs of wheat flour added with seeds of guava (*Psidium guajava*) flour with fat and without fat, for the obtention of an optimal formulation for the elaboration of products of high fiber content. The experimental design consisted in the addition of 2.5, 5, 7.5, and 10% of seed of guava flour with fat and without fat, the tests were analyzed the texture profile analyzes, extensibility and adhesivity with texture analyzer in doughs of wheat flour. The proximal chemical analysis of guava seed (*Psidium guajava*) flour showed: 4.6% of protein content, 3.75% of fat, and 81.42% of dietetic fiber. The texture profile analyzes in doughs showed that hardness decreased with the addition of the fiber, for the adhesivity of dough in the adhesión work increased in the seeds of guava (*Psidium guajava*) flour without fat, the extensibility decreased with the addition of seeds of guava (*Psidium guajava*) flour with and without fat, the optimal formulation of the doughs was the elaborated with 2.5% of fiber of seeds of guava (*Psidium guajava*) flour without fat. This formula can be used for elaboration of cakes with high content of fiber.

Physicals characteristics of mixtures of flour wheat and flour ataulfo mangoe

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Bioactive compounds found in the mangoes, among other plants and herbs have been shown to have possible health benefits with antioxidative, anticarcinogenic, antiatherosclerotic, antimutagenic, and angiogenesis inhibitory activities. The magoe ataulfo is agroindustrial waste, this fruit is not procecessed, for this the objective was evaluating dough quality of mixtures of wheat flour (*Triticum aestivum*) and ataulfo mangoe flour, using "Kieffer dough and gluten extensibility rig" (extensibility) and dough system inflation analysis as indicators were measured in a TAXHDi. It was prepared from wheat flour mixed with 0, 2.5, 5, 7.5, and 10% of ataulfo mangoe flour. Results obtained for extensibility were 21.6, 12.3, 9.8, 9.6, and 1.7 cm to 0, 2.5, 5, 7.5, and 10% of ataulfo mangoe flour, respectively. For R max the results showed values of 67, 62, 70, 71, and 111 to 0, 2.5, 5, 7.5, and 10% of ataulfo mangoe flour, respectively. Maxime pressure averages of dough were 5.6, 6.5, 11.0, 12.0, and 14.0 in to, 0, 2.5, 5, 7.5, and 10% of ataulfo mangoe flour, respectively. The extensibility showed in the dough system inflation analysis was of 11.0, 29.0, 33.0, 38.0, and 35.0 cm for 0, 2.5, 5, 7.5, and 10% of ataulfo mangoe flour. It was concluded that mixture 97.5% of wheat flour and 2.5% of ataulfo mangoe flour has the best quality to prepare dough with *Triticum aestivum*.

Improving the functionality and bioactivity in wheat bran

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The objectives for this work are to develop processes for production of improved bioactive whole grain ingredients with improved functionality. Chemical, physical, and enzymatic processes to modify wheat bran were

evaluated individually and in combination to create an optimized process. Processes were optimized to maximize release of bound phenolics while enhancing bran water hydration capacity and viscosity. Visual confirmation of modifications are seen in SEM micrographs of processed wheat bran. High-pressure homogenization (HPH) dramatically reduced particle size regardless of pretreatment conditions used. Optimizing the pretreatment temperature, time, and chemical concentration prior to HPH processing yielded a 47% increase in water hydration capacity (WHC). Preprocessing with alkali followed by HPH doubled the water extractable bran fraction, increased soluble dietary fiber more than fourfold, and increased solution viscosity by more than sixfold. Free ferulic acid levels in untreated bran are extremely low. Alkali pretreatment increased free ferulic acid in bran more than 300-fold and up to 0.45 g/100 g. Xylanase enzymes were effective in increasing the free and soluble conjugate phenolics content in bran samples. HPH followed by enzyme treatments improved the efficiency of the enzyme reaction. The animal feeding study showed significantly positive effects on obesity rats with the optimally processed wheat bran vs. control bran. This research is innovative and significant because it uses new and combined approaches to integrate ingredient functionality with the enhanced health benefits of phytochemicals in whole grain ingredients.

Effect of phenolic compounds on starch hydrolysis by pancreatic amylase

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Antioxidant properties of phenolic compounds have been proven to have many health benefits. Several studies have shown that polyphenols also reduce starch digestibility. The goal of this study was to investigate the effect of different phenolic compounds on starch hydrolysis by pancreatic amylase. The phenolic extracts were obtained by brewing green or black tea in 200 ml of distilled water at 95°C for 30 minutes. Total phenolic content of green and black tea extracts were determined using the Folin-Ciocalteau method. Phenolic extracts with different polyphenolic composition were then incubated with starches (wheat, corn, or potato starch) at a concentration of 0.7% dry starch basis in the presence of 150 mg/ml of pancreatin. Concentration of polyphenols in extracts was 8968 µg/ml and 7082 µg/ml for green and black tea, respectively. The RVA program used was as follows: 5 min at 37°C, heating to 95°C at 10 degree/min, and then cooling to 37°C at 10 degree/min. The results showed that polyphenols from the two sources had different effects on starch hydrolysis at the equivalent level of total phenolic content. For example, black tea extract exhibited 100, 99, or 91% reduction in hydrolysis of corn, potato, and wheat starches, respectively, while green tea exhibited only 16.5% reduction in hydrolysis of corn starch and no reduction for potato or wheat starches. Other beneficial attributes and mechanisms of action will also be discussed. The results will shed light on extracts that are most promising for reducing glycemic index and improving antioxidant properties of different products.

Validation of on-site rapid methods for food allergen management

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Food allergy, an immune response to a protein present in food that the body mistakenly believes is harmful, is an important health problem in modern society. One of the major risks for food manufacturers is the potential for cross contamination with food allergens during production processes. For this reason, allergens continue to be the largest single cause of global product recalls. The aim of this study was to validate AgraStrip® Allergen Test Kits, immunological rapid tests in a lateral flow format, developed for the detection of allergens in food, rinse waters, and environmental swab samples. An extracted sample is transferred to an incubation vial that contains specific ready-to-use antibodies. If the sample contains an allergen, an antigen-antibody complex will form. This is subsequently detected by means of the test strip. Extensive validation studies on a range of food matrices, including yoghurt, biscuits, chocolate, and cooking sauces indicated low detection limits of 5 mg/kg gluten, 1 mg/kg almond protein, 1 mg/kg peanut protein, and 1 mg/kg casein and showed no false-positive or false-negative results. Furthermore, the AgraStrip® Allergen Test Kits are easy to use, give a result in approximately 10 minutes, and can be conducted without further equipment which is very important for on-site testing in the manufacturing facility.

Functional properties of germinated Yakkong (*Rhynchosia nulubilis*) flour and its application in rice cookies

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The objective of this study was to prepare black bean, Yakkong (*Rhynchosia nulubilis*) flour with functionality and to make rice cookies containing the flour. First, the influences of germination time and additional heat treatments (boiling or roasting, each for 15 min) on functional properties of Yakkong were investigated. When Yakkong was germinated up to 48 h at 23°C, total isoflavone content increased from 2.15 to 3.21 (mg/g), while beyond that time the content slightly decreased. For the 48-h germinated Yakkong flour (GYF), additional heat treatment slightly decreased isoflavone content, however, GYF with roasting showed the highest level in total phenol content and antioxidant test [2,2-diphenyl-1-picrylhyddrazyl (DPPH), an 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulphonic acid)(ABTS)] among samples. Composite rice flours containing 10, 20, or 30% GYF following 15 min roasting was made into cookies. All the rice cookies containing GKF with roasting showed higher brittleness and lower hardness in texture and lower L* value and higher a* value in color than control (100% rice flour cookies). In result of sensory test, cookies with GYF with roasting improved the quality of cookies, and the effect was especially obvious for flavor and texture. Sensory analysis indicated that the most acceptable level of GYF with roasting in rice cookies was 30%.

Prediction of rice noodle quality through the rice gel properties

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Rice noodle quality is difficult to predict from flour or dough characteristics. Traditionally, rice noodles are made from long grain rice containing over 22% amylose. Nevertheless, the relationship between amylose content and the final processing properties of the rice cannot be well predicted. The objective of this study was to determine the factors needed to predict rice noodle quality. Two indica lines and seven japonica lines with diverse rapid visco analyzer (RVA) pasting characteristics were evaluated for their physicochemical and gel textural characteristics relative to their suitability for making rice noodles. Rice gel (10%, w/v) was prepared using RVA and stored at 4°C for 24 h. Tensile strength showed no correlation with the RVA gel texture, but showed a significant positive correlation with noodle TPA. The main criteria for assessing the overall quality of rice noodles were an evaluation of the strength (Rmax) of the cooked noodles, the solids loss during cooking, and a puncture test curve of RVA gel. The pasting parameters of RVA, except for breakdown, were significantly correlated with cooking loss and Rmax. Good-quality cooking flour, which showed low cooking loss, high Rmax, springiness, and hardness of cooked noodles, produced a bell-shape curve in a puncture test of RVA gel. Among gel properties, the shape type of the force-distance curves of the puncture test was selected as a key factor for predicting the quality of rice noodles. RVA parameters and textural parameters of gels formed in the RVA canister were well correlated with actual noodle texture, and therefore may be used for predicting rice noodle quality in breeding programs.

Rice varieties in relation to rice bread

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Two indica lines (Hanareumbyeo and Chenmaai) and seven japonica lines (Jinsumi, Goamibyeo, Manmibyeobyeo, Milyang261, Seolgaeng, Suweon517, and YR24088 Acp9) were analyzed for bread-baking qualities. Rice flour was prepared by wet milling followed by lyophilization and passed through a 115-mesh sieve. Hanareumbyeo is classified as having low-amylose content (AC, 10–20%); Goambyeo, YR24088 Acp9, and Chenmaai are classified as having intermediate AC (20–25%), while Milyang261 is classified as having high AC (32%). Analysis of particle size showed similar bimodal peak distributions at 4.24–27.39 µm and 27.39–69.62 µm, except for Manmibyeo. Suweon517, Milyang261, and Manmibyeo were classified as having a high water absorption index (WAI), and Goamibyeo, YR24088 Acp9, Jinsumi, Seolgaeng, Hanareumbyeo, and Chenmaai had low WAI. Stickiness of rice flour dough was highly correlated with water absorption of flour and a high WAI; Milyang 261 showed the lowest stickiness. The Mixogram with 70% hard wheat flour showed a proper extensibility and elasticity of dough compared to the same parameters of standard hard wheat dough. The overall gelatinization temperature of the flour ranged from 54.4~87.9°C. Gelatinization enthalpy varied from 11.0 to 16.4 J/g. After a 2-week storage period, gelatinization enthalpy ranged from 94 J/g in Chenmaai to 1.9 J/g in Manmibyeo. Most of the high-amylose rice flours showed a high retrogradation rate, except for Goamibyeo. The bread volumes of Jinsumi, Chenmaai, YR24088 Acp9, and Goamibyeo were compatible with wheat flour, and the others were not suitable for bread due to small volumes and hard textures. The firmness rates of Goamibyeo and Chenmaai were the

comparatively low. The high-amylose lines of Chenmaai and Goamibyeo showed the most appropriate properties for making bread with high volume and low firmness, although Chenmaai showed a high retrogradation rate at DSC.

Relationship between starch structures in rice flour and solubility of starch molecules in water

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Increased cold-water solubility of starch is one of the common phenomena observed with increasing damage to starch granules. In the past, it has been associated with the molecular degradation of amylopectin caused by grinding forces. Using cryogenically milled and hammer-milled rice flours with various degrees of damaged starch granules, the relationship between starch structures at different levels and starch solubility was re-evaluated to understand the mechanism underlying this relationship. Starch molecular degradation was evident in the hammer-milled flours, but it is minimal in the cryogenically milled flours. The results showed that molecular degradation is not the precondition for the increase in cold-water and hot-water solubility of starch in rice flour. The molecules located near hilum are loosely packed and easily leach out from starch granules when the hilum is exposed, commonly seen with damaged starch granules. Furthermore, damaged starch granules are smaller, if not the same size, than the intact starch granules, increasing the relative surface area from where starch molecules can leach out in hot water. This information is important in improving the processing and the selection criteria of rice flour.

Effects of milling processes on starch digestibility of rice flours

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Grinding of rice grains has been shown to cause damage to starch granules, which increases the starch digestibility. Furthermore, increase in relative surface area with the reduction of grain particles can also increase the starch digestibility of uncooked flour. However, rice flours are consumed mostly as cooked products, and the relationship between starch structures and starch digestibility of cooked rice flours is not well established. The objective of this study is to understand the mechanistic relationships between starch structures at different levels and starch digestibility of cooked and uncooked rice flours. Rice flours were previously prepared using cryogenic milling and hammer milling to produce various flour particle sizes and degrees of damaged starch granules. Molecular degradation of starch was also observed in the hammer-milled flours, whereas it is minimal in the cryogenically milled flours. Starch digestibility of uncooked rice flours is negatively and positively correlated with flour particle size and degree of damaged starch granules, respectively. However, the molecular structures of starch in the rice flours did not show significant correlations with the starch digestibility of uncooked flours. Moreover, there were no significant correlations between the starch structures and the starch digestibility of cooked rice flours and between the starch digestibilities of uncooked and cooked rice flours, suggesting that starch structures do not affect the starch digestibility of cooked rice flours, even though the rice flours with larger particle sizes showed higher pasting viscosities when they are heated in an RVA. In the uncooked flours, diffusion rate is a factor determining the starch digestibility, which is not the case when the starch molecules have dispersed after cooking. This information is important in designing rice products with better nutritional values.

Effect of processing on the antioxidant activity of genotypes of chickpea (*Cicer arietinum* L.) desi

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Chickpea is the third most important legume worldwide. Several investigations place this legume as a food with nutraceutical properties; however, few studies exist about the effect of processing on the antioxidant activity. The objective of this study was to evaluate the effect of processing on the antioxidant activity of desi chickpea genotypes, from the World Bank Germplasm, grown in Sinaloa, Mexico. Three desi chickpea genotypes (red 14872, green 5613, black 4418) were studied. Blanco Sinaloa 92 (BS92) variety type kabulli of commercial importance in Mexico was used as reference. The grains were subjected to two processes: extrusion (1): single-screw extruder (extrusion temperature 151°C, screw velocity: 190 rpm) and cooking in boiling water. Cooking time determination was carried out using a Mattson bean cooker (red = 118 min, green = 115 min, black = 146 min, BS92 = 147 min) The antioxidant activity was evaluated in methanol extract of raw materials and processed using the methodology radical absorbance capacity oxygen (ORAC) (2). The antioxidant activity of desi chickpea genotypes ranged from 605 to 1062 µmol Trolox equivalents (TE)/100 g (dw); the lowest ($p \leq 0.05$) and higher ($p \leq 0.05$) antioxidant activity corresponded to the green genotypes (5613) and red (14872), respectively. The USDA has reported antioxidant activity chickpea genotypes of 847 µmol TE/100 g (dw). Some researchers have reported desi chickpea genotypes with antioxidant activity of 858–1140 µmol TE/100 g (dw). The extrusion and cooking caused decreases ($p \leq 0.05$) in antioxidant activity of green and red genotypes of 15–34 and 39–52%, respectively. The extrusion and cooking processes caused a decrease of 22 and 58% in antioxidant activity of BS92, respectively. Further studies are required to optimize processes for the food industry using as response variables nutraceutical properties.

Antimutagenic activity of desi chickpea (*Cicer arietinum* L.) cultivars grown in northwest of México

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Chickpea is one of the principal legumes in the perspective of global industrialization ever increasing demand and scientific awareness regarding the nutritional and nutraceutical properties of food. Antimutagenic potencial of crops like chickpea is of great importance in their development and commercialization. The objective of this work was to evaluate the antimutagenic activity of pigmented desi chickpeas from the World Bank of Germoplasm. Nine desi chickpeas were studied: four browns (ICC-3512, ICC-14872, ICC-13124, ICC-5383), three blacks (ICC-4418, ICC-3761, ICC-6306), one green (ICC-5613), and one cream (ICC-3,421). Kabulli variety (Blanco Sinaloa 92 – BS92) of commercial importance in Mexico was used as reference. All materials were grown at the same location at northwest of México. Antimutagenic activity of methanolic extracts (0–500 µg/tube) was evaluated using the *Salmonella* microsuspension assay (YG1024 strain); 1-NP was used as the mutagen (50 and 100 ng/tube). The methanolic extracts of whole grain chickpea flours were neither toxic nor mutagenic and the percentage of inhibition on 1-NP mutagenicity was in a range of 34 and 69% at doses of 500 ng/tube. Seven desi chicpeas (four browns: ICC-5383, ICC-3512, ICC-13124, ICC-14 872; two blacks: ICC-6306, ICC-376; and one cream: ICC-3421) showed high antimutagenic activity (range of inhibition of mutagenicity = 60–80%). The materials could be used for producing functional foods with high nutritional and nutraceutical properties; furthermore, they could be utilized in breeding programs to improve this important legume.

Investigation of molecular reaction patterns among amylose and amylopectin branch chains within a model reaction system

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An understanding of starch reactivity at the molecular level is needed to better control modification conditions to maximize functionality of the modified products. Using a simplified "model" reaction system, this work investigated specific proportions of normal wheat starch amylose (AM) and amylopectin (AP) branch chains derivatized (while in the granular state) over the course of a 24-h reaction period (0, 0.5, 4, 12, or 24 h). The "model" reaction system employed a fluorescent probe (5-(4,6-dichlorotriazinyl)aminofluorescein) as a reagent to allow straightforward determination of molecular patterns of reaction (based on fluorescent label) via size-exclusion chromatography (SEC). Starch derivatives were first debranched with isoamylase and fractionated into three populations (Unbound, Bound1, and Bound2) based on charge density (derivatized groups imparted a negative charge to starch chains) using anion-exchange chromatography. For Unbound, Bound1, and Bound2 populations of each reaction time, relative proportions of starch chains (AM and AP long-, intermediate-, and short-branch chains) and their extent of derivatization were assessed by SEC equipped with refractive index (RI) and fluorescence (FL) detection. Almost all FL of AP branch chains was recovered in the two bound fractions, comprising approximately 11–12% of the total starch chains (24-h reaction). In contrast, 32–44% of the FL for AM was associated with the unbound fraction, possibly due to a diffuse reaction pattern on these chains. In the two bound fractions, AP long chains accounted for the greatest extent of FL, though the extent of reaction on AP intermediate- and short-branch chains increased in the latter stages of reaction, suggesting progression of reaction into granule crystalline regions. In short, granule architecture does impact molecular reaction patterns on starch chains.

Glass transition and retrogradation of conventionally and UHP-assisted cross-linked corn starches with $POCl_3$

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Glass transition and retrogradation of conventionally and UHP assisted cross-linked corn starches with $POCl_3$ were investigated using differential scanning calorimetry (DSC) and X-ray diffractometer (XRD). Corn starches were cross-linked with phosphorous oxychloride ($POCl_3$) in an aqueous alkaline condition containing sodium hydroxide under two different conditions at 45°C for 2 h under atmospheric pressure or at 25°C for 15 min under 400 MPa of ultra high pressure (UHP). Gelatinized starches were stored at 4°C for 2 weeks of period. During storage, glass transition temperature, ice melting enthalpy, and relative crystallinity were measured and retrogradation rate was estimated using Avrami equation. The glass transition temperatures of both conventionally and UHP-assisted cross-linked corn starches were higher than native corn starches. Avrami exponents (n) from glass transition temperature, ice melting enthalpy and relative crystallinity of all samples were close to 1.0, indicating that recrystallization at a single temperature have an instantaneous nucleation followed by rod-like growth of crystals. Whereas, retrogradation rate for UHP-assisted cross-linked corn starch was higher than native and conventionally cross-linked corn starches. It is clear that glass transition temperature, ice melting enthalpy and relative crystallinity are different physicochemical properties of starch, but those characteristics are closely related with starch retrogradation phenomenon. In other words, specific trend was observed for the retrogradation rate of the cross-linked corn starch using ultra high pressure (UHP). But, it is not observed clear relationship among the recrystallization, Tg, and ice melting enthalpy.

Using lateral flow devices for semi-quantitative analysis of GMOs

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Lateral flow devices are often used for rapid, qualitative testing for the presence of GMOs in grains. These rapid tests are widely used in the field for screening purposes. The purpose of this study was to adapt a series of these tests for semiquantitative use by incorporating a strip reader to analyze the results rather than relying on a visual reading, as is common practice in the qualitative methods. These tests are lateral-flow devices based upon sandwich ELISA principles. Samples are extracted with buffer, and the extracts are allowed to travel up the device. After 5 minutes incubation, the presence or absence of a visual marker on the device indicates the presence or absence of a selected GMO trait in the sample. The marker varies in intensity with varied concentrations of analyte in the sample. This variation in intensity of the visual marker, in conjunction with a strip reader measuring the reflectance or optical density of the line, may be used to semiquantitatively measure the trait in a sample. Validation studies on this technology were performed for CP4 EPSPS in soy and PAT, Bt-Cry1Ab, and Bt-Cry1F in corn. These methods were found to be semiquantitative over a range of 0.1–4% CP4 EPSPS in soy, 0.9–4% PAT in corn, and 0.5–4% Bt-Cry1Ab or Bt-Cry1F in corn modified seed in unmodified seed when the test was run from 21 to 35°C. Based on the results of fortified samples, GMO content can be semiquantitatively determined within set rages (for example, 0.1–0.5%, 0.5–1.0%, 1.0–4.0%, or >4%). The limit of detection was found to be 0.1% CP4 EPSPS in soy, 0.9% PAT in corn, and 0.5% Bt-Cry1Ab and Bt-Cry1F in corn. The use of digital imaging software with a reader allows for objective semiquantitative methods with results independent of the individual user's visual readings.

Effect of granule surface/channel protein removal on granular and molecular reactivity of corn and wheat starches under nonswelling conditions

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Corn and wheat starch granules possess channels (penetrating their granule interiors) which may impact starch reactivity by providing reagent access to the granule interior. Further, channels within granules were shown to be lined (corn starch) and/or plugged (wheat starch) with protein. This research investigated the effect of removal of granule surface proteins (those located at external granule/channel surfaces) on granular and molecular reactivity under nonswelling (nonhydrated) conditions. Normal and waxy corn and wheat starch granules were treated as follows: 1) no treatment, 2) treatment with Tris-HCl buffer, 3) treatment with Proteinase K + Tris-HCl buffer, or 4) treatment with a protease cocktail (type XIV) + Tris-HCl buffer. Confocal laser scanning microscopy (CLSM) was used to monitor protein removal (using a protein-specific fluorescent probe, 3-(4-carboxybenzoyl)quinoline-2-carboxaldehyde) and granule porosity (via methanolic Merbromin solution). Reaction patterns within granules were tracked via CLSM following derivatization with a fluorescent probe (5-(4,6-dichlorotriazinyl)amino-fluorescein), while molecular reactivity of amylose and amylopectin branch chains was quantified by size-exclusion chromatography (via fluorescence and refractive index detectors). Both buffer and protease treatments removed granule surface/channel proteins from granules and enhanced internal porosity and reactivity of granules (exception: normal wheat starch was minimally impacted). For molecular reactivity, both amylose (normal starches) and amylopectin long-, medium- (waxy starch only), and short- (waxy starch only) branch chains were more densely derivatized following protease (and sometimes buffer) treatment. Thus, removal of starch granule surface/channel proteins generally enhanced access of starch chains to reagent under nonswelling conditions.

Effect of maturity and frozen storage on corn wet-milling yields and starch pasting properties

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Harvesting corn at or before physiological maturity increases the ruminant digestibility of the corn stover and decreases the lignin in the corn stover (Pordesimo et al 2005). However, early harvest increases the cost of corn drying and increase potential damage to the corn kernel. Using frozen storage to preserve the high- moisture corn instead of drying has advantages of less energy consumption and lower storage cost (Eckhoff 2010). The objective of this study was to evaluate the effect of maturity and frozen storage on corn wet-milling yields and the pasting properties of the resulting starch. The corn hybrid harvested at three maturity stages (prematurity, maturity, and postmaturity) were stored frozen for 3 days or 5 months, followed by wet-milling. The pasting properties of the resulting starch were evaluated using a rapid visco analyzer. The yields of starch and germ increased by 1.2 and 1.9 percentage points from prematurity to postmaturity stages, respectively. And the yields of steep water solids, total fiber, and gluten decreased by 2.1, 0.7, and 0.6 percentage points from prematurity to postmaturity stages, respectively. The frozen corn had lower coarse fiber yields but higher fine fiber yields. The starch pasting properties showed that peak and breakdown viscosities decreased by 8% (3824 ± 36 cp vs 3520 ± 38 cp) and 13% (2336 ± 47 cp vs 2029 ± 60 cp) from prematurity to postmaturity stages, while peak time increased by 5% (6.32 ± 0.06 min vs 6.62 ± 0.07 min). The setback and final viscosities of starch from long-term frozen storage (5 months) were 14% (1574 ± 65 cp vs 1828 ± 79 cp) and 8% (3063 ± 27 cp vs 3317 ± 101 cp) lower than that from control (unfrozen corn), respectively.

Effect of corn harvest moisture on dry grind fermentation characteristics and DDGS composition

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The effects of corn harvest moisture on fermentation characteristics and dried distillers grains with soluble (DDGS) was evaluated using a conventional dry grind corn process. Corn was harvested at seven different harvest dates from Aug. 21st to Nov. 23rd, 2009, with harvest moistures from 73 to 21%. The ethanol concentration from corn with harvest moisture of 54% (110 days after corn planting, kernel dent stage) was 3–13% higher than that with any other harvest moisture. With the corn harvest moisture drying down from 73 to 21%, the residual starch content in DDGS increased from 8 to 15%, while the protein content in DDGS decreased from 29 to 25%. No significant differences ($p < 0.05$) of fiber content in DDGS were observed with different harvest moistures.

Resistant starch content and estimated glycemic index of starches from different varieties and modification

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Resistant starch is defined as a small fraction of starch which is resistant to hydrolysis by exhaustive a-amylase and pullulanase in vitro. Recently, resistant starch is recognized as a significant contributor to gastrointestinal health. The objectives of this study were to compare the resistant starch content and estimated glycemic index of starch from different varieties and modification. Four high-amylose starches from local crops were isolated, including mung bean, water caltrop, and yam (TN1 & TN2) starches, as well as one commercial corn starch (Hylon VII) was purchased for this experiment. Rice starch was used as control sample in this experiment. Two modified methods including osmotic pressure treatment (OPT) and simultaneous heat-moisture and phosphorylation treatments (HMPT) were involved in this study.

The measurement of resistant starch is based on the enzyme hydrolysis on the gastrointestinal digestion of starch. The digestion kinetics and estimated glycemic index (EGI) of the modified starch were calculated. The results indicated that the starches from four local crops exhibited a varied amylose content ranging in 34–45% as compared to the commercial Hylon VII corn starch with 71.6% amylose content. The results also evidenced the higher amylose content had an obviously impact on the resistant starch content (6.02–14.5%). After OPT and HMPT treatment, the resistant starch content significantly increased with the progress of treated time in the ranges of 0–180 min. The estimated glycemic index of starches decreased with the increases of treated time of modification from the ranges of 76.85–78.79 to 48.85–56.26. These findings suggest that both OPT and HMPT methods increased resistant starch content and decrease EGI which can provide the availability for individuals suffering from impaired glucose tolerance.

Processing performance capabilities of an experimental parboiling unit

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Cereal Foods World 56:A46

Parboiling is a process that strengthens rice kernels by fusing fissures in the endosperm, thus improving head rice yields. The University of Arkansas Rice Processing Program has recently developed a pilot-scale experimental parboiling unit (EPU). This study measured the EPU parboiling performance and identified potential sources of variability from run to run, and among samples within a run. Two experimental trials were performed. The first observed pressure and temperature control in the EPU during a parboiling process. The second trial evaluated the effects of sample size and sample location within the EPU on parboiling performance. Long-grain, pureline cultivar Wells was used in each trial and quality was assessed in terms of milled rice yield, head rice yield, and L* (whiteness). The first trial demonstrated that the EPU maintained precise control of temperature and pressure levels. The second trial showed that sample size did not affect milled rice yields, but did significantly affect head rice yields. Sample position within the EPU tank resulted in no significant differences in head rice or milled rice yields, but color values were darker ($\alpha = 0.05$) near the top of the EPU, presumably due to closer proximity to the steam inlet nozzle.

Textural changes of gluten-free pastas during cooking and cooking quality evaluation

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Pasta products made from composite flours containing neither durum nor soft wheat are highly demanded by people suffering from celiac disease. The textural quality of cooked pasta is one of the main criteria that determine consumer acceptance. The aim of this study was to evaluate textural changes of four gluten-free (GF) pastas made from either rice (100%) or rice and amaranth (75:25%) under different heat treatments and semolina pasta (control) during cooking and compare their cooking quality. The firmness and cooking quality evaluations were undertaken according to the AACC methods. Firmness changes of pasta during cooking were measured with a texture analyzer. The cooking quality was evaluated by weight increase, solid loss into the cooking water, and texture analysis. Pasta firmness decreased with cooking time and the rate of reduction varied with the pasta sample. The optimum cooking times for GF pastas were 1–3 min higher than that of the control pasta. The percentage of weight increase during cooking was higher for the control pasta (102.7) than for pastas 1, 2, and 3 (around 70%), and the lower percentage was for pasta 4 (57.4). Solid loss (%) among the GF pastas were comparable ($p < 0.05$), but at least 5.6 times that of control pasta. All GF pastas optimally cooked showed firmness values similar to those of control, but pasta 3 presented the lower firmness value compared with the other GF pastas. The GF pastas evaluated in this study were of lower quality than control, but GF pastas could be rather acceptable if compared with other commercial GF pastas.

Difference in gluten aggregation kinetics in flours with similar protein content

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Cereal Foods World 56:A46

Lactic solvent retention capacity (SRC) is an established technique to predict the functionality of flours based on the glutenin characteristics, while the gluten peak tester (GPT) is a new shear-based technique to measure gluten quality. The use of small sample quantities and short analysis times are the key features that make GPT valuable to the cereal industry. Whole meals and refined flours of 14 soft wheat varieties were screened to select four varieties with similar protein contents but different lactic-SRC% and GPT torque and peak maximum time (PMT). The variety SWW-270 with 8.6% protein showed PMT of 4.55 min and lactic-SRC of 118.4%. However, SRW-852 with similar protein content of 8.9% exhibited lower PMT (1.5 min) and lactic-SRC (95.5%). Osborne fractionation analysis revealed half the gliadin content for the SRW-852 as compared to the SWW-270 and showing almost three times lower PMT. The other two varieties SRW-747 and SRW-170 (9.1 and 9.0% protein, respectively) and similar gliadin contents also resulted in similar PMTs of 1.55 and 1.7 min, respectively. SRW-747 exhibited higher glutenin content and resulted in higher torque (37.4 BE) as compared to SRW-170 (29.1 BE), which had lower glutenin content. SDS-PAGE of protein fractions also revealed clear discrimination between the varieties. These findings indicate GPT is a sensitive technique capable of discriminating the functionality of flours with similar protein contents based on gluten quality. The quantitative distribution of protein fractions, gliadin and glutenin, in flour is the determining factor which governs the gluten aggregation and is reflected by the PMT and torque. Kinetics of gluten aggregation in the same context would be discussed further.

Gelatinization and retrogradation of acha (*Digitaria exilis*), iburu (*D. iburua*), and tamba (*Eleusine coracana*) starches

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The gelatinization and retrogradation properties of starches from three African cereal grains, acha (*Digitaria exilis*), iburu (*D. iburua*), and tamba (*Eleusine coracana*) starches were examined by glucoamylase digestion (DG-g), iodine titration (DG-i), and differential scanning calorimetry (DSC). Corn starch was evaluated for comparison. Values (%) obtained for DG-g and DG-i were acha (94, 93), iburu (97, 95), tamba (95, 93), and corn (90, 89), respectively. DG-g and DG-i data for retrogradation during storage of gelatinized starch at 0°C showed similar tendency typical of cereal starch. Values for gelatinization temperature (To °C) and enthalpy (Δ H J/g) were acha (64.3, 15.30), iburu (66.1, 15.15), tamba (66.2, 16.50), and corn (65.3, 15.53), respectively. DSC revealed that the three starches had similar To and Δ H values for transition of the starch crystallites with the corn starch. Tamba starch had the highest Δ H value of 16.50 J/g for peak 1 of DSC thermogram, suggesting more order in the crystalline structure than the other starches. The endothermic transitions of retrograded starches had lower To and Δ H values compared to the same parameters for gelatinization. These results complement the research and development on African cereal grains currently experiencing renewed interest not just in Africa but the rest of the world; hence the EU's program (2006–2009) on fonio (acha and iburu).

Conformation and aggregation of cereal arabinoxylans in water

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The solution properties of arabinoxylans, including their conformation and aggregation behavior, have significant bearing on their functionality in food systems and in the body. Chemical structure of arabinoxylans affects their solution behavior. Thus, arabinoxylans from various cereal sources, which have different structures, show different properties in solution. Studies on wheat arabinoxylans have suggested a semiflexible rod-like conformation in water, with varying estimates of persistence length and flexibility. Much less attention has been given to the aggregation behavior of these polymers and differences in these properties based on cereal source and structure. In the present study, the conformation and aggregation behavior of alkali extractable arabinoxylans from corn and wheat bran were investigated by SEC-MALLS and dynamic light scattering. The mass (M_w) dependence of radius of gyration (R_g) could be scaled as $M_w \sim R_g^{d_f}$. The fractal dimension (d_f) is a measure of compactness, with higher values indicating more compact structures. The d_f of corn arabinoxylans was 1.47, while that of wheat arabinoxylans was 1.42. The structure factor $\rho = R_g/R_h$ was 1.70 and 2.23 for corn and wheat arabinoxylans, respectively, indicating a stiffer conformation for wheat arabinoxylans. This may be attributed to higher branching, as evidenced by a higher arabinose-to-xylose ratio. Based on the "wormlike chain" model without considering intermolecular interaction, the persistence length (L_p) of corn arabinoxylans was found to be lower than that of wheat arabinoxylans. Even in very dilute solutions, both corn and wheat bran arabinoxylans formed compact aggregates with a fractal dimension of about 3.0. The concentration dependence of aggregation of wheat arabinoxylans was much stronger than that of corn arabinoxylans. The study clearly shows that the structure of arabinoxylans affects their solution behavior and functionality.

C-chain distribution in barley amylopectin clusters

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The internal structure of the major starch component amylopectin has been shown to differ between crops. The differences were traced down to the building block level of clusters in potato, cassava, amaranth, and barley. However, the studies did not distinguish the C-chain, which carries the reducing end, from the B-chains. In this study, fluorescence labeling was used to detect the C-chain in clusters from barley of four different genotypes. Two of the barleys possessed the *amo1* mutation, which was shown to affect the internal structure of the amylopectin. These samples were compared with two barleys of waxy type. 2-Aminopyridine was used for fluorescence labeling. This compound is coupled to the reducing end and subsequent debranching and fractionation by HPSEC reveals the C-chain distribution. In order to study differences in the internal structure, all samples were transformed to φ, β-limit dextrins by the enzymes phosphorylase and β-amylase. Calibration of the HPSEC system used for analysis was done with size-fractionated linear chains of potato amylopectin with known degree of polymerization. These fractions were run both labeled and nonlabeled, and the label did not influence the elution time, which means it did not change the hydrodynamic volume. Our results showed that groups of clusters (domain structures) isolated from the amylopectins generally possessed longer C-chains than single clusters, suggesting their role in interconnection of the clusters.

Statistical analysis and kinetics of folic acid fortification in rice during the parboiling process

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Recent studies have shown that nutritional content of rice may be further enhanced by the addition of appropriate nutrients during the parboiling process. Folic acid was chosen as the fortificant candidate due to its proven benefits nutritionally. The objective of this work was to develop a predictive model to describe the fortification process and to optimise the parboiling parameters so as to maximize the efficiency of folic acid fortification using the traditional rice-parboiling setup. Based on ANOVA results, both soaking time (ST) and milling duration (MD) exhibited statistically significant effects, at 95% confidence level, on folic acid retention in parboiled rice. The predictive model for folic acid concentration in the parboiled rice is given as: Y = a0 + a1*XST + a2*XMD. The sign of the coefficients (at the respective doped folic acid concentration) of soaking time was positive whereas those of milling time was negative, suggesting that residual folic acid concentration in rice was enhanced by prolonged soaking time but reduced by the lengthened milling time. Further analysis based on the milling kinetics at the four fortification levels successively revealed the optimal soaking time for folic acid fortification as 2 h. The folate retention rate data implicated a first-order kinetics in fortificant concentration. Similar analysis was done on the fortificant concentration kinetics which showed that the optimal milling time for fortified parboiled rice was 70 mins. Transient pH measurements also permitted evaluation of the rice hydrolysis kinetics. Based on the pilot study, the optimum folic acid concentration may be estimated from constrained optimization using the predictive model as the objective function.

Expression analysis of selected raffinose family oligosaccharide biosynthetic genes in developing lentil (*Lens culinaris* Medik.) seeds

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Cereal Foods World 56:A47

Lentil (*Lens culinaris* Medik.) is economically important to Canada since it is the largest world exporter of this commodity. High protein content with the presence of essential amino acids makes it a good substitute for meat products. However, presence of high concentration of raffinose family oligosaccharides (RFO) in seeds causes stomach discomfort and flatulence. This contributes to decreased consumption of lentils in the western world. RFOs are galactosyl derivatives of sucrose which include raffinose, stachyose and verbascose. The RFO biosynthetic enzymes galactinol synthase (GAS), raffinose synthase (RFS), stachyose synthase (STS), and verbascose synthase (VBS) synthesize galactinol, raffinose, stachyose, and verbascose, respectively. The objective of this study is to assess the expression profiles of these genes during seed development. Partial sequences of *GAS*, *RFS*, and *STS* were obtained by amplification of genomic DNA using degenerate primers. To determine the temporal expression of the respective genes, seeds at various days after flowering (DAF) were collected from 12 to 32 DAF at two-day intervals. RNA was extracted for RNA gel blot analyses. The amplified lentil partial sequences were used as probes. Maximum expression of these three genes was obtained from 18 to 26 DAF. A cDNA library will be constructed from selected developmental stages showing high expression for all three genes to isolate and characterize full length cDNA clones. Accumulation of individual RFO during seed development, expression analysis of the biosynthetic genes and changes in enzyme activities will facilitate identification of the key rate limiting enzyme in the pathway.

The effect of kernel maturity on the thermal properties of sorghum starch

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Starch is a widely used component in both food and industrial applications. Critical components in the functionality of starch in a food or industrial system are its thermal properties. The objective of this study was to determine if the thermal properties of starch change as sorghum develops. Two sorghum hybrids, a red pericarp/purple plant and a white pericarp/tan plant (food grade), were grown in irrigated plots at Kansas State University in 2008 and 2009; upon reaching the midbloom stage in maturity approximately 200 heads were tagged. Samples were regularly collected beginning ten days after anthesis (DAA) until harvest. The samples were then decorticated, the starch isolated and the thermal properties measured using differential scanning calorimetry (DSC). The onset gelatinization temperature means of both hybrids ranged from 61.4 to 67.0°C. The change in enthalpy (ΔH) ranged from 7.6 to 15.8 J/g in 49 and 14 DAA, respectively. Statistical separation was also observed between the two sorghum hybrids for gelatinization temperatures and ΔH. The samples were then retrograded for 7 days at 4°C. The onset temperature of the retrograded samples ranged from 41.8 to 45.7°C. Enthalpy change ranged from 2.1 to 4.2 J/g in 49 and 14 DAA, respectively. These thermal variations suggest structural changes occurring throughout kernel development as well as hybrid differences. The thermal properties of the sorghum starch could allow for utilization of the starch in differing applications. These developmental variations will provide more insight into how sorghum starch is assembled in maturing caryopsis.

Effects of variable rate fermenting fibers on luminal and mucosa-associated microbiota in different segments of the large intestine

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Little is known about the bacteria intimately associated with intestinal lining, particularly in the area of substrate specificity. C57BL6/J mice were used to investigate the effect of differently fermentable fibers on the luminal and mucosa-associated microbiota in different parts of the large intestine. Forty mice aged 6 weeks were acclimatized for a week and then fed with four test diets (n = 10) for a period of 2 weeks. Test diets contained fermentable fibers (10% w/w), namely slow-fermenting starch-entrapped microspheres, fructo-oligosaccharides (FOS), resistant starch type II (RS2), and a nonfermentable fiber, lignin, as a control. Stool samples were collected at days 0, 3, 7, 11, and 14. At day 14, intestinal contents and tissues were collected upon dissection. FOS caused cecal hypertrophy and also increased content weight. To assess dietary fermentation, stool and intestinal contents from cecum, proximal, and distal colon were analyzed for short-chain fatty acids (SCFA) using GC. In all the treatments, SCFA increased from day 0 to 14 in the stool and decreased with the site of fermentation from cecum toward the distal colon. Total SCFA were highest during RS2 fermentation that also showed extended fermentation toward the distal colon. Butyrate was slightly higher during the fermentation of starch-entrapped microspheres in the proximal colon and to some extent in the distal colon. Molar percent butyrate in the distal colon was twice as high as RS2 in this group. DNA was extracted from cecal and distal colon tissues and stool at day 0 and 14 to perform length heterogeneity PCR (LH-PCR). Principal coordinates analysis indicated clustering of specific microbiota in tissues from cecum, distal colon, and 14 d stool, indicating an alteration in the mucosa-associated and luminal microbiota in response to fermentable dietary fibers, which was different from the control.

Correlation between phenolic compounds and antioxidant activity in brown rice before and after parboiling

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Phenolic compounds, from an analytical point of view, can be classified into free, conjugated (soluble), and bound (insoluble) substances. The objective of

the study was to investigate the effect of parboiling brown rice on the phenolic contents and their correlation with antioxidant capacity. Twenty-seven nonpigmented brown rice samples were grown in 2008 by different producers and provided by the Institute of Agronomy (Epagri - Itajaí Experiment Station) in Santa Catarina, Brazil, before and after parboiling. Soluble phenolic compounds were extracted with EtOH 80% and bound phenolics were released by NaOH, then extracted with ethyl acetate and analyzed for their phenolic contents. Antioxidant activity was measured by the oxygen radical absorbance capacity (ORAC) and the 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging methods. The ratio between soluble and insoluble phenolics in nonparboiled brown rice was 55:45. Parboiling decreased in about 59% the contents of soluble phenolic compounds which were the most affected by the process, while the insoluble phenolic fraction showed in average a slight increase after rice parboiling, probably due to polymerization and complexation reactions. Correlation coefficients between levels of soluble phenolics and antioxidant activity were high and independent on the method used. The coefficients were $r^2 = 0.825$ ($p < 0.01$) for ORAC and $r^2 = 0.855$ ($p < 0.01$) for DPPH. For bound phenolics, coefficients were weak ($r^2 = 0.547$ [$p < 0.01$] and $r^2 = 0.366$ [$p < 0.01$] for DPPH and ORAC, respectively). Although the absolute antioxidant activity, measured by the two methods showed different order of magnitude, correlation coefficients were similar. In conclusion, antioxidant activity is due mainly to soluble phenolics in nonparboiled rice, while in parboiled rice soluble and insoluble fractions contribute almost equally with antioxidant capacity.

Effects of enzymatic chain elongation on the characteristics of rice starches with varied amylose contents

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Neisseria polysaccharea amylosucrase (NpAS) achieves sequential synthesis of linear α-(1,4)-glucan by transferring glucose units from sucrose. In the presence of gelatinized starch as an acceptor, NpAS translocates glucose units from sucrose onto nonreducing ends of starch molecules exclusively. This study investigated the impact of amylose contents on molecular structure and digestibility of rice starch modified with NpAS. Selected four rice starches possessed amylose (AM) contents of 3.6, 11.4, 18.9, and 27.3% (dry starch weight basis or s.b.) by a colorimetric method. Gelatinized starches were treated with NpAS at 37°C for 24 h, washed, and freeze-dried. Native and NpAS-treated starches were debranched with isoamylase, after which amylopectin (AP) branch-chain distribution profiles were obtained using intermediate-pressure size exclusion chromatography. Chain-elongated structure of NpAS-treated gelatinized rice starches resulted in the greater resistance toward digestive enzymes. Resistant starch (RS) content in gelatinized starch was determined through digestion (for 16 h) with a mixture of pancreatin and amyloglucosidase. The RS contents of NpAS-treated starches ranged from 17.6 to 47.9% (s.b.), and the highest RS were observed for waxy starch (3.6% AM). For AP branch-chain distribution, regardless of AM contents, the highest DP (degree of polymerization) peaks in the profiles was shifted upward from 9 to 18 (27.3% AM) to 20 (3.6% AM), by NpAS treatment, and the profiles were narrower for NpAS-treated (relative to native) starches. These findings suggested that NpAS actions appeared to occur predominantly at A and B1 branch-chains exposed to the outer environment of APs and/or AP clusters. Overall results likely imply that absence of amylose further facilitates elongation of AP branch-chains by NpAS.

Contamination issues in continuous fermentation for ethanol production

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Cereal Foods World 56:A48

Continuous fermentation processes are employed by corn wet-milling plants all over the world to convert starch to ethanol. Contaminations by bacterial microorganisms like *Lactobacillus* and wild yeasts like *Brettanomyces* are common and result in lower ethanol yields. Contaminants compete with inoculated yeast for nutrients and produce inhibitory end products, leading to stuck fermentations and expensive down times required for cleaning unit operations. Low ethanol yields and poor yeast viabilities in continuous fermentations for ethanol production were investigated. For hydrolysate preparation, starch liquefaction and saccharification steps at a commercial ethanol facility were reproduced in laboratory. Fermentations with hydrolysates prepared in laboratory were compared with plant hydrolysate for final ethanol concentrations and total yeast counts. Fermentation controls were prepared using hydrolysates (plant and laboratory), but were not inoculated with yeast. Hydrolysates prepared in laboratory resulted in higher final ethanol concentrations (15.8% v/v) than plant hydrolysate (13.4% v/v). Controls resulted in ethanol production from both laboratory (12.2% v/v) and plant hydrolysates (13.7% v/v), indicating the presence of a contaminating microorganism. Upon further experimentation, involving yeast colony counts on cycloheximide and virginiamycin plates, we confirmed the presence of a contaminant. DNA sequencing and fingerprinting studies conducted also were indicative of dissimilar communities in samples obtained from fermenters, coolers, saccharification tanks and thin stillage.

Interactional effects of beta-glucan, starch, and protein in cooked oat flour on viscosity and in vitro bile acid binding

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Many health benefits from the consumption of oat-based foods are attributed to the soluble dietary fiber, beta-glucan. Other main components, starch and protein, may also affect the physical properties and physiological effects of oat-based foods. Evaluated in this study were the contributions of beta-glucan, starch, protein, and their interactions to the viscosity of oat slurries, measured by using a rapid visco analyzer (RVA), and to in vitro bile acid binding. Oat flour from the experimental oat line 'N979' (7.8% beta-glucan) was mixed with water (1:8 ratio) and cooked for 25 min. The oat slurries were treated with alpha-amylase, lichenase, and proteinase to remove starch, beta-glucan, and protein, respectively. Cooking of oat flour in water did not significantly reduce the peak and final viscosities ($p > 0.05$). The peak and final viscosities after enzymatic hydrolysis of starch, beta-glucan, and protein decreased ($p < 0.05$). The oat slurry treated with lichenase had the lowest viscosity values among enzyme-treated oat slurries. The decrease of viscosity after enzymatic hydrolysis of beta-glucan was related to beta-glucan concentration and molecular weight. The raw oat flour bound the greatest amount of bile acid: cooking decreased the bile acid binding. Assuming the positive control, cholestyramine, bound bile acid at 100%, the relative bile acid binding of raw oat flour, non-enzyme-treated oat flour, and amylase-, lichenase-, and proteinase-treated oat flours were 15.1, 13.8, 13.1, 12.3, and 12.7%, respectively. These findings might be explained by the contribution of beta-glucan and its interactions with starch and protein to in vitro bile acid binding. These results will help to develop oat-based food products with desirable health benefits.

Preparation of aqueous ceramide nano-dispersions by complex formation with dextrin

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Ceramide nano-dispersions could be prepared by complex formation with a dextrin prepared from amylomaize starch. Complex formation between dextrin and ceramide was performed either in a two-phase system of separated solvents or in an aqueous batch system, followed by an ambient storage. The dextrin-ceramide complexes yielded V6I-type crystals with two reflections at 13.03 and 20.35° (2θ) under an X-ray diffractogram. Storage conditions after complex formation including temperature and time were important in determining interactions between dextrin and ceramide. By storing at 25°C for 1 day, for example, interactions between dextrin and ceramide produced the crystalline structures of increased perfectness. Physical treatment after the complex formation such as ultrasonication or homogenization resulted in smaller size (less than 100 nm) and higher zeta potential (–34 mV) of the complex particles.

Low-digestible rice starch: Preparation by using hydrothermal and amylosucrase treatments and structural characterization

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Amylosucrase (AS) from *Neisseria polysaccharea* (E.C. 2.4.1.4) uses sucrose to synthesize alpha-(1→4)-glucan, releasing fructose. This enzyme elongates glucose units at nonreducing ends of external chains on the acceptors. AS and hydrothermal treatments were employed to increase the formation of slowly digestible starch (SDS) and resistant starch (RS) in normal and waxy rice starches. The structural and physiological properties of these starches were investigated. The optimal conditions established using response surface methodology, which had the highest SDS and RS fractions, were 18,700 units of AS per 2% starch with 100 mM sucrose and reaction time of 13 h 40 min. The AS-treated starches were adjusted to 25, 30, 35, and 40% moisture contents, and were heated at 100°C for 40 min. After the AS treatment, SDS and RS contents of normal rice increased from 10.3 to 14.1% and from 12.0 to 42.6%, respectively. The SDS and RS contents of waxy rice increased by 35.2

and 22.4%, respectively, compared with the AS control. After dual modification, the sum of SDS and RS contents in starches considerably increased as moisture level increased. The proportion of short chains (DP 6–12) decreased, whereas long side chains (≥DP 25) increased. The X-ray diffraction pattern of normal and waxy rice starches showed a typical A-type. The AS-treated normal rice starch changed from A-type to B-type pattern. However, the AS-treated waxy rice starch did not change the crystalline pattern. The gelatinization temperatures of dual-modified starches increased. RVA measurement showed that dual-modified starches had lower paste viscosity, higher pasting temperature, and more stable viscosity with no breakdown and setback. In sum, the AS and hydrothermal treatments led to increases in SDS and RS contents and altered the physicochemical properties of normal and waxy rice starches.

Retrogradation kinetics of conventionally and UHP-assisted cross-linked corn starch with STMP/STPP

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Retrogradation kinetics of conventionally and UHP-assisted cross-linked corn starches with STMP/STPP were compared. Corn starch was cross-linked with STMP/STPP at 45°C for 3 h under atmospheric pressure or at 25°C for 15 min under 400 MPa of ultra high pressure (UHP). Gelatinized starches were stored at 4°C for several periods. Tg' and ice melting enthalpy were measured by differential scanning calorimetry (DSC), and relative crystallinity was measured by X-ray diffractometer (XRD). In both conventionally and UHP-assisted cross-linked corn starches, ice melting enthalpy and relative crystallinity increased significantly during first 7 days of storage and leveled off thereafter, whereas, Tg' decreased until 5 days of storage and consecutively leveled off. No significant difference was observed between conventional and UHP-assisted cross-linking methods, but small difference was observed depending on measured physicochemical properties. Avrami exponents from ice melting enthalpy and relative crystallinity were closd to 1 (instantaneous nucleation followed by rod-like growth of crystal) but that of Tg' was close to 2. UHP-assisted cross-linked starch showed different retrogradation rate with conventionally cross-linked starch. Although Tg', ice melting enthalpy, and relative crystallinity are different physicochemical properties, they can be used as an indicator for starch retrogradation.

Preparation of starch granules with enhanced load-carrying capacity by citric acid treatment

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Based on their particulate and porous nature, starch granules are utilized industrially as plating, carrying, and/or encapsulating agents. The aim of this research was to investigate conditions by which corn starch granule porosity might be increased to enhance load-carrying capacity via treatment with an organic acid. Native corn starch was treated with three levels of citric acid (0.5, 1.0, or 1.5 M), three levels of temperature (40, 50, or 60°C), and five lengths of treatment (1, 2, 3, 5, or 8 h). At temperatures of 40 and 50°C, citric acid treatment induced minimal physicochemical changes. In contrast, load-carrying capacities of starch granules treated with citric acid at 60°C were significantly enhanced, with the highest water and oil absorption values (15.69 and 14.48 mL/10 g starch, respectively) obtained with 0.5 M citric acid after 2 h (compared to respective native starch values of 7.71 and 8.26/10 g starch). Total recovery of granular starch under these conditions was approximately 92%, implying that load-carrying capacity could be almost doubled (relative to native starch) without excessive loss of starch material. Scanning electron microscopy revealed changes to the external surfaces of citric acid-treated granules, while confocal microscopy demonstrated enlargement of central cavity regions within treated granules. Citric acid treatment (60°C, 0.5 M citric acid, 2 h) significantly enhanced granule hydration capacity at room temperature (from 0.97 to 1.91). The gelatinization onset temperature of citric acid-treated starch was slightly increased (72.8°C) relative to that of native starch (70.5°C), while gelatinization enthalpy decreased (from 10.6 to 7.4 J/g) after treatment. Enhanced load-carrying capacity of citric acid-treated corn starch was best explained by an enlarged central cavity region and modification of granule amorphous/crystalline regimes.

Moisture and oil uptake during processing of soy-based extruded snacks

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Oil or lipids comprise 20–40% of the weight of most savory snack products. These products also usually have high amounts of refined carbohydrates and low protein. This study focused on a novel high-protein soy-wheat-based composite snack produced using extrusion followed by a combination of soaking and frying. The primary hypothesis was that water and oil transfer during processing is impacted by the presence of soy and monoglycerides in the extruded matrix, and the overall objective was to optimize the soaking and frying conditions using experimental and simulation methods. Extruded soy-wheat pellets were produced using twin-screw extrusion with different ratios of soy flour to wheat flour (25:75, 50:50, 75:25). Monoglycerides, added at levels of 0.375 and 0.75% as a processing aid, were also evaluated for 50:50 ratio of soy to wheat flour. The water holding capacity and oil uptake in extruded pellets during soaking and frying, respectively, were experimentally determined. The soy-wheat pellets were soaked in water for about 60–75 min and air dried for about 30 min. They were subsequently fried in oil at ~150°C for 2–3 min. By evaluating the color and textural properties of the final product, optimum soaking and frying times were found to be 75 and 2 min, respectively. With the same ratio of soy to wheat flour, water-holding capacity during soaking and oil uptake during frying decreased by 7.8 and 9.3% respectively, with the increase in monoglycerides from 0.375 to 0.75%. The water holding capacity decreased by 20.7% where as the oil uptake increased by 13.8% with the increase in soy from 25 to 75%. Heat and mass transfer models were used to simulate soaking and frying operations and understand the dynamics of processing these snacks.

Investigating the gas content of dough with changes in dough strength

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The consistency of dough affects its air entrainment capacity, a critical parameter influencing crumb cell structure in the resulting loaf of bread. Despite the importance of dough gas content to bread quality, no systematic investigations of the effect of dough strength and water content on the density of dough appear to have been performed. One way of manipulating dough strength is to increase the gluten content incrementally, but previous studies where doughs were made from starch-gluten-water blends have shown that such farinograms are not "normal". The objective of this study was to examine the influence of dough strength on dough gas content by manipulating water and gluten content and determining how air entrainment in starch-gluten-water blends differed from real doughs. A wide range of dough samples differing in gluten content and water content were prepared using a farinograph. The gluten-starch mixtures resulted in farinograms similar to those of conventional doughs only at the higher gluten and water contents. A time of 9.7 +/– 0.9 min was the average development time for the higher gluten and water content formulations. This mixing time was used to create new doughs from the starch-gluten-water blends from which dough density was determined (measured using a specific gravity bottle). The contrasting finding that reduced water content and increased gluten content decreased dough density indicates that gas content of the dough is not a simple function of dough consistency. Studies such as this that help understand the mechanics of air entrainment during dough mixing will permit dough aeration to be optimized according to formulation and process method in order that good crumb structure can be created in specific baked goods.

Investigating the ruggedness of AOAC 991.43 Total Dietary Fiber (TDF) Method using an automated dietary fiber instrument

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In order to effectively develop an automated process for the analysis of TDF, it was important to investigate key variables of the method. After evaluating numerous variables separately in preliminary studies a Youden's ruggedness test was performed. This study evaluated the impact of seven variables at two levels on insoluble (IDF) and soluble (SDF) dietary fiber results. The experiment was conducted with three sample types, cereal, oat bran, and carrots. All analyses were performed by a newly developed automated dietary fiber instrument. The different variables were programmed into the instrument and automatically controlled. The variables tested included sample size, protease starting temperature, amyloglucosidase (AMG) pH, number of IDF water rinses, temperature of 95% ethanol, ethanol to water ratio, and flocculation time. None of these variables resulted in differences that were significant across all sample types but significant individual differences were found. IDF values were about 2% higher ($p < 0.01$) for oat bran and carrots when using 1.0-g sample versus 0.5-g sample size. An increased temperature of 10°C in the starting temperature of the protease incubation produced significantly ($p < 0.01$) higher (0.5%) IDF results for the cereal sample. An increase in pH from 4.5 to 5.2 for the AMG incubation significantly ($p < 0.01$) lowered the IDF values of the oat bran sample by 1.0%. Computer automation of the method parameters enabled precise control of the variables throughout the study. The pooled SD for the IDF results ranged from 0.21 to 0.39, while the SDF results varied slightly more with SD between 0.28 and 0.48.

Characterization of rheological properties of U.S. hard white wheat flours using the Mixolab, Glutomatic System, and the Kieffer dough extensibility rig

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Asia is the world's largest wheat importing region. There is a need for the United States to tap into this market to expand its export base as well as to find new end-use applications for U.S. grown wheat. One of the strategies of wheat breeding programs in the United States is to develop hard white wheat (HWW) varieties which are suitable for both domestic and foreign markets. An in-depth study of our existing lines is crucial in determining their potential for Asian products. HWW lines grown in South Dakota from 2006 to 2009 were obtained from the South Dakota State University wheat breeding program (N = 186). Rheological properties of the flours were determined using the Mixolab, the Kieffer extensibility rig fitted on the Texture Analyzer TA.XT.plus, and the Glutomatic system. Mixing profiles, dough extensibility data, and gluten content and quality parameters were evaluated. Pearson's correlations were calculated to identify the relationships between the different parameters. Principal component analysis (PCA) was used to identify the different patterns in the data and to identify the lines exhibiting similar characteristics. The study showed significant and strong correlations between Mixolab stability and Mixolab C2 (r = 0.704), dough strength (Rmax) and dough extensibility (Emax) (r = –0.635), initial slope of extensibility curve (Ei) and Rmax (r = 0.803), Ei and Emax (r = –0.81), dough development time and gluten index (GI) (r = 0.447), and Mixolab stability and GI (r = 0.442). PCA on the different rheological parameters identified lines that showed characteristics similar to our check flours: Glenn and Briggs (hard red spring wheat), Snowbird (Canadian white wheat), and Australian Standard White (Australian white wheat). This study will permit us to identify the U.S. wheat lines that are suitable for noodle production.

Quality protein maize in Africa: Is it still quality protein under small-scale farmer, low-input conditions?

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Quality protein maize (QPM) hybrids with significantly increased amounts of the essential amino acids tryptophane and lysine, with good yield and vitreous endosperm is now widely available in Africa. Maize is the primary staple food in most African countries. The aim of this study was to determine what happens to protein quality under low nitrogen (N) production conditions, as experienced by most small-scale farmers. One hundred and eight QPM hybrids and a non-QPM check were evaluated under optimal and low nitrogen conditions in two countries, Ethiopia and Zimbabwe. Protein and tryptophane content, zein composition, and starch content were measured. Protein content was significantly reduced by low N conditions, and there was also a decrease in tryptophane content, but the values were still significantly higher than for the non-QPM check under optimal conditions. The zein profiles were also significantly influenced by low N conditions, and zein profiles of QPM and non-QPM maize differed under both optimal and low-N conditions. Starch content was significantly negatively correlated with both tryptophane and protein content under both optimal and low N conditions. It was concluded that even under low N conditions the protein quality of QPM remained very good and that governments should encourage and help farmers to plant QPM to improve nutritional status in the poorest communities.

The feasibility of alkylresorcinol metabolites in urine spot samples as biomarkers of whole grain and cereal fiber intake in U.S. women

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High whole grain (WG) intake has been associated with reduced risk for developing type 2 diabetes and coronary heart disease. In most studies, food frequency questionnaires (FFQ) have been used for intake assessment. This method is subject to errors caused by consumers' difficulties in recognizing WG, few WG items included in the FFQ and limited food composition databases. A biomarker may be used as an objective measure of WG intake because it does not rely on subject's self-reports. Alkylresorcinols (AR) have been evaluated as biomarkers of WG wheat and rye intake. As AR in plasma have a rather short elimination half-life they mainly reflect short- to medium-term intake. In a recent study, the main AR metabolites, 3,5-dihydroxybenzoic acid (DHBA) and 3-(3,5-dihydroxyphenyl)-1-propanoic acid (DHPPA), were suggested to have a longer half-life than intact AR in plasma and they may therefore reflect more long-term/habitual intake. In the present study, we tested the feasibility of using AR metabolites in spot urine samples as biomarkers of habitual WG and/or cereal fiber intake in American women (n = 104). AR metabolites were analyzed with a GC-MS method developed in our laboratory. To evaluate the long-term reproducibility of AR metabolites, intraclass correlation coefficients (ICCs) were calculated in samples taken 1–3 year apart. Spearman's correlation coefficients were calculated between long-term WG and fiber intake and AR metabolites in morning spot urine samples (corrected for creatinine). Preliminary, we found that the ICC between samples taken 1–3 years apart was poor for DHBA (ICC = 0.17 [95% CI: 0.05, 0.43]) and modest for DHPPA (0.31 95% CI: [0.17, 0.51]). The correlation coefficients between mean WG or cereal fiber intake and AR metabolites were in the range 0.27–0.52, $P < 0.05$. We conclude that DHPPA in spot urine samples may serve as a medium-term biomarker of WG or cereal fiber intake in populations where the main source is wheat.

Trapping phenolic acid by lipophilization and complexation

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Abstract not available.

Effects of acid and base catalytic pretreatments on releasing fermentable sugars from rice bran under autoclaving condition

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The conversion of the food processing waste such as deproteinized and defatted rice bran into bioethanol is advantageous due to environmentally beneficial method of its disposal. Pretreatment is the first step in the process of converting biomass into bioethanol. We evaluated three different pretreatment conditions on deproteinized and defatted rice bran: one with uncatalyzed pure water, another one with sulfuric acid at 0.1 N, and the last one with sodium hydroxide at 0.1 N. All pretreatments were performed at 121°C/1.5 psi for five different residence times, and the slurry was separated into the solid and liquid fractions. The amount of unreleased glucan materials in the solid fractions of uncatalyzed, acid-catalyzed, and alkali-catalyzed samples were 8.8–21.8, 6.2–7.0, and 12.5–21.1%, respectively, depending on pretreatment time periods. This result suggested that the amount of released glucan materials into the liquid fraction would be greatest for the acid-catalyzed pretreatment compared to other pretreatments. As expected, the highest concentration of glucose up to 77.0 g/L in the liquid fraction was found in acid-catalyzed pretreatment for 30 min. With alkali-catalyzed pretreatment for 60 min, the concentrations of hemicelluloses sugars, xylose and arabinose, were highest up to 11.7 and 14.3%, respectively, in a liquefied form. It is very important to obtain carbon sources like either hexose or pentose from raw biomass materials with high yields. In this study, relatively higher amount of a hexose, glucose, was released with acid-catalyzed pretreatment whereas xylose and arabinose from hemicellulosic materials were more efficiently extracted with the alkali-catalyzed pretreatment. Further study on enzymatic hydrolysis of the pretreated deproteinized and defatted rice bran will be pursued to find an optimal saccharification process.

Aflatoxin risk management in Texas: Comparative analysis of testing variability by multiple agencies

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Aflatoxin concentration was measured in corn samples collected using a hierarchical design from commercial grain elevators (facility and bin), transporters (truck), and individual and composite probes of grain by multiple testing agencies. The intent of the study was to validate previously published variance estimates for measuring aflatoxin in bulk corn and develop aflatoxin risk management strategies for the commercial grain industry. This study was performed in a commercial setting involving approximately 2000 tons of corn. The coefficient of variation (CV) values of aflatoxin concentrations for individual probes within a truck ranged between 0.0 and 92.2% with an average of 28.4% across 65 trucks. The total variance was partitioned into facility, bin, and truck. The data analysis results showed that the total variance of aflatoxin concentration mainly consists of bin variance and residual error. The bin variance accounted for 75% of the total variability associated with aflatoxin concentration within the heirarchial design. Variance component analysis results of the composite samples were similar between the two agencies. The correlation in aflatoxin concentration of composite samples measured by the two agencies resulted in a correlation coefficient of $r = 0.80$. These observations support previous variance estimates performed in a non-commercial setting and provide useful insight into risk managment regulatory strategies for monitoring aflatoxin concentration of corn shipped by commercial grain elevators.

Effects of heat treatments and storage on the physicochemical properties of oat starch

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The objective of this study was to understand impacts of heat treatments and storage of oat grains on the physicochemical properties of oat starch. Oat kernels of two lines, Dancer and Rockford, were selected for the following treatments: steaming (95°C, 15 min), roasting (106°C, 120 min), and dehulling. Oat kernels with hull were used as the control. The samples were stored at 85% relative humidity and 23°C for up to 2 months. Starch isolated from the steam-treated kernels showed smaller gelatinization enthalpy-changes than the control, indicating partial gelatinization of the starch. There was a greater melting enthalpy-change of the amylose-lipid complex for the steam-treated samples. This enthalpy change decreased after 2-month storage. Thermal properties of the starch obtained from oats with other treatments did not change after storage. Compared with the control, the peak viscosity of the ground oats increased after steam treatment, but decreased after 2-month storage, from 98.4 to 131.6 and then to 121.2 RVU and 110.7 to 134.1 and to 121.0 RVU for Dancer and Rockford, respectively. This could be because of the hydration of β-glucan from the steam treatment. There was an additional viscosity peak developed when the steamed samples were held at 95°C, which could also be a result of β-glucan hydration. The final viscosity of the control, roasted, and dehulled samples increased after storage but not that of the steamed samples of either line. The enzymatic hydrolysis of starch in uncooked ground Dancer and Rockford kernels was reduced by steaming, from 78.8 to 66.3% and 70.5 to 67.0%, respectively, after incubation with porcine pancreatic α-amylase for 24 h.

Effects of high growing temperature on starch structure in sorghum grains

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Sorghum is an important cereal crop for Australia because of its tolerance to warm, arid environments. Understanding the effects of high growing temperature on sorghum starch structure is important, especially for the climate in Australia. The effects of high growing temperature on sorghum starch structure were examined using grains from three varieties of sorghum: BTx623, Is8525, and Karper669. The high-temperature-treated (HTT) grains were collected from the crops grown at a 38°C/22°C (day/night) regimen from sowing until final harvest, and the control grains were collected from the crops grown at a 30°C/22°C regimen. The starch and amylose contents were not significantly different between the HTT and the control grains, but the HTT samples had significantly higher protein contents. The molecular weight distributions of debranched starch obtained using size exclusion chromatography showed that the amylopectin in the HTT samples from BTx623 and Is8525 varieties had a higher ratio of long B chains (B2, B3, …) to short chains (A and B1) than the control counterparts but that in the HTT and control samples from Karper669 variety showed a similar ratio. The results indicate that high growing-temperature does not affect amylose biosynthesis in sorghum grains, but it can affect the branching structure of amylopectin, which is probably attributed to the differences in the activities of amylopectin synthesizing enzyme (starch synthase or starch branching enzyme) at different growing temperature. In addition, the effects of high growing temperature seem to be influenced by the genetic background of sorghum grains.

Effects of acid concentration and temperature on characteristics of pyrodextrins

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Changes in color, resistant starch content, and solubility of pyrodextrins, preparing from normal corn starch with various amounts of hydrochloric acid (0, 0.1, and 0.2% starch basis), different temperatures (120 to 140°C), and durations (1 to 3 h), were observed. Results showed that pyrodextrins prepared without acid had similar values of color difference (ΔE) and slightly higher solubility as compared to the native normal corn starch. The resistant starch content of pyrodextrins, ranging from 4.9 to 11.4%, was higher than that of the native starch (1.4%). Starch treated with higher temperature and long duration tended to produce more resistant starch. The ΔE of pyrodextrins prepared with acid obviously decreased with increasing concentration of acid, treatment temperature and pyrolysis duration. The resistant starch content and solubility of pyrodextrins ranged from 34.3 to 92.1% and 87.4 to 100.0%, respectively. Pyrodextrins prepared with higher acid concentration and temperature had relatively higher content of resistant starch. Results suggest that the alternation in color, resistant starch content, and solubility of normal corn starch after prepared without acid was less profound than that of starch prepared with acid. Furthermore, pyrodextrins with high resistant starch content (>50%) and solubility (>90%) can be prepared by treating starch with 0.1% hydrochloric acid at 120°C for more than 1 h.

Effect of starch on rheological properties of carrageenan dispersions

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Rheological properties of carrageenan-starch dispersions, composing of 0.6% carrageenan and different concentrations (1 to 3%) and botanic sources of starch (waxy rice, japonica rice, indica rice, waxy corn, normal corn, Hylon V, tapioca, and potato starches) were examined and compared. Results showed that G' (storage moduli) of carrageenan-starch dispersions were obviously higher than that of carrageenan or starch alone, and were increased with increasing concentration of starch. While only minor difference on tan δ was found between carrageenan-starch dispersions (range from 0.17 to 0.28) and carrageenan (0.23) alone. G' of carrageenan-starch dispersions composed of starch from the same botanical source (either rice or corn) increased with increasing amylose content of starch. Furthermore, despite of starch source, G' of carrageenan-starch dispersions correlated positively ($r^2 > 0.810$, $p < 0.05$) with the amylose content of starch. It was also found that G' of carrageenan-starch dispersions showed a quadratic correlation ($r^2 > 0.890$, $p < 0.05$) with the swelling power of starch. G' of carrageenan-starch dispersions, composed of starch with swelling power lower than 30 g/g, obviously increased with decreasing swelling power of starch. On the other hand, starch with swelling power higher than 30 g/g had less effect on the G' of dispersions composed. Results suggest that the gel properties of carrageenan can be modified by composing of starch, but the gel properties of carrageenan-starch dispersions highly depend on starch source. Moreover, amylose content and swelling power of starch can be used as indices for predicting gel properties of carrageenan-starch dispersions.

Single lab validation of resistant starch assay by AOAC 2002.02 and in vitro digestion of some starch materials under the same conditions

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The official resistant starch method was evaluated within a single lab and was found to be acceptable with reasonable RSD (2–8%) and accuracy (90–110% recovery of spiked samples). Four commercial and research starch materials were examined for their digestion rate under the conditions of the AOAC 2002.02 and 991.43 for up to 16 h. It was found that the pressure cooking of the starch slurries significantly promoted the digestion of all resistant starch samples. The results suggest that certain processing conditions may cause reduction of measurable dietary fiber when such materials are used.

Effect of chia seed meal on baking quality of cakes

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Chia seed is a good source of dietary fiber and complete proteins; chia seeds contain many health-promoting compounds and can be incorporated into baking goods for high-protein, high-fiber diet. Food-grade chia seeds were obtained from a local grocery store and ground into meal using Retsch Model VDE 0530 centrifugal mill to produce a chia seed meal fraction that passes through size 60 sieve. The chia seed meal fraction was used as flour substitution in a cake formulation based on AACC Method 10-90. The Faringraph testing was conducted to measure optimal mixing time and optimal water absorption of mixtures of flour and water, incorporating 0, 5, 10, and 20% chia seed meal, respectively. The effects of chia seed meal substitution, mixing time, and water on properties of cake batter and cake were examined—batter viscosity, specific volume of batter, cake volume, crumbgrain, cake color, cake texture, moisture of cake, water activity of cake, and sensory evaluation. The optimal chia seed meal substitution based on these measurements was determined.

Relationship between bran particle size and bran starch of milled soft wheat grown in Michigan

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Health benefits of dietary fiber in the human diet have been well-documented. Wheat bran is a major source of fiber as an ingredient in cereal-based products. During wheat milling, bran is separated from the endosperm, though a clean separation is not possible as there is always some starch adherent to the bran (namely, bran starch). The particle size of the milled bran, amount of bran starch, and composition of the bran starch could all play important roles in the processing of cereal-based foods and, in turn, quality of the end-products. The aims of this study were to determine the variations in bran size, bran starch content, and dietary fiber content among different Michigan soft wheat varieties and to investigate the relationships among these parameters. Bran samples were obtained from laboratory milling of 17 soft wheat varieties that were each grown at three locations in Michigan in three years. Sifted bran fractions containing particles larger than 2 mm (large bran particles, LBP) were collected and weighed. Contents of bran starch on LBP and dietary fiber of water-washed LBP were determined by Megazyme kits. Five varieties with relatively high crop yield and milling softness equivalence were chosen from the 17 varieties. Percentage of LBP and bran starch content were found to be significantly different (p = 0.0002 and p = 0.0019, respectively) among the five varieties. A negative correlation was found between percentage of LBP and bran starch (R^2 = 0.865). No significant differences were found in soluble and insoluble fiber contents among five varieties. These findings may provide a foundation for comparing properties of bran starch with endosperm starch from the same wheat sample.

Engineered "smart" starch-based biomaterial for functional food ingredient and nonfood industrial applications

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Plant-based biopolymers such as starch have been increasingly utilized as building blocks to synthesize a new class of green biomaterial. Especially those with "smart" responsive properties that undergo swelling, contraction, or phase transitions with external stimuli, such as pH, temperature, or specific ions are of particular interesting for many bio-based industrial applications. With recent development in green chemistry, these environmental friendly materials can be produced in solid-state conditions without the employment of organic solvents, reducing auxiliary waste and substantial environmental impacts. To enable the control of starch signature gelatinization and retrogradation properties and introduce add-on stimuli-response functionality, native starch was chemically modified via solid-state esterification with naturally occurred tri-carboxylic acid, citric acid. The resultant functionalized starch comprised anionic citrate/carboxylate moieties, demonstrating limited swelling in acid solution (pH < 3), yet swelled pronouncedly in neutral solution. In addition, the modified starch granule exhibited temperature-responsive swelling in solution at 45°C or greater and was thermally stable without dissolution at 100°C and repeated heating for over 4 h. Furthermore, citric acid-modified starch appeared to be highly resisted to digestive enzyme hydrolysis. Through careful selection of the reaction conditions, the magnitude of gel swelling can be controlled between 100 and 800 times of original starch granule volume and the degree of resistant starch to be as high as 90%. The engineered "smart" starch can be considered as a versatile biomaterial for many bio-based applications such as functional ingredients for low calorie food, controlled delivery matrix for nutrients/drugs, and superabsorbent for environmental cleanup.

The synergistic effects of amylose and phosphorus on rheological, thermal, and nutritional properties of potato starch and gel

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The synergistic impact of amylose and phosphorus on the rheological, thermal, and structural properties and nutritional fractions of native potato starch, dry starch gel, and freshly cooked gel were investigated in this study. The results indicated that starch with a high amylose level and higher phosphorus content showed enhanced retrogradation extent, associated with a well-formed and rigid gel structure and more ordered structure, compared to starch with a lower phosphorus content. Phosphorus content in starch was positively correlated to resistant starch content in native starch ($p < 0.001$) and to the slowly digestible starch content in the starch gel ($p < 0.05$). Amylose content alone appeared not to be a good indicator of the starch digestibility. Phosphorus content played a dominant role in some physicochemical properties of starch when the amylose content was above a threshold level. The temperature ramp test appeared to be a sensitive method to detect the recrystallization of starch molecules during the early stages of retrogradation.

Structure and properties of thermoplastic potato starch film cross-linked by UV irradiation

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UV irradiation, as a physical process, is an environmentally friendly technique to modify starch. In this study, potato starch film was prepared through extrusion and its surface was treated by ultraviolet irradiation (wavelength ~302nm) in the presence of sodium benzoate as a photosensitizer (PHS). PHS concentrations in the starch films were varied in the range of 0.2–1.0% (based on dry starch). Crosslinking reaction was proven by gel mass and swelling degree measurement when immersed in dimethylsulfoxide. Gel fraction of irradiated starch film increased with irradiation time and tended to a limiting value, depending on the initial PHS concentration. The surface structure of starch films was characterized by ATR-FTIR to investigate the changes of the surface properties with UV irradiation time. Physical properties, such as water contact angle and glass transition temperature, were measured to characterize the influence of the surface crosslinking modification. The result showed that water contact angle and glass transition temperature of the crosslinked starch film increased with UV irradiation.

Functionality of kamut and millet flours in macro wire cut cookie systems

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Substitution of wheat flours with nonwheat flours has received considerable attention in recent years due to their positive health benefits and effects on product attributes. Millet and Kamut flours were blended with soft wheat flour (0, 25, 50, 75, and 100%) and analysed for proximate composition, farinograph, and gluten peak tester (GPT) profiles and cookie quality attributes. Farinograph evaluation showed a positive relationship between increasing amounts of Kamut flour and increased water absorption (50.8–70%), development time (1.2–3.2 min), and time to breakdown (2.6–5 min). GPT analysis exhibited significant increases in torque (34.55–69.15 BE) and reduction in peak maximum time (PMT) (1.45–0.60 min) with increasing amounts of Kamut flour. In contrast, with increasing millet flour supplementation (0–50%) GPT torque declined (34.55–25.10 BE) without significantly affecting PMT. Cookie spread ratio was not affected (8.81–8.99) from 0–50%, but was significantly reduced to 6.51 at the 100% Kamut flour level. GPT torque and PMT was significantly correlated to protein content (r^2 = 0.98 and –0.91, respectively) of Kamut flour blends, and their cookie spread (r^2 = –0.79 and 0.66, respectively). Interestingly, with the millet flour system spread was highest at the 25% level (9.84) and similar at the 0 and 50% levels while it further declined to 5.89 at the 100% level. Cookie hardness reduced (4905–3092 g) from 0–50% replacement of millet flour with further increases in hardness to 4466 g at the 100% level which was similar to the control cookie ($p < 0.05$). L, a, and b values of millet supplemented cookies declined

with incremental replacement while L value improved and a value decreased with Kamut supplementation. The current findings suggest the both Kamut and millet flours can successfully replace soft wheat flour up to the 50% level without significantly affecting cookie quality attributes.

Influence of microwave irradiation on β-glucan and fiber content of barley

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Microwave heating may affect some nonstarch polysaccharides of cereal kernels. This can be positive for functional properties and the final product. Therefore, the purpose of this work was to explore the effects of microwave heating on mechanical properties, malt extract yield, wort viscosity, β-glucan of wort, and soluble, insoluble, and total dietary fiber in malting and feed barley. The barley kernels were microwave heated for 4 and 8 sec, and compared to a control (0 sec) with no microwave irradiation treatment. The thickness of barley kernel bran layers were related to the mechanical properties. The modulus of elasticity decreased after 4 sec of heating but increased after 8 sec. This effect is good for malt extract yield because it increased about 7% in the two barley types with 4 sec of heating. Irradiation had an effect on nonstarch polysaccharides, such as β-glucan and fiber. β-glucan decreased after 4 sec about 50 mg/L in the malting barley and 130 mg/L in the feed barley. The wort viscosity decreased from 1.57 cP in the control (0 sec) to 1.32 cP in 8 sec of microwave heating. The insoluble and total dietary fiber followed the same trend as β-glucan, but the soluble fiber content increased with longer microwave heating, in malting barley increased about 1.25 to 2.13% in the feed barley. The effect of microwave heating should increase barley value in the brewing industry and also improve health benefits.

Application of enzymatically treated corn starch in breakfast cereal coating

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Currently, breakfast cereals are covered with a sugar coating to retain its desirable crisp texture for an extended time in milk. Because of health concerns associated with high intakes of sugar, alternatives are being sought to limit added sugar in foods. This study was designed to evaluate the efficacy of enzymatically treated corn starch as a breakfast cereal coating. Corn starches of three different amylose contents (25, 50, and 70%) were debranched with isoamylase and then treated with beta-amylase to varying degrees, allowed to retrograde, and characterized for their physiochemical and nutritional properties. Enzymatically treated high-amylose corn starches were shown to have higher thermal stability, crystallinity, and resistant starch content, therefore were evaluated in cereal coating. Enzymatically treated high-amylose corn starch at two different concentrations (10 and 20% w/w) was sprayed onto breakfast cereal flakes and then dried at 50°C for 24 h. The coated cereal was subjected to milk soaking for 3 min. The milk absorption was determined by weight gain, and the peak force of the coated cereal was measured by a texture analyzer with a 10-blade Kramer shear cell attachment. At 10% concentration, the debranched high-amylose corn starch showed a peak force 58% higher than an uncoated control. This increase in peak force was comparable to a coated control using a current industrial formulation and starch treated with both beta-amylase and isoamylase. At 20% concentration, the debranched high-amylose corn starch showed a peak force up to 167% higher than the uncoated control and 64% higher than the commercial coating at the same concentration. There was no significant difference in milk absorption among the coated samples. The results demonstrate that enzymatically treated high amylose corn starch can function as a coating to extend the bowl-life of breakfast cereals.

The effect of wheat maturity and freezing on grain and end-product quality attributes

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Harvesting wheat at an immature and/or frosted state in western Canada poses challenges to farmers and grain processors. The aim of this study was to investigate the effect of premature wheat harvested under normal and freezing temperatures on wheat qaulity. Six cultivars with a wide range of quality were grown in a randomized plot design. Samples were harvested weekly starting at one week past anthesis until physiological maturity. One half of the wheat from a harvested plot was immediately frozen at –18°C and the other half was air-dried at ambient temperature. Wheat harvested at 4 to 6 weeks past anthesis was chosen for further quality evaluation. Grain quality was assessed for color, hardness, weight, diameter, and protein content and composition. Flour quality was evaluated for color and rheological properties. End-product quality was evaluated using small-scale pan bread and tortilla production. Grain and flour color depended strongly on the maturity level of wheat at the time of harvest and on the postharvest thermal treatment. In general, the immature grain showed inferior quality (darker and harder kernels) when compared to the mature grain. When the immature wheat was frozen, deterioration in grain, flour, and end-product quality was significant. The freezing treatment resulted in inferior grain and flour color, inferior farinograph dough development time and stability, lower loaf volume, and inferior bread characteristics. Freezing of the immature grain also halted the development of polymeric proteins and this is likely the explanation for some of the observed inferior quality in the flour and end-products.

Effect of the xylanase enzyme on the viscoelasticity and polymeric proteins in frozen dough and on loaf volume of French-type bread

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In order to maintain maximum freshness in bread, the use of enzymes in frozen dough seeks minimize the damage caused by the transition of water from liquid to solid. The aim of this study was to determine the effect of a xylanase enzyme in viscoelasticity, and proteins in frozen dough, as well as in volume and firmness of bread. Dough was prepared using the straight process, with four formulations: a control for fresh bread (100% flour, 2% shortening, and 2% yeast), and three formulations for frozen dough. The three frozen doughs were one with 5% shortening, 3% yeast, and without enzyme, and two frozen doughs adding xylanase enzyme at 0.02 or 0.06% concentration. Dough was prefermented for 10 min, then frozen and stored at –18°C during 6 weeks. Samples were thawed each week at refrigeration conditions (4°C) and fermented for 50 min. Fermentative capacity and viscoelasticity measured as storage (G') and loss (G'') moduli and the phase angle delta of doughs were evaluated. Changes in protein solubility of dough were measured by size exclusion chromatography (HPLC-SE). Furthermore, the specific volume and maximum firmness of bread were determined. The fermentative capacity of dough increased with the xylanase enzyme compared to the control. The elasticity of dough decreased 5%, raising the delta angle from 32.26 to 33.9 rad. It was a reduction in the amount of soluble polymeric protein fraction due to xylanase enzyme, which reflected the positive effect on the damage by depolymerization of gluten proteins during freezing. The concentration of 0.06% xylanase produced the highest volume and softest bread crumb.

Grain quality evaluation of NERICA rice varieties

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NERICA (New Rice for Africa) varieties were developed by the Africa Rice Center from crosses between *Oryza sativa* and *Oryza glaberrima* and classified generally as "lowland" and "upland" varieties according to their preferred ecologies of cultivation. One of the main objectives for the development of NERICA was to bring together the high yielding potential of the *O. sativa* and the stress tolerance of the *O. glaberrima* in one variety. Although this has been largely successful agronomically, the grain qualities of these varieties continue to pose challenges in many countries. The physicochemical properties of 18 upland and 60 lowland NERICAS were compared to some of the parents from which they were developed. The samples were milled using a Satake testing husker (THU 35A) and a Yamamoto testing rice laboratory mill (VP-31 T). Apparent amylose content was determined according to Juliano (1971), grain dimensions and chalkiness using a Cervitec 1625 grain inspector (Foss Analytical, Denmark). Viscosity profiles were determined using a rapid visco-analyzer. Whereas over 80% of the "lowland" Nericas had amylose contents higher than 25%, the majority of the "upland" Nericas had amylose contents between 20 and 24%. The Nericas were generally found to have chalky grains with 60% and 85% of "upland" and "lowland" varieties having chalkiness of over 15%. "Lowland" Nericas tended to swell less than with about 50% of them having peak viscosities of under 2300cP with peak viscosities of most "upland" Nericas being over 2800cP. The average grain length of "upland" Nericas was 6.60 mm compared to 6.66 mm for the "lowland" Nericas.

Structural analyses of starches using partially methylated alditol acetate method

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Partially methylated alditol acetate method (PMAA) is based on methylation of free hydroxyl groups from dispersed nongranular polymers before complete acid hydrolysis followed by acetylation of liberated hydroxyl groups on monosaccharide units. By analyzing derivatized sugars using gas chromatography-mass spectrometry (GC-MS), nonreducing ends (NRE), body glucose units, and alpha(1-6) branch glucose units could be separated and quantified with identities confirmed by retention index and mass spectral library comparison. The objective of this study was to determine if PMAA could be used for starch structural analysis by comparing the results of five different starches (corn, waxy corn, high-amylose corn, potato, and waxy potato) and their beta-limit dextrins and 60-day lintners. Artefacts were discovered in method which complicated analysis as undesired chromatographic peaks were found including alpha(1-3) branch linkages. Attempts were made to optimize method at several critical stages including different dissolving conditions, NaOH amounts, methylation times, and hydrolyzing acids with different hydrolysis times, but artefacts could only be minimized. Using maltose and panose, undesired peaks were found to be relatively constant based on method conditions allowing for a baseline correction. Therefore, results allowed trends to be observed with the optimized method. High-amylose corn showed the most body units to nonreducing ends indicating longest average chain length while waxy corn had least body units and most branch points. There was an increase in branch units per body units for beta-limit dextrins corresponding well with the ~55% loss in mass due to beta-amylase exoenzyme attack. Lintners showed a dramatic decrease in relative branch units, indicating they were preferentially located in amorphous regions as opposed to crystalline regions where acid cannot penetrate and hydrolyze glycosidic linkages.

Effect of the addition of different fat blends formulated using an artificial neural network on the rheological properties of wheat flour

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In the production of pan bread, fat increases bread volume and softness. Rheological analyses help predict dough behavior during different stages of the bakery process. Artificial neural network (ANN) technology is successfully used in the formulation of vegetable fats. In this study, the effect of four different "zero *trans*" fat blends (BL01, BL02, BL03, and BL04) on the rheological properties of refined wheat flour dough were evaluated using a farinograph and extensigraph. The blends were formulated using ANN technology, combining two different soybean fat bases and soybean oil. The fat and flour premixes evaluated contained 4% fat and were compared to a control sample, without fat (C). In the farinographic analyses, absorption (ABS), dough development time (DDT), stability (STA), and mixing tolerance index (MTI) were measured. STA for C was 19.2 min and the addition of fat reduced STA 7% in average. The average MTI of 24 Brabender units (BU) for the samples with the fat blends was approximately 37.5% greater than the control (15 BU), showing a lower tolerance to mixing. In the other parameters (ABS and DDT), there were no alterations. In the extensigraphic analyses, resistance (R), maximum resistance (Rm), extensibility (E), and the ratio between resistance and extensibility (D) at 135 min were measured. R and Rm for C were 370 and 750 BU, respectively. There was an increase in R and Rm of 2 and 1.2 times, respectively, when the blends were added, while E decreased about 4%. Parameter D of the samples with the fat blends was in average 2.1 times superior to that of the control (2.0). Among the blends, some differences were observed in the values of R and Rm. In general, it was observed that the addition of the fat blends reduced mixing stability and tolerance, but increased dough resistance after a 135-min resting period.

Effects of flour milling methods on the compositional, functional, and physical properties of whole and split yellow pea (*Pisum sativum*) flour

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With increased demand for healthier foods, the use of novel flours in food applications has gained considerable attention. The addition of yellow pea flour to food products will enhance levels of protein, fiber, vitamins and minerals making it an attractive ingredient for developing healthier foods. Little is known however about the effects of milling variables on the resulting flour properties. The purpose of this research was to determine the effect of different milling methods on the compositional, functional, and physical properties of whole and split yellow pea flour. Three different milling methods were used including hammer, pin, and roller milling. Two mill screens (1.5/64" and 3/64" sieve apertures) were used for hammer milling. Pin-milled samples were processed at 10,000 and 20,000 rpm. Roller-milled samples were premilled using 8/64" hammer milling screen and a fine and coarse flour was produced by sieving through a 150- and 212-µm screen, respectively. Flours and separate mill streams were tested for their moisture, protein, and ash contents and water absorption capacity. Starch pasting profiles and particle size distribution were determined on the flours and mill streams using a rapid visco analyzer and a Malvern Mastersizer respectively. Significant differences ($P < 0.05$) were found among the various mill streams and flours for ash, protein, and starch pasting properties, including peak viscosity, breakdown, and peak time. Differences in particle size distribution were found among the various flours and mill streams. These findings suggest that some pea flours and/or mill streams are more suitable for certain end-use applications than others based on their different properties. This research will lead to the optimization of yellow pea flour ingredients for specific food use applications based on their compositional, functional, and physical properties.

Phenolic compounds in raw and cooked rice (*Oryza sativa* L.) and their inhibitory effect on the activity of angiotensin I-converting enzyme

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Whole rice has been widely studied due to the abundance of bioactive compounds in its pericarp. Some of the beneficial effects of these compounds on human health have been attributed to their antioxidant and other biological activities, such as enzyme inhibition. In this work, we evaluated the contents of total, soluble, and insoluble phenolic compounds of 6 red and 10 nonpigmented genotypes of whole raw rice, their inhibitory effect, as well as the effect of cooking on the activity of angiotensin I-converting enzyme (ACE). Red genotypes showed the highest contents of phenolic compounds with an average of 409.7 ± 62.9 mg ferulic acid eq./100 g, mostly represented by soluble phenolics (proanthocyanidins and anthocyanins). Insoluble phenolics contributed only 20% of total phenolics. Nonpigmented rice showed overall lower average levels (99.4 ± 19.1 mg ferulic acid eq./100 g) almost equally distributed between the soluble and insoluble fractions. Pigmented rice displayed an almost 100% inhibition of ACE, significantly correlated with the content of soluble phenolics ($r = 0.8985$, $p < 0.05$). Cooking was found to reduce the average content of total phenolics in the pigmented group by about 50%. However, in nonpigmented rice, either insoluble or total phenolics were slightly affected by cooking; the average 12% decrease was not statistically significant and total content remained 87.2 ± 15.3 mg FA eq./100 g. The average content of soluble phenolics in pigmented rice dropped by 83% after cooking, indicating that the soluble phenolic fraction was the most affected by the thermal treatment. Rice cooking also reduced ACE inhibition (on average 84%), the extent of which was proportional to the loss of soluble phenolic compounds.

Protein changes in three wheat cultivars with the yellow berry disorder

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Bread wheat crops in the state of Sonora in Mexico are presenting a physiological disorder known as "yellow berry" (YB), characterized by the presence of floury endosperm and a low protein content, which affects their quality for baking and marketing. The aim of this study was to investigate the changes in protein fractions of bread wheat with different contents of YB and thus advance in the understanding of the causes of the problem and the effect on bread quality. We collected 97 samples of three wheat cultivars, Kronstad, Rayon, and Tacupeto, received by a commercial wheat mill in 2008. We analyzed the YB presence, the protein content and the insoluble polymeric protein (IPP) using the LECO nitrogen analyzer. The soluble (50% propanol) protein fraction was analyzed by size exclusion liquid chromatography (HPLC). Gliadin subclasses and glutenin subunits were analyzed by reverse phase HPLC. YB had a greater prevalence in wheat of the Tacupeto cultivar. Wheat with YB had lower protein and IPP contents. When the IPP values were corrected by the protein content, the relationship was inverse. Significant differences ($p < 0.05$) in the proportion of the different fractions of soluble protein were also observed. The proportion of soluble polymeric protein(PPS) and that of the higher molecular mass gliadinas decreased. However, there was an increase in the proportion of lower-molecular-mass gliadins fraction and albumins and globulins. The content of the ω gliadins, α + β gliadins and LMW glutenin subunits decreased. The decrease in the protein content and the IPP, as well as the change in the proportion of soluble protein, impact on the quality of wheat bread with YB.

Gliadin solubility and baking properties of dough of hard and soft wheat flours with microbial transglutaminase

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To know the effect of the incorporation of the different subclasses of gliadins to the insoluble polymer, microbial transglutaminase (MTGase), a protein-glutamine γ-glutamyl - transferase (E.C. 2.3.2.13), which catalyzes acyl transfer reactions by introducing a covalent crosslink between L-lysine and L-glutamine residues, was used. Hard and soft wheat cultivars were evaluated and two different concentrations of the MTGase (0.5, and 1.0U/g gluten) were tested. Rheological measurements were done with the farinograph and alveograph, and baking tests were also performed. Dough proteins were extracted and analyzed by RP-HPLC, and solubility of gliadin subclasses and glutenins subunit types was evaluated. The combustion procedure was used to determine protein content and the amount of the insoluble polymeric protein (IPP). Increased dough stability measured with the farinograph and increased strength measured as alveographic W, without increasing dough tenacity, measured as alveographic P were observed in dough with MTGase. Cortazar, Salamanca, Rayon and Tacupeto, soft and hard wheat cultivars of low baking quality, improved bread volume, observing that these same cultivars increased the IPP content. All cultivars showed a reduction in the solubility of omega gliadins. The cultivars that improved bread volume in higher proportions showed a reduction in gamma gliadins solubility. The incorporation of omega and gamma gliadins to the insoluble polymer, positively affected the rheological and baking properties of soft wheat and low quality hard wheat flours.

Effect of gliadin-to-glutenin ratio on gluten aggregation

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The functional properties of wheat are largely dictated by composition of the gluten proteins. All flours contain gliadin and glutenin but produce varying quality baked products, which demonstrates cultivar specific differences in gluten proteins that dictate quality. A common method to study differences in gluten properties which is utilized in this study is fractionation and reconstitution to understand how varying gliadin to glutenin ratios and how fractions from different wheat sources affect gluten aggregation. Gliadin and glutenin from a vital wheat gluten were fractionated with 70% ethanol and reconstituted at various ratios. Gliadin and glutenin from a Canadian Eastern soft, Eastern hard, and Western hard wheat were fractionated and interchanged at the native gliadin to glutenin ratio of the flours. Gluten combinations were evaluated with a gluten peak tester at constant temperature and mixing. Varying gliadin to glutenin ratio showed that 50:50 is optimal for fast gluten aggregation while amount of glutenin dictates strength. Substitution experiments showed that replacing good quality gluten fractions with those from a lower quality wheat decreases gluten quality, and vice versa. It was also shown that cultivar specific differences in gliadin and glutenin are more important in dictating gluten strength (torque), while gliadin to glutenin ratio dictates aggregation time (PMT) almost independent of cultivar. The study demonstrated the ability of the GPT method to evaluate gluten aggregation by controlling for all variables except the one being tested. The data also revealed information about gluten aggregation properties that was previously poorly understood.

Transglucosidase immobilized to polymer beads via covalent attachment for isomaltooligosaccharide production

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Isomaltooligosaccharides (IMO) are gaining interest due to their low caloric value, bifidus stimulating activity and low cariogenic properties. One of the IMOs, Panose is a mildly sweet trisaccharide that is non fermentable by oral microorganism, imparting a low cariogenic property while acting as a sweetener. It also can act as an anti-fading agent in food pigments and as an antioxidant. However, an efficient process of panose production is still under investigation. Immobilizing an enzyme to a non soluble solid surface has several benefits including increased stability, reusability of enzyme and less contamination of the product with enzyme. The present study was carried out to evaluate the optimum immobilization parameters and stability and activity of the immobilized enzyme. Transglucosidase from *Aspergillus niger* was immobilized onto commercially available polymer beads and was used for the production of IMO, including panose from maltose. Immobilization resulted in 80–95% immobilization efficiency. The immobilized enzyme retained its activity after 10 washing cycles, implying that it is covalently bound to the polymer bead. The optimum immobilization conditions were 400 mg of polymer beads with 20 units of transglucosidase at pH 7.5 for 48 hours at 25°C with shaking at 150 rpm. Immobilization efficiency of 83–95% was seen at phosphate buffer concentrations of 0.2–1.0 M. Optimum temperature and pH for the conversion of maltose to IMO was 60°C and pH 4.0, respectively. Immobilization did not affect the optimum reaction conditions but immobilized enzyme had improved activity and stability than the free enzyme at different temperatures and pH. The results obtained could be used in producing IMO from maltose with the repeated use of the enzyme.

Nutraceutical beverage elaborated from mixture of flours of extruded maize and chickpea

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Consumption of whole cereals and legumes has been associated with the reduction of chronic diseases; these grains contain phytochemicals or bioactive non-nutrient compounds, some of which act as antioxidants. The aim of this study was to determine the best combination of extrusion process variables for the production of extruded maize (EMF) and chickpea (ECF) flours to prepare a mixture (60% EMF + 40% ECF) suitable to elaborate a nutraceutical beverage with high acceptability and nutritional quality. Maize and chickpea kernels were broken to obtain grits (1-2 mm); maize grits were mixed with lime (0.21 g lime/100 g grits). Maize and chickpea grits were added with distilled water to reach a moisture content of 28%. Extruder operation conditions were selected from a factorial combination of process variables: extrusion temperature (ET, 120–170°C) and screw velocity (SV, 120–200 rpm). A central composite experimental design with five variation levels generated 30 assays. Response surface methodology was applied over two response variables: antioxidant capacity (AC) and acceptability (A). Mixtures of each assay were evaluated for AC and used to prepare 30 beverages that were evaluated for A. Predictive models for response variables were developed. A common optimum value for the two response variables was obtained using the desirability method. The best combinations of extrusion process variables for EMF and ECF were ET = 113°C/SV = 159 rpm and ET = 132°C/SV = 160 rpm, respectively. The optimized mixture had a global desirability of 0.907; it contained 14.19% proteins (DM). The AC of 200 mL of beverage prepared from the optimized mixture was 1,057 μmol TE. The acceptability of the beverage was between "I like it" and "I like it extremely". This nutraceutical beverage could be used as an alternative to beverages with low nutritional value.

Effect of resistant starch on dietary fiber content and quality of extruded RTE breakfast cereal quality

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RTE breakfast cereal is a good source of dietary fiber. This study evaluated the effect of resistant starch (RS) on the physical characteristics and bowl life of a high-fiber RTE breakfast cereal. A phosphorylated cross-linked RS4 resistant wheat starch containing 85.5% total dietary fiber (TDF) replaced 5–20% of the whole corn flour in an extruded ring-shaped RTE breakfast cereal formulation. TDF content (AOAC Method 991.43) of the dry blend increased ~ 3.6% per 5% added RS. Although TDF loss during extrusion processing increased as RS level increased, 78–89% TDF was retained in the final product. Product density increased as RS level increased but no effect on specific mechanical energy was observed. X-Ray Microtomography imaging (Model 1072, Skyscan, Belgium) showed RS level had no significant effect on internal cell wall thickness, size or porosity of the cereal rings. Expansion of cereal rings containing 5% and 10% RS did not differ significantly from control rings; however, rings containing 15% and 20% RS were significantly smaller. Cereal ring crispness was measured using a TA.XTPlus Texture Analyzer (Texture Technologies Corp., Scarsdale, NY/Stable Micro Systems, Godalming, Surrey, U.K.) with a 5-blade Kramer Shear Cell attachment. Crispness was the force to shear the cereal rings. Bowl life was the loss of crispness after soaking in milk for 0.5, 2.5, and 5.0 min. Crispness of dry and soaked cereal rings containing 5% and 10% RS were not significantly different from control rings. However, rings containing 15% and 20% RS were significantly more crisp initially and after soaking for all testing times. Thus, high levels of RS extended bowl life. In general, moisture content and moisture uptake of the cereal rings during soaking did not appear to influence the crispness of milk-soaked cereal rings and was not significantly affected by RS level.

Genotype and environment effects on physical and chemical properties of wheat starch

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The variability of starch between and within plant species causes difficulties in predicting functional performance in food processing and human nutrition. The variability of starch results from diversity of structure, which reflects the genetics of starch biosynthesis and environmental influences during plant growth. Variability in growth conditions is increasing from one year to the next and is now considered a major factor that affects the quality of cereal grains. Our research is aimed at increasing the understanding of environmental factors that influence variability of starch structure, and in turn starch properties that affect cereal grain quality. Starch was isolated from grain harvested from five commercial Australian wheat varieties that were grown in five different climatic regions of Australia in two years. Analyses were performed on the isolated starch to examine the extent to which genotype, growth location and year influenced variability of physical and chemical properties of starch. The properties that were examined included: total starch content of the grain, total and free amylose content of the starch, granule size distribution, amount of protein associated with starch granules, and starch swelling power. Statistical analysis of variance indicated that all of these properties for each genotype were significantly affected (significant at $p < 0.001$) by growth location and year. Specific correlations were also identified between starch variability and characteristics of the growth locations (soil properties, rainfall, atmospheric temperature and number of clear days). Interactions between growth year and location contributed significantly to the variance in total amylose content and starch swelling power, whereas interactions between year and genotype were significant for total and free amylose and the amount of protein associated with starch granules.

Hydration kinetics and mechanical deformation properties of wheat kernels

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Proper tempering of wheat prior to milling is a major contributor to high yields of low ash flour. Properly tempered wheat will have tough, plastic bran, weaker interactions between endosperm and aleurone and a softer endosperm. Since milling is a physical process involving fracture and separation of bran from endosperm it is important to study factors affecting kernel hardness in terms of measurable mechanical properties. Achieving optimum final moisture using proper time and temperature during tempering improves the yield of low ash flour and conserves energy by minimizing the force required to disintegrate the kernels during milling. The objective of this work was to study hydration kinetics and mechanical deformation behavior of wheat varieties varying in SKCS hardness. To determine how wheat structural properties vary with respect to moisture content, kernels were soaked in water at temperatures of 20–40C. Changes in moisture over time were determined by air oven. The effects of hydration conditions on the absorption rate, saturation moisture content and time were evaluated by fitting the data to Peleg's equation. After the soaking period, kernels were crushed (1 mm/s, 80% strain) using a texture analyzer to determine effects of moisture on the compressive deformation behavior. Kernel initial moisture content ranged from 8.6–10.8% (db). Post soak moisture ranged from 20.8–30.6% after 60 min and 33.1–44.7% after 8 h. Sorption data fitted to a linearized form of Peleg's equation had $r \geq 0.96$. Model constants k1 and k2 ranged from 1.38–2.37 and 0.026–0.039, respectively. Both coefficients and wheat hardness values decreased as soak temperature increased. Fracture force at initial moisture content ranged from 6.7-13.4 kg and decreased to 3.4–9.4 kg after 2 h soaking. Beyond 2 h, kernels started to show elastic-plastic deformation rather than fracture.

Condensed tannin content is not correlated with in vitro starch digestibility of cooked grain sorghum (*Sorghum bicolor* (L.) Moench) flour

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Condensed tannins in sorghum (*Sorghum bicolor* (L.) Moench) have been shown to complex with proteins and reduce their digestibility. It was hypothesized that condensed tannins may also complex with starch and reduce its digestibility. The objective of the study was to determine if a relationship exists between condensed tannin content and starch digestibility of cooked, whole-grain sorghum flours. Fifteen samples of sorghum containing 0.1 – 63 mg catechin equivalents of tannins/g dry sample were obtained. Starch digestibility of cooked, whole-grain flours was measured using a modification of the Englyst method. Corn starch was used as a reference. Results were expressed as rapidly digestible starch (RDS), which was converted to glucose in the first 20 min of in vitro digestion; slowly digestible starch (SDS), which was converted to glucose between 20 and 120 min of digestion; and resistant (RS), which was the fraction of starch that was not converted to glucose after 120 min of digestion. The starch in the cooked whole sorghum flours ranged from (g starch/g dry sample) 0.44 ± 0.03 to 0.53 ± 0.01 for RDS, 0.07 ± 0.01 to 0.17 ± 0.04 for SDS, and 0.09 ± 0.004 to 0.2 ± 0.03 for RS. The fractions of starch in the normal corn starch (control) had 0.68 ± 0.07 RDS, 0.2 ± 0.13 SDS and 0.07 ± 0.07 RS, grams of starch digested per gram dry weight. No significant correlations between the RDS, SDS, or RS fractions and condensed tannin contents in the sorghum flours ($p > 0.05$) were observed. These data suggest that the differences in digestibility of sorghum flours cannot be explained by condensed tannin content. More research is necessary to confirm these results using purified components and different cooking conditions.

Effect of extrusion on antioxidant capacity of two varieties of amaranth (*Amaranthus hypocondriacus*)

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Mexico has a great diversity of autochthonous foods like chili, pumpkin and amaranth. These kinds of foods have been losing over the years, particularly, amaranth. However, in the last years amaranth has become interesting due to its agronomical and nutritional qualities. Also, has been attributed some nutruceutical properties to this grain. In Mexico, amaranth is cultivated in small amounts, but in the last years the production has been increased, because of, largely, their nutritional and agronomical features. Commonly, amaranth is consumed popped. However, there are many alternative technologies to process this grain, one of them is extrusion. Extrusion, is a high temperature–short time technology, is fast and doesn't generate effluents. This technology has been used to get pre-cooked flours of high nutritional value. The objectives of this work were, optimize the conditions to obtain pre-cooked flours of two types of amaranth (dark brown (DBA) and light brown (LBA)) with high levels of antioxidant capacity (AC) and evaluate the effect of extrusion on AC. The extrusion process was optimized using Surface Response Methodology (SRM) to get flours of extruded amaranth. As process variables were chosen extrusion temperature (ET) and screw velocity (SV) (70–130°C and 100-220 rpm). The response variable was AC. The optimal conditions obtained with SRM were 125°C and 129 rpm to ET and SV respectively. Once the optimal conditions were obtained, the amaranths grits were mixed with lime and water. The treated grits were extruded with a single screw extruder operating at 125°C and SV of 129 rpm. The AC of raw flours of LBA and DBA was 3,518 and 4,403 µmol of Trolox equiv/100 g DW respectively. The AC in extruded flours optimized, showed higher values compared with the raw flours (3,903 and 5,046 µmol of Trolox equiv/100 g DW to LBA and DBA respectively).

Evaluation of anticarcinogenic potential of tortillas produced from pigmented maizes processed by conventional nixtamalization and extrusion cooking

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The effect of traditional nixtamalization and extrusion cooking on ferulic acid content (free and bound form) and anticarcinogenic potential (inhibiton of Caco-2 cells) of Mexican pigmented maize (white, yellow, blue and red) processed into tortillas were performed. Tortillas prepared from extruded corn flours retained 58–96.7% of total ferulic acid (TFA) compared to 19.6–55.8% assayed in traditonal nixtmalized tortillas. Approximately 97-99 of TFA in raw kernels and their tortillas was in its bound form. The retention of TFA in traditional nixtamalized tortillas was significantly lower compared to tortillas from extruded flours. Caco-2 cell treated with free ferulic acid extracts from raw corn were substantially more sensitive to treatment. Among all varieties, the yellow and white maize showed the highest ($p < 0.05$) inhibition of Caco-2 cell (0 and 5% viability), whereas the cell viability in red and blue raw corn was 52 and 60%, respectively. These results indicate that free ferulic acid extracts from raw corn had cytotoxic effect on Caco-2 cells. Bound ferulic acid extracts from tortillas prepared with nixtamalized flour significantly ($p < 0.05$) decreased cell viability on Caco-2 cell compared to tortillas prepared with extruded flours. The percentage of cell viability from tortillas prepared

with nixtamalized flour was 4–64%. Tortillas from nixtamalized blue, yellow and white corn flours showed the highest ($p < 0.05$) decreased metabolic activity (4,6,10% cell viability), while tortillas from nixtamalized red corn flour had 64% cell viability. Results indicate that the alkaline cooking process increases the release of compounds with anticarcinogenic potential.

The effect of alpha-amylases and xylanases in the bread dough

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Enzymes play an important roll in bread baking. Especially alpha-amylases and xylanases are widely used in many cases. Generally enzyme activities have been estimated at soluble condition. In this research, enzymes were used in less water (dough) condition and their additional effects were verified. We picked up several enzymes with no or small faint activities of the other enzymes from commercial market, and chose 3 alpha-amylases and 1 xylanase from 12 alpha-amylases and 7 xylanases. The dosage of enzymes that were used in the tests were estimated in Mixolab analysis (AACC International method 54-60.01.), and adjusted C2 in 0.50 0.04 Nm. Dough, prepared with flour and enzyme, was incubated or heated in several fermenting conditions. Monosaccharide and oligosaccharide in dough were analyzed with HPAE-PAD (high-performance anion exchange chromatography with pulsed amperometric detection). Alpha-amylases provided monosaccharides and the oligosaccharides only in the heating (baking) process, and xylanase provided arabinose in the incubating (fermentation) process. Moreover rheological test of fermented dough was done with farinograph. Alpha-amylases showed the reduction of the peak torque, and xylanase showed the reduction of the development time.

Amylolysis of small and large granules of triticale, wheat, and corn starches at subgelatinization temperature using granular starch-hydrolyzing enzyme

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Starch granular structure-amylolysis relationship is important to bioethanol industry. The objective was to study the amylolysis of small and large granule starches at subgelatinization temperature. The hypothesis was that small and large starch granules significantly differ in their degree of hydrolysis, and present challenges in precise control of saccharification. Triticale, wheat and corn starches were fractionated into small and large granules using a sedimentation protocol. The morphology of fractionated granules after hydrolysis using a granular starch hydrolyzing enzyme (Stargen 002) was characterized with microscopic techniques (SEM and CLSM). The effect of amylose (AM) content and relative crystallinity (RC) on amylolysis was also evaluated. The AM content and RC of fractionated starches ranged between 12.4–28.5% and 20.8–26.8%, respectively. Initially, the degree of hydrolysis (DH, % db) was significantly higher in small (21–74%) granules than in large (3–64%), where the difference narrowed with time of hydrolysis. A negative correlation between AM content and DH was found in small granules, whereas opposite trend was found in large granules. RC had a negative correlation with DH in both small and large granules. Unfractionated starch from triticale had the highest DH (70–77%) initially followed by wheat and corn, and all starches had DH >90% after 72 h. SEM showed that starch surface erosion was in the order of triticale > wheat > corn. CLSM illustrated that corn starch granules were hydrolyzed along the channels from interior to surface, whereas wheat and triticale starch granules were hydrolyzed along surface pores of equatorial groove and channels towards the granules interior. Thus, understanding the resistance of small and large starch granules towards amylolysis will enable the optimal selection of starches in order to improve the cost efficiency of ethanol production.

Soluble fiber fortification of breakfast cereals: Enhancing nutrient density and beneficial caloric intake

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A dextrin-based soluble fiber was formulated into two test cereals: 10% fiber was incorporated into an extruded oatmeal cereal and 7.5% fiber was added to a whole grain corn-based cereal. The soluble fiber was also formulated into a glaze (at 27%). The objective was to attain at least 2.5–5 g of fiber per serving, representing 10–20% of the RDI for fiber. While whole grain cereals are traditionally associated with nutritional and health benefits, some breakfast cereals have low fiber content with high sugar and caloric levels. The 2010 Dietary Guidelines recommend increased intake of nutrient dense foods to enable consumers to meet recommended intakes for nutrients such as fiber. Soluble fibers are 50% lower in calories than regular carbohydrates and have various nutritional and health benefits. Incorporating fiber into breakfast cereals has traditionally been challenging due to the high water holding capacity of conventional fibers. In low moisture systems, addition of hygroscopic polymers impacts formulation and sensory quality. New ingredient technology however has enabled the development of soluble fiber ingredients that can be formulated into low moisture systems. Cereal formulation containing dextrin-based soluble fiber was extruded in a six-barrel Clextral EV 53 twin-screw extruder at a feed rate of 180 kg/h, and temperature of 145–160°C. The soluble fiber was also dissolved into a glaze containing 38% sugar, heated to 140°F and sprayed onto whole grain cereal, with an air gun to evenly distribute. Both cereals showed 98–100% retention of fiber. Bulk density was comparable to the control. The whole grain cereal provided 7.5 g fiber per 30 g serving, qualifying for an excellent source of fiber claim. Incorporating certain soluble fibers into breakfast cereals can therefore enable enhanced nutrient density and beneficial caloric intake.

Effect of growing environment of soft wheat on amylose content and its relationship with cookie and sponge cake quality and solvent retention capacity

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Cereal Foods World 56:A57

The effect of growing environments of soft wheat on amylose content and its relationship with baking quality and solvent retention capacities (SRC) was investigated. Near-isogenic soft wheat lines of 'Norin 61' differing in granule-bound starch synthase (Wx protein) activity and grown in three different regions of Japan [Hokkaido (spring-sown) for 2006 and 2007, Kanto and Kyushu (autumn-sown) for 2007] were evaluated. Spring-sown samples produced grains of greater protein content (10.9–12.4%) than autumn-sown samples (7.3–9.1%). In contrast, spring-sown samples of 2007 with higher maturing temperature had lower amylose content (25.5% for 'Norin 61') compare to autumn-sown and spring-sown samples of 2006 (27.6–28.4% for 'Norin 61'). Amylose content was strongly correlated to sugar snap cookie (SSCD) diameter ($r = 0.957$ to 0.961; $n = 10$ (all samples); $P < 0.001$, $r = 0.701$ to 0.976; $n = 7$ (partial waxy and nonwaxy samples)) and Japanese sponge cake (JSCV) volume ($r = 0.971$ to 0.993; $n = 10$; $P < 0.001$, $r = 0.764$ to 0.922 ; $n = 7$ (partial waxy and nonwaxy samples)), regardless of seeding season and growing conditions. The strength of the JSVC-amylose relationship (slope) was similar among the three regions, whereas the strength of the SSCD-amylose relationship was slightly weaker for spring-sown samples and slightly stronger for partial waxy and nonwaxy samples of autumn-sown. Among of the four solvents (water, solutions of sodium carbonate, sucrose, or lactic acid), water-SRC showed the greatest correlation to amylose content ($r = –0.969$ to –0.996; $n = 10$; $P < 0.001$, $r = –0.629$ to –0.983; $n = 7$ (partial waxy and nonwaxy samples)), indicated that amylose content can be accurately estimated from the water-SRC within the samples from the same grown environment.

Functionality of whey as gluten-free bread ingredient

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Most of commercially available gluten-free breads are inferior in quality to their gluten-containing counterparts and they also have a relatively short shelf life. Whey incorporation from cheese production could be a potential ingredient to improve gluten-free bread characteristics. Four different gluten-free bread formulations were prepared replacing the soya and tap water content of control formulation with acid or fresh whey: A) half soya (related to the control) with acid whey (HSAW), B) without soya with acid whey (WSAW), and the same formulations with fresh whey instead of acid whey: C) HSFW and D) WSFW. Bake loss, specific volume, water activity, color and texture were analyzed at days 1, 3 and 5 of storage. Preliminary trials showed similar values of specific volume, ranging from 2,5 to 2,8, while bake loss was significantly higher in WSAW bread (11,02%). There were not significant differences in water activity and color values from different formulations (results not shown). Significant differences were found between hardness (g) values of HSAW, WSAW, WSFW, HSFW formulations (819,98, 953,55, 761,1, 951,69, respectively) and control (569,87). After 5 days of storage, formulations including fresh whey showed an increase in hardness similar to control formulations, while hardness of breads including acid whey

showed a higher increase. Water replacement with whey resulted in a thicker batter structure and higher hardness in breads. Further study and new formulations are needed to deeply understand whey functionality in gluten-free dough structures.

Effects of heat treatment on the tyrosinase activity in wheat and color stability of noodles

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Cereal Foods World 56:A58

Color and its stability is a key trait in consumer acceptability of fresh yellow alkaline noodles. Reducing tyrosinase based browning is one possibility to improve noodle appearance. Wheat samples were conditioned to 10–16% in moisture content, and then followed with 10 seconds of heat treatment with hot water of 70–98 degrees Celsius. The reduction in tyrosinase activities was related to wheat moisture and hot water temperature. Treatment at condition of 16% wheat moisture and 70 degrees Celsius water temperature resulted in a 20% reduction in tyrosinase activity. There was no reduction in tyrosinase activity even with 90 degrees Celsius water if the moisture of wheat is at or below 10%. The reduction in tyrosinase activity was less in flour than in wheat. In order to achieve a 20% reduction in tyrosinase activity, the wheat moisture should be above 12% and hot water temperature higher than 90 degrees Celsius. Based on dough mixing properties and gluten recovery, it is possible that tyrosinase activity can be reduced by heat treatment without significant damage on dough by selecting condition of heat treatment. There was only a slight reduction in noodle discoloration when noodles were made from the flour milled from heat-treated wheat. The results suggested that tyrosinase located in the outer part of wheat grains is not a predominant enzyme which contributes to noodle discoloration.

Characterization of roasted quinoa

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Quinoa (*Chenopodium quinoa* Willd.), a native Andean pseudocereal was an important staple in the Incan civilization, who replaced the animal protein in their diet with quinoa. It is a valuable source of quality protein, carbohydrates, essential fatty acids and micronutrients. The objective of this study was to roast quinoa to improve his flavor profile and characterize it with regard to particle size, proximate, fatty acid, starch digestion, and polyphenols analyses. Whole quinoa seeds were roasted at 350°F for 15 (R15), 30 (R30) and 45 min (R45). Both unroasted (NR) and roasted quinoa were milled using the same settings. Triplicate batches were prepared per treatment and analyzed along with three different lots of commercial quinoa flour (CQF). Mean geometric mean diameters were 794, 802, 664, 578 and 197 µm for NR, R15, R30, R45, and CQF, respectively. Moisture decreased significantly with roasting time (11.1% wb for NR to 0.2% wb for R45). NR quinoa had lower protein content than all roasted flours (14.6 vs. 16.6%). Fat content increased with roasting time but was lower than that of CQF (4.8% vs. 6.1%). Fiber content was lower than all roasted flours but no different from CQF (6.5% vs. 8.9%). Ash content increased with roasting time (2.4% to 2.6%), was lower for NR samples (2.3%) but higher than CQF (2.2%). Carbohydrates decreased with roasting time and were higher for NR (71.8%) and CQF (69.7%). Differences among palmitic (0.5%), oleic (1.6%) and linolenic (2.6%) acids were not detected among NR, all roasted flours and the CQF. At the same time, no differences were found among all samples regarding rapidly digestible (182 mg/g), slowly digestible (394 mg/g), resistant (326 mg/g) and total starches (692 mg/g). Total phenolics with fast blue BB increased as roasting time increased (419 mg GAE/100 g vs. 569 mg GAE/100 g). These preliminary results show promise for the use of roasted quinoa in the development of healthy gluten-free baked goods.

Effects of rough rice drying conditions and exposure durations on bran removal

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The degree of milling of rice is a measure of how well germ and bran layers were removed from the surface of rice kernels during milling. Measuring the surface lipid content of milled rice is one way to quantify the degree of milling. The objective of this study was to evaluate the effect of drying temperature and duration on bran removal rate during milling. Experiments were performed on pureline long-grain cultivar Francis and hybrid long-grain cultivar CLXL729 in which samples were dried at three temperatures (80°C, 60°C, and 40°C) and two relative humidities 43% (shorter exposure duration) and 83% (longer exposure duration) to a target moisture content of 12.5%. After drying, the rice were dehulled and then milled using a McGill No. 2 mill for 10, 20, 30, and 40 sec. Rice surface lipid content was extracted with petroleum ether using a Soxtec method. Results showed that surface lipid content of rice samples dried at the experimental conditions and milled for similar durations were not significantly different. The length of time for which the samples were exposed to high or low temperatures did not have a significant effect on bran removal rate from rice kernels during milling. Overall, the amount of residual bran found on rice kernels after milling was dependent on cultivar and the degree of milling.

Functional and nutritional characteristics of wheat grown in organic, no-till, and conventional cropping systems

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There is growing consumer demand for organic and no-till wheat, due to their perception as being safe, healthy and sustainable. Considering the known effects of environmental conditions on grain yield and quality, we hypothesized that wheat grain characteristics would vary among different cropping systems. We have analyzed functional and nutritional wheat grain characteristics, including protein content, protein quality, total phenolic content, antioxidant activity, and mineral composition of wheat grown in organic, no-till, and conventional cropping systems. In the first study, a soft white wheat cultivar was compared in no-till vs. conventional cropping systems. Wheat from the no-till cropping system had significantly greater kernel diameter and weight and lower protein content than wheat from the conventional tillage system. In the second study, hard red and soft white wheat cultivars were compared in organic vs. conventional cropping systems. Organic soft white wheat exhibited greater test weight, kernel diameter and kernel weight than wheat grown under the conventional cropping system. Organic cropping systems appeared to produce harder kernels than conventional systems. Compared to conventional wheat, grain protein content was 2.3% lower in organic soft white wheat and 1.2% lower in organic hard red wheat. SDS sedimentation volume was lower in organic soft white wheat but was similar in organic hard red wheat compared to conventional wheat, even though organic wheat had lower protein content. Our results indicate that wheat grain characteristics are significantly altered by organic and no-till cropping systems.

Qualitative portrayal of nonstarch polysaccharides extracted from spring wheats

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In the present study, effort was made to characterize eight different spring wheats, e.g., Lasani-08, FSD-08, Mairaj-08, Shafaq-06, Sehar-06, Bhakkar-02, Uqab-2000 and Inqalab-91 with special reference to non-starch polysaccharides (arabinoxylan and arabinogalactan) extraction followed by their utilization in baked product. Arabinoxylan (AX) and arabinogalactan (AG) were extracted by different methods (i.e. ethanol, alkali, acid, and enzymatic method), and were examined for various attributes for instance; total, soluble and insoluble dietary fiber, chemical analysis, mineral profile, rheological characteristics, and phenolic compounds. The extracted phenolic compounds were detected through HPLC; whilst the monosaccharides (arabinose, xylose and galactose) were determined through gas chroma-tograph-mass spectrometer (GC/MS). Bread was prepared and analyzed for physical characteristics, rheological, textural and sensory attributes. The AX and AG content in whole wheat flour of different wheat varieties ranged from 2.93 to 4.68% and 0.47 to 0.93%, respectively while in bran, they ranged from 11.71 to 18.38% and 1.07–4.43%, respectively. Phenolic compounds i.e. ferulic acid, p-coumaric acids were 1.12 and 19.6 mg/100 g, respectively. Owing to presence of these phenolic compounds, it has persuasive antioxidant potential. AX has negative impact on gluten quality as reduced gluten strength was observed while significant results were obtained for rheological characteristic. Moreover, adding AX and AG in bread formulation resulted in significant increase in volume and texture of the final product. Additionally, significant reduction in proofing time was achieved with the addition of arabinoxylan. Conclusively, it may be inferred that non-starch polysaccharides holds potential to be extracted and utilized in cereal based products for best quality and value addition.

Effect of thermoplastic extrusion of maize on the efficiency of bioethanol production of high-gravity worts fermented with *Zymomonas mobilis*

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The growing demand for efficient processes and fermentation technologies for fuel ethanol production have been the driving force for the implementation of thermoplastic extrusion. This technology allows the quick gelatinization of starch. The aim of this research was to compare the use of extruded maize meals with ground maize in terms of characteristics of worts obtained after conventional liquefaction and saccharification. The extruded and ground maize feed stocks contained 17.5 and 7.6% water solubility indexes, respectively. The notorious difference is attributed to structural changes due the mechanical and thermal stresses produced during thermoplastic extrusion. Worts were evaluated in terms of °Plato (12 and 20 ºP), pH and free amino nitrogen (FAN) contents. Results indicated that worts contained a similar initial pH (5.51 ± 0.09) and FAN contents. The rate of consumption of FAN compounds present in worts adjusted to 12°P was not significant different among treatments ($p > 0.05$). However, the thermoplastic extruded maize increased approximately 15.5% the rate of FAN consumption after 8 hr. The initial fermentable sugar content of worts adjusted to 20°P was 2.1% higher in the extruded maize wort compared to the regular ground maize. *Zymomonas mobilis* was capable of fermenting with good efficiency worts adjusted to 20°P. Worts adjusted to 20°P obtained from extruded meals had approximately 21.2% less fermentable sugars after 8 h fermentation and thus generated more ethanol compared to counterparts produced from regular maize meal. This research demonstrated that *Zymomonas mobilis* was capable of fermenting 20°P worts and that the bacterium was more efficient fermenting liquefied and saccharified extruded meals.

Advanced single object grain quality assessment by image analysis

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Cereal Foods World 56:A59

Certain quality parameters such as protein and moisture in grain are measured on a bulk sample. More advanced parameters such as kernel damage or foreign species are single object phenomena, which traditionally are assessed by visual inspection. Such inspection is subjective, costly, time-consuming and often based on a small number of kernels. In spite of these shortcomings, visual classification plays a pivotal role in grain trade and handling. Consequently, there is an urgent need for a machine-based replacement. An image analyzer has been developed integrating: A feeder system; a high resolution 2D and 3D digital camera; a processor handling high-performance chemometrics transforming the information from the images into quality classes; and a network link to provide central control of the system. A 10,000 kernel grain sample is processed in 3 minutes, matching the logistic requirements at grain intake. A single kernel corresponds to 1,5 MB information, corresponding to 15 GB for a sample. Repeatability and transferability across instruments is excellent. Accuracy can, per definition, only be as good as that of the inspectors, as their input is used for calibration of the system. The system will be presented, and performance statistics in comparison with results from traditional visual inspection will be discussed based on instruments used for wheat and barley assessment by Australian grain handlers.

Improving the quality and shelf life of whole wheat bread

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The market share of high fiber and whole wheat bread products is increasing within the U.S. and Europe. Both the authorities and consumers are aware that bread made from refined wheat flour does have limited nutritional value and are therefore looking for more healthy alternatives on the market. A critical success factor when launching the whole wheat bread products lies in the art of producing a texture delivering high sensory quality along with the nutritional benefits. It is well known that a number of food ingredients can be added to whole grain flour or dough to optimize the final bread product both with regards to texture, volume and shelf life. This study's focus is on use of dough strengthening emulsifiers and anti-staling enzymes. Different dough strengthening emulsifiers are tested vs. each other to evaluate the optimal process stability and dough handling conditions. The dough stability is studied by use of dough shock test, measuring the amount of soluble protein found in the dough liquid phase and evaluation of the final bread by volume measurements, C-cell of the grain texture and sensory evaluation. Dryness and crumbliness are some of the key issues when producing a good whole wheat bread and the presentation will demonstrate the superior effect of a maltotetraose producing amylase (G+) improving the final texture, softness and eating quality significantly. Baking trials followed by texture profile analysis are evaluated with regards to crumb softness and resilience. In addition NMR and DSC measurements are conducted to monitor the changes in water properties and to measure the amount of crystalline amylopectin during storage. Both methods are highly correlated to TPA analysis. Finally, sensory evaluations have been conducted and correlated to the analytical data.

Extract of *Cephalaria syriaca* is a powerful agent to strengthen wheat dough

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Wheat flour possessing low protein content does not form strong viscoelastic fibrils. Accordingly, for weak wheat flours, oxidants are used to strengthen dough. A common inorganic oxidant is potassium bromate, however there are safety considerations. *Cephalaria syriaca* is a perennial weedy plant that commonly found in cereal fields and is sometimes used in the Middle East and Central Asia as a natural dough strengthener. The goal of this study was to evaluate dynamic rheological properties of wheat flour with added *C. syriaca*, as well as to identify the constituent in *C. syriaca* that improves dough structure. Oscillatory measurements indicated that addition of 3% defatted *C. syriaca* considerably increased the storage modulus (G') compared to bromated (oxidized) flour. The glutenin macropolymer (GMP) gel extracted from a mixture of wheat flour and 3% *C. syriaca* exhibited high elasticity and structural stiffness. To examine its effect on protein polymerization, chicken egg albumin was used as a model protein. Phenolic extract of *C. syriaca* led to increased protein polymerization as observed in SDS-PAGE due to formation of disulfide bonds and promotion of sulfhydryl-disulfide interchange. These results suggest that the phenolic compounds of *C. syriaca* improve dough strength through interaction with gluten protein.

Mechanisms of stabilizing fibre-enriched dairy products

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Acidified dairy products are one of the oldest types of food products. Unfortunately all of them are low in dietary fibre. Thus, fortification with dietary fibre seems an attractive means of improving the nutritional profile of products such as yogurt or yogurt drinks. However, dairy products enriched with Glucagel (a commercial product high in barley b-glucan) were found to suffer from textural defects. When the Glucagel concentration exceeded a certain value (5 g/L), dramatic phase separation was observed in set yogurt and yogurt drink whose volume fraction of casein micelles exceeded 0.11. To investigate interactions of b-glucan polymers and casein micelles in the milk prior to setting of yogurt, mixtures of yogurt milk and Glucagel were systematically studied. Depending on the volume fraction of casein micelles and the Glucagel concentration, a stable phase or a gel or a sedimented material could exist. The driving force for phase separation was depletion flocculation of casein micelles in the presence of b-glucan. The phase separation responsible for textural defects in yogurt systems supplemented with high amounts of Glucagel can be avoided by the reduction of b-glucan molecular weight, a process that limits the range of attraction between micelles. Incubation of Glucagel with lichenase for varying times shifted the phase separation lines to higher concentration. Enzymatic manipulation of Glucagel is thus an effective means of assuaging product quality issues as the natural properties of the healthful fibre ingredient change.

Higher quality whole grain pasta products: Challenges and opportunities

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Pasta is a low cost, versatile, and healthy grain food served as part of a main entrée or side dish for meals consumed at home and in away-from-home eating environments including restaurants, worksites, and schools. A diverse array of pasta dishes with varied taste, flavor, and textural attributes can be achieved through the use of unique pasta shapes, sizes, and accommodating sauces. Although pasta can be made from a variety of whole grains, whole wheat pasta is the most common. A quality pasta product requires sound execution from grain sourcing and milling to manufacturing, storage, and service. In particular, whole wheat pasta challenges manufacturers because along with the enhanced nutritional benefits comes multiple obstacles in processing, labeling, shelf life, and overall consumer acceptance due to its darker color, grainier texture, and whole wheat flavor. Improvements in whole grain pasta quality could be obtained if manufacturers had a better understanding of processing procedures that affect key attributes of the final product. These improvements could involve changes in wheat flour particle

size, in extrusion and drying techniques, or in formulations to include non-traditional ingredients. Higher quality whole grain pasta products could lead to healthier dining choices via the incorporation of more whole grains per serving. Collaborative efforts by government, industry, and academia along with the input throughout the supply chain of scientists, technologists, regulatory, and policy experts will be required to effectively address grain sourcing and milling, product development, policy guidelines and regulatory issues related to health attributes and use of whole grain pasta by the general public and in-school settings.

Characterization of waxy isogenic lines starch using asymmetric flow field-flow fractionation

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In bread wheat, waxy genes are present at three loci (Wx-A1, Wx-B1 and Wx-D1) and are responsible for amylose synthesis in the grain. The aim of this study was to investigate the relationship between waxy alleles and the molecular weight distribution of starch using asymmetric flow field-flow fractionation with multi-angle light scattering and refractive index (A4F-MALS-RI). Isogenic lines (ILs) of the cultivar Tremie with either one, two or three were used for this investigation. Flour samples were first washed with tris-HCl SDS solution and then starch was extracted by dissolution in 95% dimethylsulfoxide/water, followed by a precipitation and finally solubilised in an alkaline solution with the aid of microwave. Several concentrations of alkaline solution were tested to get the full recovery without any molecular alteration. Integration of RI peak areas enabled calculation of amylose/ amylopectine ratios. The results showed that the waxy null alleles affected the quantitative distribution of molecule fractions of starch. Waxy modifications had an impact on the molecular weight distribution of amylopectine. In the case of the presence of three waxy null alleles, the molecular weight of amylopectine was two times higher than that of normal cultivar.

Effect of annealing on the acid susceptibility of different starches

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The aim of this study was to investigate the effect of annealing on acid hydrolysis of Peruvian carrot, cassava, and potato starches. Starches were annealed for 24 h at 3°C below their onset gelatinization temperatures. Native and annealed starches were then suspended in 2.2 M HCl for 21 days at 35°C. Peruvian carrot starch was the most susceptible to the acid (98%) followed by cassava (75%), and potato (61%) starch. Annealed starches were more susceptible in the first phase (rapid) of hydrolysis, when mainly amorphous areas of the granules were degraded and an expressive decrease of amylose content of starches was observed. On the 9th day of hydrolysis, amorphous areas were completely degraded and the granule shapes, observed by SEM, had faceted surfaces and sharp edges that were characteristic of crystalline material. X-ray patterns of the native and annealed Peruvian carrot (B-type), cassava (C_A-type), and potato (B-type) starches kept unchanged during hydrolysis. The crystallinity of all starches increased until 9 days of hydrolysis, especially for annealed starches caused by the higher degradation of amorphous areas. After 18 days, the crystallinity reduced due to acid action on granule crystalline areas. The amylopectin long branch-chains (DP>37) of native starches were most susceptible to the acid hydrolysis, but chains with DP 13-24 were the most resistant, determined by HPAEC-PAD. After annealing, chains with DP 6-12 of Peruvian carrot starch were more attacked, and cassava and potato starches had their amylopectin long branch-chains less degraded. Analysis of native and debranched hydrolyzed starches suggested that cassava starch had more branch points located in the crystalline lamella, which were further protected against the acid after annealing. Annealing modified hydrolysis profile due to rearrange of starch chains, which exposed the granule amorphous areas to the acid hydrolysis.

Effect of nitrogen fertilization, water stress, and cultivar on the phenomenon "yellow berry" in bread wheat (*Triticum aestivum*)

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In Mexico, the state of Sonora is the largest producer of wheat. However, in recent years, a physiological defect called "yellow berry" is presented in mature grains. This defect does not only affect the yield, but also the quality of grain, which originates penalties in the price, affecting the economy of the farmer and the country. The aim of this study was to evaluate the effect of nitrogen fertilization, water stress and cultivar in phenomenon "yellow berry" in baking wheat. Three levels of total nitrogen available (75, 150 and 250 kg ha^{-1}), three conditions of irrigation (3, 4 and 5 irrigations), and two cultivar of baking wheat (Tarachi and Kronstad) were used. An experimental design of random blocks was used in sub-subplots with three replications. Wheat was harvested and the percentage of yellow berry, thousand grain weight, hectoliter weight, moisture content and protein content was determined. The percentage of yellow berry varies depending on the dose of nitrogen, water quantity and variety, being up 73.47% of yellow berry for treatment with 75 kg nitrogen ha^{-1} (the lowest level), 5 irrigation (the highest level) and cultivar Tarachi. It was concluded that the physiological defect "yellow berry" is a multifactorial phenomenon.

Major determinants of slow fermentation rate in alkali-extractable arabinoxylans and their hydrolyzates from corn, rice, wheat, and sorghum brans

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Arabinoxylans with varying structures have dissimilar fermentation profiles and can result in variable advantages to colon health and general well-being. The objective of this study was to investigate the major structural determinants of slow fermentation rate of arabinoxylans. All alkali-soluble arabinoxylans were extracted from brans, and some were hydrolyzed by endoxylanase and precipitated with ethanol. Alkali-extractable arabinoxylan from corn bran fraction 40–60% ethanol-precipitated (CAX) and from sorghum bran (SAX), wheat hydrolyzate fraction 40–60% (WH), corn hydrolyzate fraction 40–60% (CH) and rice hydrolyzate fraction 60–90% (RH) were used for in vitro batch fecal fermentations and their linkages were characterized. The slowest rate of fermentation was found in WH, followed by CH, CAX, SAX, RH, respectively. Linkage analyses showed that these arabinoxylans are highly branched polymers with degree of substitution higher than 64%. The major structural factor associated with slow fermentation was found to be type of linkage of the branched constituents. Overall, slow fermenting WH, and CAX and CH had high amounts of branches with single xylose units. A unique structural difference that may be responsible for the slower fermentation rate of the WH was the amount of a oligosaccharide side chain with two second level sugars linked at O-2,3 of the xylan backbone-linked arabinose residue. The next less important structural feature related to fermentation rate seemed to be the amount of oligosaccharide side chains with the second sugar (xylose, arabinose, or galactose) linked at O-2, O-3, and O-5 of the xylan backbone-linked arabinose residues. Finally, for these highly substituted arabinoxylans studied, degree of disubstitution with single arabinose units appeared not to be a contributor of the slow fermentation property.

Effect of commercial source on xanthan gum composition and effect on processing and cooking quality of pasta containing nontraditional ingredients

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The objective of this research was to determine the effect of commercial source on xanthan gum effects on the processing and cooking quality of pasta containing nontraditional ingredients. Durum, soy, and oat flours were obtained commercially. Xanthan gum was obtained from three different commercial sources. Durum flour was fortified with nontraditional ingredients (soy flour or oat flour, 10% w/w) and xanthan gum (2% w/w). Blends were analyzed for dough strength using a mixograph. Spaghetti was made with blends and was dried using a high temperature drying cycle (70°C). Processing and cooking quality data of spaghetti was recorded. Results indicated that protein, ash, bulk density, water holding capacity, and total starch content significantly varied among different commercial sources of xanthan gum. Xanthan gum increased the dough strength of durum flour and the extent of strength was related to the source of xanthan gum. For example, time to peak was 2.75 – 4.25 min; peak width was 2.5 to 3.75 BU; and end width was 2 to 3 BU depending on the commercial source of xanthan gum. Processing properties of samples containing xanthan gum differed depending on commercial source of xanthan gum. Samples containing xanthan gum from the commercial source that had the finest particle size (range 68.66–99.67%) required the lowest mechanical energy (range 253.0-270.1 KJsec-1) and had the greatest extrusion rate (range 3.38-3.65 gsec-1), both of which resulted in the lowest specific mechanical energy (range 69.13-78.56 KJg-1) required to

extrude spaghetti samples. Cooking loss (g) and cooked firmness (gcm-1) were not affected by the commercial source of xanthan gum. However, the xanthan gum with the lowest protein content and highest ash content resulted in pasta with the lowest cooked weight.

Determination of oligosaccharide concentration by HPLC using an ion-exchange column with a refractive index detector

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This study compared two methods that quantitatively determine the concentration of oligosaccharides of individual degree of polymerization (DP) up to 8-9. It is often needed in carbohydrate chemistry to understand the oligosaccharide patterns in a sample. Sometimes the content of DP 3-9 fractions is particularly of interest. Traditionally, DP fractions of oligosaccharides are analyzed by using high performance anion exchange chromatography with pulsed amperometric detection (HPAE-PAD). Oligosaccharides with various DPs have different responses on PAD, thus the method required calibration with DP standards. The HPAE-PAD method therefore becomes time consuming due to the requirement of calibration curve for each oligosaccharide DP. In contrast, the HPLC by a silver based ion exchange column (a Rezex RSO-oligosaccharide column) with a differential refractive index (dRI) detector was found to be able to easily quantify DP fractions based on their common specific refractive index increment (dn/dc). In this study, DP fractions of glucose based oligosaccharides from maltodextrins were determined using both methods. DP of 3-9 contents of these oligosaccharide samples were similar between two procedures. The results of HPLC-dRI were found to be well correlated to that of HPAE-PAD ($r^2 = 0.99$).

Analysis of volatile and nonvolatile content and composition of refined and whole wheat bread made from red and white wheat bran by GC-MS

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Adding wheat bran to refined flour in making whole wheat bread contributes a clear and characteristic aroma and flavor not generally preferred by most bread consumers. While several hundred aroma/flavor related compounds in bread have been identified, there is little information on whether there is a material difference contributed by brans of different type that could possibly affect or enhance consumer preference for whole wheat bread or other products. In earlier work reported at this meeting, analysis of headspace volatiles of refined and whole wheat bread using an electronic (E) nose, indicated some clear differences in bread aroma in line with bran color. The main objective of this study was to quantify by GC-MS the composition and concentration of volatile and non-volatile compounds in whole wheat bread formulated with bran (15% flour replacement) from (one) red- and (two) white-grained wheats compared to refined wheat flour bread. More than 50 compounds were identified. Significantly fewer were found in the crust and crumb of refined wheat bread (21) compared to whole wheat bread (average 30). Whole red wheat crumb and crust had higher number of compounds (38) in considerably higher total concentration (286 mg/kg) compared to number (26) and concentration (59 mg/kg) of whole wheat white bran bread. Major reaction compounds like furfural, 2-furanmethanol, pyranone, maltol and 5-hydroxymethyl-2-furancarboxaldehyde were present in highest concentration in whole red wheat bread. Between the two breads made using white wheat bran, significant differences were found in compound number and concentration. Results indicate that choice of bran used in whole wheat breadmaking could make a practical difference in consumer preference. Taken together, results of this study were in very good agreement with the classification outcomes by E-nose analysis.

Discrimination of aroma of refined and whole wheat bread made from red and white wheat bran using an electronic nose instrument

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While consumption of whole grain foods continues to increase, only a small proportion of total grain-based foods is eaten in North America as whole grain. Among the few barriers that are believed to limit greater adoption of whole grain foods by consumers, is the different and relatively strong aroma and flavour contributed by bran. For whole wheat products and bread in particular, there is some anecdotal information, but very little scientific evidence, that whole wheat bread produced from white-bran wheats are milder in sensory properties compared to red-bran counterparts. The main objective of this study was to evaluate how inclusion of bran from white and red wheat affected the discrimination of bread samples by electronic (E) nose (Alpha MOS FOX-3000) analysis of headspace volatiles. Whole wheat flour was formulated with a common refined flour, blended with bran (15% replacement) milled from representative samples of one hard red and two hard white wheats. A commercial formula was used for breadmaking. Results varied according to the nature of the sample, i.e. crust, crumb or whole slices. For crust, the greatest distinction in aroma was between refined flour bread and whole wheat breads as a group. When refined bread crust was misclassified, samples tended to be confused with whole white wheat crust predominantly of one genotype. Whole wheat bread crust classification results mainly reflected bran colour. For bread crumb, the pattern of discrimination was different; whole wheat bread with red bran was perfectly distinguished from all other breads, indicating a clear distinction in bread aroma according to bran color. Results support the view that wheat bran contains molecular components which, when processed by breadmaking, manifest a pattern of volatiles characteristic of bran color and possibly, in part, also genotype. The E-nose appears to be very capable of revealing these differences in bread.

Fully stable 13C-labeled internal standards for mycotoxin analysis

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The popularity of LC-MS/MS methodology for analysis of mycotoxins is increasing. However, interferences from matrix components in these methods can lead to differences in analyte ionization. Ionization efficiencies can vary between matrix samples and pure standard calibrants, causing the mass spectrum to show different signal intensities. Because of this, the sample analyte peak cannot be compared to the calibration curve (made from pure standard calibrants) for concentration calculations. To overcome this ionization effect, 13C isotope-labeled internal standards were used. 13C-labeled mycotoxins have the same characteristics as their 12C analogues, eluting at the same retention time in chromatography. They are separated by the mass difference between the 12C and 13C mycotoxins. The 13C peak, representing the known amount of 13C labeled mycotoxin added, can be used to calculate the unknown amount of the 12C mycotoxin. A method utilizing this technology was developed for the simultaneous detection of eight Fusarium mycotoxins in cereal grains, including maize and wheat. The toxins included type A and B trichothecenes and zeralenone. LODs ranged from 1 to 4 ug/L, and LOQs ranged from 2 to 20 ug/L. The %RSD of multiple repetitions of spiked samples was less than 15% overall, and most data points showed variation of less than 10%. Recoveries of the toxin from spiked matrices varied by toxin and matrix and ranged from 50 to 110%. The results were also compared with a GC-ECD method. They compared favorably, with only a 2% difference seen between the methods over concentrations ranging from 30 to 1000 ug/kg. The use of 13C-labeled internal standards with LC-MS/MS allows for methods which are applicable to a wide variety of analytes, with no limitations by molecular mass, a straightforward sample preparation, and no chemical derivatization required. This is the basis for multi-mycotoxin analysis.

A rapid and efficient micro-scale extraction procedure for total yellow pigments in durum semolina and whole meal

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Cereal Foods World 56:A61

Total yellow pigment (TYP) content is a key quality trait in durum wheat because of its importance in determining the color of pasta. High TYP content is the target of durum breeding programs. The standard methods for measurement of TYP require a large sample size and a 16–18 hour extraction time, which limits their application as a screening tool for breeders. This study developed a rapid and efficient micro-scale extraction procedure for TYP in durum semolina and whole meal. Durum wheat semolina or whole meal (200 mg) was homogenized with 1.0 ml of water saturated butanol for five minutes in a micro-centrifuge tube with the presence of a steel bead. The mixture was rested for 1 hr before centrifugation. Absorbance of the supernatant was measured using a spectrophotometer and converted to yellow pigment concentration as specified by the AACC method. TYP of a set of samples with a wide range in pigment concentration were extracted by both the new method and the standard AACC method. The TYP contents obtained using the new extraction procedure were 4–7% higher than those using the standard method for the same sample. This indicates that the new method with homogenization increases the pigment extraction efficiency in both semolina and whole meal. The new pigment extraction procedure significantly reduces the sample size and extraction time for pigment measurement in durum semolina or whole meal, and therefore can be used for early generation screening in durum wheat breeding programs. It is also useful in preparing pigment extracts for biochemical analysis.

Rice pasta with soy protein isolate, modified albumin, and pregelatinized rice flour

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Rice can be used for the development of gluten-free products, mainly for people with celiac disease. However, protein content in rice flour is low and deficient in essential amino acids. The aim of this study was to develop increased protein rice pasta following a Central Composite Rotational Design with three independent variables: soy protein isolate (SPI), 0–20%; desugared and cross-linked egg albumin (ALB), 0–15%; and pre-gelatinized rice flour (GRF), 0–30%. The pasta samples were produced with a laboratory pasta extruder and then dried in an oven with forced air circulation at 50°C for 2 hours and then at 60°C for 2 hours, until moisture content was below 12%. The dependent variables analyzed were cooking time, solid loss in cooking water, weight gain, firmness and stickiness after cooking. The results obtained for cooking time, solid loss in cooking water, weight gain, firmness and stickiness were between 300 and 525 s, 2.22 and 9.84%, 1.01 and 1.79, 4.82 and 11.13 N, and 0.11 and 1.03 N, respectively. Lower values for cooking time were obtained with higher levels of SPI and ALB, and 15% GRF ($p < 0.10$). Solid loss in cooking water was lower with SPI levels between 10–15%, high levels of ALB, and 15% GRF ($p < 0.10$). Weight gain was higher with low levels of SPI, 10% ALB, and 15% GRF ($p < 0.10$). Pasta with higher firmness values was obtained with extreme values of SPI, high levels of ALB, and 10% GRF ($p < 0.10$). The independent variables did not influence stickiness. For all the variables that showed a significant difference, the R^2 value was higher than 0.70 and the p-value was lower than 0.003. The relationship between F_{calc}/F_{tab} was 2.95 for weight gain, 4.12 for firmness, 4.82 for cooking time, and 19.83 for solid loss in cooking water. Pasta with the best technological characteristics was obtained with 17% SPI, 15% ALB, and 15% GRF.

Evaluation of vital gluten addition, moisture content, and extrusion temperature in the production of a meat extender through thermoplastic extrusion

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Isolated soy protein is used for the production of meat extenders using the extrusion process at low moisture contents (20–25%). The aim of this work was to evaluate vital gluten addition (X_1 – 0–40%), moisture content (X_2 – 16–30%); and the 3rd and 4th zones temperature (X_3 – 100–160°C) in the production of a meat extender following a Central Composite Rotational Design. The trials were processed in an intermeshing co-rotational twin screw extruder (model ZSK 30 – Werner Pfleiderer Corp.) with 1st and 2nd zone temperatures at 60 and 80°C, respectively, screw speed (300 rpm) and circular die (2.6 mm) and dried at 85°C using a convective heated air dryer until moisture content was below 8%. The dependent variables evaluated were compression force (CF), fat absorption index (FAI), water hydration capacity (WHC), and protein dispersibility index (PDI) of the meat extender. The values obtained for CF, FAI, WHC, and PDI were between 14.92 and 97.61 N, 187.33 and 210.19%, 0.92 and 3.94 $mL.g^{-1}$, and 12.78 and 19.29%, respectively. High levels of vital gluten addition and moisture content resulted in lower FAI, WHC and PDI, and in higher CF ($p < 0.10$). The increase of 3rd and 4th zones temperature resulted in lower PDI. The highest values for CF and FAI were obtained with an intermediate extrusion temperature (130°C) ($p < 0.10$). However, 3rd and 4th zones temperature did not influence WHC. In all cases, the R^2 value was higher than 0.85, p-value below 0.006 and the ratio between F_{calc}/F_{tab} was 2.39 for FAI, 5.70 for CF, 7.44 for PDI, and 12.38 for WHC ($p < 0.10$). The lower values of PDI obtained with vital gluten addition were the result of the lower nitrogen solubility of the gluten fraction. In general, higher protein denaturation was obtained with low moisture contents and intermediate extrusion temperatures. Acknowledgements to CNPq, SOLAE, and GRANOTEC.

Mechanism of deterioration of bread baked with frozen dough

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We prepared dough A (a mixture of wheat flour, sugar, salt, and water), dough B (a mixture of dough A and yeast), and dough C (1st, and 2nd -proofed dough B), and froze (–20°C) them for 6 days. They were thawed at 5°C for 16 h, and subjected to their breadmaking processes. Results indicated that breadmaking properties (bread height (mm) and specific volume (cm3/g)) after dough A and B processes were same to that of control dough (non-frozen dough), however, dough C process showed depression of the breadmaking properties. Sugar was added to frozen and thawed dough C (dough C-1), and yeast was further added to dough C-1 (dough C-2), and they were subjected to their breadmaking processes, respectively.

Effect of the addition of pregelatinized rice flour and modified albumin on the technological properties of fettuccini-type rice fresh pasta

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Celiac disease is a genetic disorder that is characterized as intolerance to gluten in different degrees, and its treatment is only the withdrawal of wheat, rye, barley, oats and malt from the diet. Rice is the most suitable cereal for the production of gluten-free products for being considered less allergenic. The aim of this study was to develop fettuccini type rice fresh pasta through the process of cold extrusion. To obtain the pasta, a 2^2 Central Composite Rotational Design (CCRD) was used, where the effects of the addition of pre-gelatinized rice flour (PGRF, 0–60%) and modified egg albumin (MEA, 0–10%) were studied. The dependent variables were the results of the cooking test (cooking time, weight gain and loss of solids in the cooking water) and texture (firmness and stickiness). The amount of water added to each formulation was determined according to the Water Absorption Index (WAI) previously determined for the raw materials and for the 12 trials of the experimental design. The optimum cooking time for all the formulations of rice fresh pasta was 3 minutes. It was found that MEA had a greater effect in increasing the weight of the final product after cooking when compared to PGRF. It was verified that, by increasing the addition of PGRF, there was an increase in the loss of solids in the cooking water, whereas MEA exerted the opposite effect on this parameter. Moreover, the maximum level of albumin had a positive effect on pasta firmness, making it firmer, while PGRF exerted this effect only if added in small quantities. The maximum values of PGRF and MEA increased the stickiness of the pasta. Based on these results and on the parameters considered most important (less stickiness and less loss of solids), the rice pasta with better technological characteristics was that with the maximum levels of MEA (10%) and no addition of PGRF.

Formulation of additives to retard the discoloration of white salted raw noodles

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Color is a primary quality attribute of all noodles as noodles are "seen" before they are eaten. Asian noodle discoloration, which is mainly caused by polyphenol oxidase (PPO) activity in the flour, is unacceptable to consumers. Use of appropriate antioxidants, chelating agents or pH modulating agents has shown some effectiveness in inhibiting PPO activity in Asian noodles, thus retarding the browning process. Combined use of various browning inhibitors can produce synergistic effects to achieve optimal results. In this study, seven additives, i.e., ascorbic acid (Vc), ascorbyl palmitate, magnesium-L-ascorbyl-2-phosphate, N-acetyl-L-cysteine, L-cysteine-hydrochloride, sodium acid pyrophosphate (SAPP-28), and inositol phosphate, were tested as to their retarding impacts on the white-salted raw noodle discoloration. Vc, magnesium-L-ascorbyl-2-phosphate, and SAPP-28, which were found more effective, were optimized to give a formulation with the highest protection of noodle color. The optimized formula, compared to the control, reduced the reduction in the L* values (lightness) and hardness values (determined on the boiled noodles using the TA-XTPlus Texture Analyzer) of the noodle after 48 h of storage under room temperature by ~50% and ~25%, respectively. The anti-oxidative, pH lowering and chelating functions of the additives are suggested to account for these effects.

A novel liquefaction enzyme for single pH corn to ethanol process

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Liquefaction is a significant unit operation in converting corn to ethanol in a dry grind corn process. During liquefaction, high temperature (85°C) and high pHs (pH 5.8 to 6.0) are used with conventional alpha amylases for solubilizing and gelatinizing the starch. The pH has to be adjusted down (pH 4.8 to 5.2) for the following unit operation of simultaneous saccharification and fermentation (SSF). This existing industrial process requires multiple pH adjustments and split dose addition of liquefying enzyme. The pH adjustment using sulfuric acid results in higher sulfur content in DDGS which is environmentally undesirable and adds chemical cost. These problems were overcome using a novel liquefaction enzyme. This product enables unadjusted pH to be used for liquefaction and SSF unit operations and offers single dose in the liquefaction

step. The product's properties, application and the benefits to ethanol producers and their customers will be discussed.

Rheological properties of bran-enriched steamed bread
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Wheat bran is one of the major dietary fiber sources widely used in the food industry in order to produce fiber-enriched foods. The effects of wheat bran substitution (0–30%), water absorption (46–62%) and electric power (4–12 kW) of steamer on stress relaxation and textural parameters of steamed breads were evaluated by Texture Analyzer. Results showed mechanical stress relaxation data of steamed breads were fitted well by both Peleg-Normand and three-element Maxwell models. At 10–40% strains tested, bran-enriched steamed breads were more elastic measured at low strain. It was suitable to perform the stress relaxation test of steamed bread at 20% strain. Generally, increasing the substitution of flour by bran resulted in less elasticity and more hardness of steamed bread. Medium and high water absorptions (54–62%) produced fiber-enriched steamed bread with better elasticity and texture. The elasticity of the steamed bread was the lowest at 4 kW electric power of steamer. Significant correlations were found between textural characteristics and stress relaxation parameters. This study suggests 20% bran-enriched steamed bread, with better elasticity and texture, can be produced at 54–62% of water absorption and 8–12 kW of electric power of steamer.

Quality characteristics of rice flours and gluten-free cupcakes from high-yielding rice varieties in Korea
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Korean rice varieties, Druryechanbyeo and Boramchanbyeo, were newly developed to get higher yielding rice varieties than general japonica type rice varieties and ultimately, to be used in processed rice products. The quality of rice flours prepared from dried rice grains after soaking with a dry milling method was investigated in order to substitute those rice flours for wheat flour. Their physical and pasting properties were compared with dry milled native rice flours' properties. The quality of rice cupcakes was evaluated by the specific gravity of cake batter and their volume, textural and sensory properties. The newly developed rice flours (NDRF) had higher apparent amylase content, water binding capacity, swelling power and peak viscosities, but had lower damaged starch, color difference, gelatinization temperature, and final and setback viscosities than commercial dry-milled rice flours (CDRF). The specific gravity of cake batter, and hardness, springiness and cohesiveness of rice cupcakes were lower in NDRF than in CDRF. On the other hand, the specific volume of rice cupcakes showed a reverse trend. The textural properties of rice cupcakes from Boramchan NDRF were more preferable than those of Druyechan NDRF. Sensory evaluation showed that air cell uniformity, volume, smoothness, softness, and moistness of rice cupcakes in a difference test and overall quality in a preference test were significantly different.

The effect of pea hull fibre particle size and addition level on wheat bread quality
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An emphasis on food and health relationships has driven bread manufacturers to pursue strategies for enriching products with healthful ingredients while maintaining a focus on optimal product quality. We studied yellow pea hull fibre's effect on bread quality arising from fibre interactions with bubbles in the dough. Four different fibre particle sizes (180, 125, 106, 90 µm) were added at 0, 2, 4, 6, 8 g/serving into a sponge and dough formulation. When water absorption was not altered from that of the control flour, the loaves' specific volume significantly decreased as fibre content increased and particle size decreased. C-cell analysis of the crumb showed that for a given fibre loading, cell size homogeneity increased as particle size decreased, suggesting that volume depression arose from high dough viscosity limiting gas cell expansion rather than from fibre particles promoting gas cell coalescence. In support of this observation, work input during dough mixing increased with fibre loading and decreasing particle size. Breads were rebaked using optimal water levels determined by farinograph absorption. Mixer work input was essentially equivalent amongst treatments. No particle size effect on crumb cell size heterogeneity was evident. Significant improvements in specific volume were observed overall, except at high fibre loadings and smaller fibre particle size. In both optimized and non-optimized loaves, the effect of pea fibre on bread quality is attributable to enhanced dough viscosity rather than to greater coalescence arising from fibre particles interacting with bubbles in the dough.

Antioxidant properties of pea hull fibre in wheat bread
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Antioxidants are a proven health-promoting ingredient for combating cellular damage caused by free radicals. Prior research has indicated that material extracted from yellow field peas (*Pisum sativum* L.) exhibits antioxidant properties. This study measured the antioxidant capacity of yellow pea hull fibre fractions and fibre-enriched bread (prepared in a sponge and dough formulation). The 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging assay was used to measure antioxidant activity. Scavenging activity was reported every 2 minutes up to 10 minutes, and then every 5 minutes up to 30 minutes. In comparison to an antioxidant control of ascorbic acid, the reaction kinetics of the pea fibre was fairly slow. All pea fibres had substantially greater antioxidant scavenging ability compared to wheat flour, but there was minimal difference in activity between the pea fibres of different particle size. The effect of baking on antioxidant activity of control bread and bread with 180 µm fibre at 6 g/serving was also determined. Although antioxidant activity decreased in the bread compared to the raw fibre, even bread with 6 g of fibre had significantly higher antioxidant activity compared to that of the control bread. In addition to the health benefits associated with fibre, this research demonstrates that there are additional nutrient benefits associated with pea hull fibre enriched bread.

Effect of trehalose on fermentation, proteins, and volume of French-type bread prepared with frozen dough
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The quality of bread from frozen dough is related to yeast viability and gluten proteins functionality. To improve frozen dough quality, trehalose has been used as a crioprotectant additive for yeast and protein. The aim of this research was to evaluate the effect of trehalose on the retention of CO2 by gluten proteins, and on the volume of French type bread. A formula containing wheat flour (100%), 3% dry yeast, 1.5% salt, and 5% shortening was used. Trehalose as additive was included in concentrations of 0, 200 and 400 mg / kg. Dough was elaborated and pre-fermented for 10 min. Then dough was molded, frozen and stored at –20°C for 8 weeks. Dough samples were taken every two weeks, thawed at refrigeration conditions (4°C), fermented for 50 min and evaluated. Production and retention of CO2 was measured in a reofermentograph, and changes in soluble gluten proteins were evaluated with Size exclusion HPLC. In addition, French type bread was made, and its specific volume was evaluated. Trehalose increased CO2 retention during fermentation, by reducing glutenin depolymerization. Trehalose also improved bread volume.

The assessment of water mobility in soy-based bread dough by magnetic resonance imaging (MRI)
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Water properties in a food matrix can affect physical and nutritional properties of functional foods. For example, during frozen storage of dough, water migrates from macromolecules to ice crystals, irreversibly disrupting the structure. Also, partitioning of phytochemicals in the water phase may affect bioavailability. To more accurately describe heterogeneous changes in the water properties of bread dough, MRI allowed the use of ^{1}H intensity and T_2 relaxation maps to measure the affects of 1) soy addition, 2) the amount and type of lipid, and 3) frozen storage time on water mobility in dough. Soy was hypothesized to hinder the water migration during frozen storage due to the protein's high ability to bind water. Different lipid components were expected to differently compartmentalize water pools. The location and mobility of water from non-yeasted wheat and 25% soy dough that was frozen for 0, 2, or 4 wks were assessed using a 4.7 T MRI. ^{1}H intensity maps showed that water did not migrate on a mm-cm scale during frozen storage. Fresh wheat dough displayed a normal distribution of T_2 relaxation times centered about 12.9 ± 0.4 ms (mean ± SD). The distribution shifted to 13.4 ± 0.5 ms with 4 weeks of storage. Addition of soy caused the T_2 distribution of fresh dough to decrease to 12.5 ± 0.2 ms, but the changes during storage occurred at a similar rate and

extent. Dough made with shortening or almonds displayed similar T_2 distributions, but that made with canola oil showed an increased average T_2 as well as a bimodal distribution. An increase in the quantity of any lipid from 3.4 to 10% showed a drastic increase in mean and SD of the T_2 distributions. In conclusion, frozen storage had a larger effect on water mobility than soy addition. The amount and type of lipid in the dough also has the potential to affect shelf life or soy isoflavone bioavailability in dough.

Effects of additives on yellow pea gluten-free pasta processing parameters and products quality

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Gluten free (GF) pastas available commercially are low in protein and dietary fiber. GF flour from leguminous crops, such as peas (*Pisum sativum*), have high protein and dietary fiber. To determine suitability of yellow pea (YP) flour for making GF macaroni, the effects of additives on the product quality and processing parameters were studied. Commercial pre-gelatinized YP flour was treated with distilled monoglycerides (DM), egg white (EW), xanthan gum (XG), and a combination of the three additives (COM). Texture analysis, cooking properties, moisture, and color were determined. Pasting properties were determined on raw flour and ground pasta. LSD statistical test were conducted to verify differences. All gluten free pastas had significantly darker color (L*) and less yellowness (b*), compared to control durum pasta ($P < 0.05$). Raw YP flour had a 3-fold lower pasting property compared to the ground YP macaroni. Compared to the control YP and durum macaroni, all additives significantly reduced pasting temperature and XG, DM, and COM decreased peak time ($P < 0.05$). YP flours had significantly ($P < 0.05$) lower extrusion rates than control durum flour during extrusion. XG increased extrusion rate compared to other treatments. Extrusion pressure, temperature, and amperage were not significantly different ($P > 0.05$) between treatments. YP pastas had higher cooking loss (15.1%) compared to control durum pasta (3.6%). XG reduced cooking loss of YP pasta to 12.1%, while COM increased cooking loss of YP pasta to 17.7%. XG, DM, and COM resulted in similar firmness value compared to control durum pasta ($P > 0.05$). Among all treatments, XG had the most beneficial effects on GF macaroni made from YP. COM decreased the product quality. Gelatinized YP is suitable for making GF macaroni however; high cooking loss is a challenge. Inclusion of higher concentration of additives is recommended.

Characterization and acceptability of pinto, navy, and black bean extrudates

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Consumer acceptance will play a significant role in determining the future of extruded beans as a viable snack food in the United States. Pinto, navy and black beans were milled using a Fitz mill. Milled samples were extruded on a twin screw Wenger TX 52 extruder at 320 rpm. Raw bean flour and extrudates were characterized for total protein, total starch, resistant starch and crude fiber. Sensory evaluation was conducted by 40 adult panelists using a hedonic scale (dislike extremely (1) to like extremely (7)) to rate appearance, flavor, texture and overall acceptability. Texture was also determined using a texture analyzer. Expansion index was calculated. Total protein in extrudates ranged from 19.8% (pinto) to 21.7% (navy) and was significantly different among three beans. Total starch ranged from 39.8%–40.6% and was not significantly different. Resistant starch in extrudates was low; 0.5% (navy) to 1.00% (pinto) although resistant starch in raw bean flours averaged 37.9%. Crude fiber in flours ranged from 3.5% (pinto) to 4.1% (navy), and was not significantly degraded after extrusion. Results confirmed excellent expansion index of beans; exceeding 3 times the die diameter in all beans. Sensory results indicated that navy extrudates had the most acceptable appearance (6.1) while black bean had the lowest (3.4). Flavor acceptances ranged from 4.1 to 4.4 and were not significantly difference among beans. Texture of black beans was the least acceptable compared to pinto and navy extrudates. Overall acceptability ratings indicated that black bean extrudates were the least acceptable (4.0) while navy extrudates was the most acceptable (4.7). The presence of a 'beany' aftertaste and stickiness of samples on teeth was noted by some panelists. However, no attempt was made to evaluate ingredients that might reduce stickiness or provide flavor masking.

Fortification of wheat flour with corn bran in baked products

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Development of wholesome and nutritious fiber rich food products with acceptable functional and sensory quality is a major industrial concern, seeking to capture consumer's interest in healthy and functional foods. Dietary fiber in corn bran is known for its beneficial effects on human health and nutrition. The main objective was to develop and characterize cakes with added corn bran to increase the dietary fiber intake Purified ultrafine food-grade corn bran (free of germ and endosperm), a byproduct from the grain milling industry that is a good source of dietary fiber replaced flour in cakes at 0, 5, 15, 20, 25, and 30% level. The effects of corn bran substitution on batter viscosity, cake volume, crumbgrain, cake color, cake texture cake were examined. Pasting temperature and peak time of cake batters were not affected by the corn bran fortification. The peak viscosity of cake batters was lowered by increasing levels of corn bran in cake batters. However, setback was not affected by corn bran addition. Hardness and springiness of cakes was not affected by the increasing levels of corn bran fortification in cake batter. The optimal corn bran fortification based on these measurements was determined. Flour fortified with 20% corn bran resulted in cakes with acceptable sensory scores based on texture, taste and overall acceptability of the cakes. This study will improve human health using functional ingredients in baked foods, and benefit the bakery industry by generating new products offering healthy alternatives.

Developing RP-HPLC method for detection of peanut allergens

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During this study various RP-HPLC conditions for detecting peanut allergens were compared. Three major peanut allergens Ara h1, Ara h2 and Ara h3 were targeted for identification using HPLC. Raw and unsalted U. S. Virginia peanuts were used for the preparation of crude peanut extract (CPE) using a published procedure. CPE, (0.0012 g/ml) was analyzed for allergens using a C18 column at various wavelengths (280 nm and 220 nm) and solvent conditions. Method 1 (Solvent A -0.05% TFA in HPLC water; B-linear gradient 0.05% TFA in methanol) and Method 2 (A - 0.1% TFA in HPLC water and B-linear gradient 0-100% acetonitrile) were used to run all the samples. CPE in distilled water (0.006 g/mL) was spiked with one of the three pure allergens obtained from USDA (New Orleans, LA). During spike test increase in peak height using pure allergens was used to identify allergen peaks in RP-HPLC chromatogram. HPLC profiles were compared for retention time of allergens, resolution (resolution from the allergen peak to the preceding protein peak) and peak heights. The best method was identified to be the one with lesser retention time, better resolution and more peak height. In general 220nm provided higher peak heights using method B. Under the best conditions Ara h 1 and Ara h 2 were individual peaks at 18.6 and 14.4 minutes, Ara h 3 eluted as a set of 3 peaks ranging from 19.2–21.2 minutes. To further confirm that the peaks are allergens, the fractions of corresponding allergens were collected, freeze-dried to run SDS-PAGE and immunoblotting tests.

Starch granules used for Pickering emulsions

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Cereal Foods World 56:A64

Intact starch granules can be used in new applications as particles for stabilizing emulsions, so called Pickering emulsions. Starch from cereals and pseudo cereals have been used to investigate the stability of emulsions, and the barrier properties of the stabilizing starch layer upon heating. The granules were modified either with octenyl succinic anhydride (OSA) or by applying dry heat to increase their hydrophobicity. Both treatments were sufficient to achieve acceptable emulsification properties of small granules. The drops in the emulsions prepared were in the 10-100 µm range and could be varied by the starch concentration used. The drop size decreased with an increased amount of added starch granules. During storage for up to 8 weeks, the emulsion drops were stable to coalescence and the volume occluded by the emulsion phase was unaffected or even increased. From rheological measurements it was seen that the emulsions formed weak gel systems. As could be expected, the higher the concentration of oil in the system, the greater the elastic modulus, and the higher the shear stress could be increased before breakdown of the gel structure in the emulsions occurred. In order to increase barrier properties of the starch at the oil-water interface the emulsions were gently heated. This induced a partial gelatinization of the starch granules. Starch gelatinization was evaluated using differential scanning calorimetry and microscopy. Barrier properties were characterized by a lipolysis experiment where the activity of lipase was measured. The lipase activity could be decreased by nearly 70% compared to an unheated emulsion. This may find use in applications where protection of substances during storage, or the release of specific substances in the gastro intestinal tract, is desirable.

Functional properties of flour from European lymegrass (*Leymus arenarius*)

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As an initial study to evaluate non commercial sources of starch for use in food applications, flour from a wild grown Swedish population of European lymegrass, *Leymus arenarius,* was analysed for functional properties. European lymegrass is a dune-building grass used to stabilize drifting sands in cold climate. Waxes produced by the plant have previously been investigated, but not the flour. Since the dunes where the lymegrass is grown is rather deficient in nutrients, the seedlings have previously not been generally regarded as interesting from a food perspective. The grass was harvested by hand and further processed into flour. The falling number was determined and starch gelatinization properties analysed by differential scanning calorimetry. In a preliminary baking study, flour was mixed with sugar, salt, yeast and water, and baked into bread buns. The shape and porosity of baked breads was then compared to breads baked using wheat, rye, and barley flour, respectively. The results showed that the shape and porosity of lymegrass bread were comparable to rye bread and gave better results than the bread baked using barley flour. The recipe used was standardized for wheat bread and thereby not optimized for other types of flour. These results indicated that interesting functional properties of lymegrass flour and/or starch can be further explored for novel applications.

Quantifying nitrogen—EDS vs. pyrolysis

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A method for accurate and reproducible nitrogen quantification is presented, which is based upon energy dispersive X-ray spectroscopy (EDS). The method reproduces the amount of nitrogen predicted by the chemical formula for the material. This EDS-based method is compared to results produced by more traditional methods like Kjeldahl, Dumas or LECO (pyrolysis-based methods), some of which have been in use for nearly 200 years. The pyrolysis methods have been questioned regarding their accuracy; however, there has not been a reasonable way of demonstrating any potential shortfall. The accurate determination of nitrogen is important to determining accurate protein content (a critical nutritional consideration). Historically, with pyrolysis, fudge factors have been used to assist in the calculation of protein content (typically 5.7–6.25, depending upon the test material and the test method). Therefore, pyrolysis results are, at best, an estimate. The EDS test methods see all chemical forms of nitrogen, working on an elemental scale rather than a chemical scale. Analyzing various amino acids from L-arginine through L-tyrosine, and using a standard-based least squares method, the EDS technique reproduces the chemical formula. Applying the method to more complicated materials such as soy flour, protein isolates or bovine albumin, the method indicates 15–28% more nitrogen (depending upon the material) than the pyrolysis-based methods indicate, prior to compensating for protein calculations. The pro's and con's for both systems are reviewed. The EDS technique may help explain why compensating factors are needed for the industry standard methods, and why they differ for differing materials.

Development of consumer acceptable new gluten-free tortilla: Nutritionally balanced with good sensorial characteristics

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Cereal Foods World 56:A65

The mayor problem linked in the production of gluten-free products is absence of gluten, the main protein in wheat flour, which is responsible for elastic characteristics of baked products. The U.K. market research showed that gluten-free tortilla is hardly available, probably because the complexity for replacing gluten with suitable ingredients. The main objective of this work was to develop realistically priced gluten-free tortillas with the good nutritional and sensorial characteristics. After assessing various formulations for sensory and functional properties the following formulation was developed: gluten-free flour, arrowroot starch, sorghum flour, rice bran, milk powder, egg, raising agents, xanthan gum and salt. All the ingredients were mixed, rolled out until thin enough, shaped into tortilla, cooked for few minutes, cooled down and vacuum packed in order to preserve freshness and prolong shelf life. The nutritional content of the gluten-free tortillas was calculated using Netwisp program. Extensibility and toughness were measured using TA – XT2 texture analyzer, shelf life during six days, water activity and Ph. Twenty members of the Coeliac society of Manchester were asked to assess the product for the following attributes: flavour, quality of the product design, value for the money and innovation by marking a 10 cm line. The following nutritional information were obtained: proteins –6.2%, CHO – 46.5%, –4.7%, fat – 10.4%, fibre – 4.2% and sodium 0.4%. A significant ($P < 0.05$) decrease of toughness and increase of extensibility was noticed over the period of 6 days. The water activity of the tortillas was 0.88 and ph 5.7. The maximum shelf life for vacuum packed gluten-free tortilla stored at 3-8C would be around 10 days. The total price for six gluten-free tortillas including 30% manufacturing cost was £3. The taste panel acceptability score was maximum for all the attributes.

Structure/function relationships of barley limit dextrinase and limit dextrinase inhibitor

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The starch debranching enzyme limit dextrinase (LD) hydrolyses alpha-1,6-glucosidic linkages in limit dextrins and amylopectin during seed germination. The activity of LD is controlled by the endogenous limit dextrinase inhibitor (LDI). Both LD and LDI have been prepared recombinantly by the host *Pichia pastoris* and the crystal structure of LD was solved at high resolution in complex with carbohydrate ligands bound at the active site. LD is highly active towards pullulan and site-directed mutagenesis has been performed of the bulky Met440 situated at subsite +4 to unravel its role in substrate specificity and of the catalytic nucelophile Asp473 to determine the crystal structure in complex with substrate. LD and LDI bind very tightly with Kd around 40 pM. Modelling is done in an attempt to point out LDI disulfide bonds situated at the protein interface and to correlate this with reduction by thioredoxin and loss of LDI activity. Crystallisation of the LD/LDI complex is in progress. This work was supported by two DTU PhD scholarships (MSM, MBVC), an Oticon M.Sc. scholarship (JMJ), and grants from the Danish Natural Science Research Council and the Carlsberg Foundation.

Influence of shape and packing efficiency on popcorn expansion volume measurements

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Expansion volume is the most important and often reported quality factor for microwave popcorn, because "lighter and fluffier" popcorn is positively correlated with more desirable sensory attributes. The objective of this investigation was to understand the effect of flake shape and packing efficiency on expansion volume measurements. In the first part of this study, an experimental design requiring 65 runs was conducted across a range of microwave wattages (800–1250 W) and oil additions (0–30%) using a set of 9 popcorn hybrid*environment samples. Data collected included the expansion volume and percentage of different flake shapes, which were characterized by visual inspection depending on whether the appendages were expanded unilaterally, bilaterally, or multilaterally. Analysis revealed the shape of popcorn flakes made a statistically significant but limited contribution to expansion volume, with a positive correlation between expansion volume and bilaterally-expanded flakes ($p < 0.01$, $r = 0.323$) and a significant and negative correlation with unilaterally-expanded flakes ($p < 0.01$, $r = –0.565$). In the second part of this study, packing efficiency for three microwave popcorn hybrids was measured by displacement method using rapeseed, amaranth seed, and sand. Results estimated the physical space occupied by popcorn flakes in bulk density measurements to be 46.3 ± 2.8% for rapeseed displacement, 35.2 ± 1.4% for amaranth displacement, and 29.1 ± 1.9% for sand displacement. These results suggest that the void spaces created by inefficient packing between popped kernels has a significant effect on the measured and reported values for popcorn expansion volume.

Effect of extrusion on breakfast cereal from special sorghums containing phytochemicals

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Extrusion of whole and ground sorghum grains produces an array of different snacks and ready to eat breakfast foods; extrudates of colored sorghums have a dark brown highly desirable color. Phenol levels in colored and tannin sorghums, which are highly associated with potential health benefits, are higher compared to white sorghum and other cereals. In black and high tannin sorghums, these compounds are found mostly in the bran. High shear during extrusion can reduce phenolic content; however, fortification with black or

high tannin bran can increase the phenols of the extruded product. Ground white, black and tannin sorghums at a level of 85% were mixed with bran from high tannin sorghum up to 6% of total formulation weight, and extruded in a twin screw extruder to produce acceptable extruded breakfast cereals. Addition of black sorghum bran produced high density extrudates because its bran has a different structure. Antioxidant activity (ABTS), total phenols (Folin-Ciocalteu assay) and tannin content (vanillin-HCl) were evaluated. Total phenols and antioxidant activity of raw sorghum and their extrudates were highly correlated ($r^2 = 0.96$). Extrusion reduced the total phenols and tannin content of black and high tannin sorghum by 70 and 82%, respectively; however, extrudates of colored sorghums had significantly higher phenols levels ($p < 0.05$) than raw white sorghum. Total phenols and tannins of extrudates from black and high tannin sorghums were significantly higher than white sorghum ($p < 0.05$). Addition of extra bran increased total phenols in extrudates by 0.44, 1.69 and 0.52 mg GAE/g for white, high tannin and black, respectively. High tannin bran can be used to increase the photochemical content in white sorghum extrudates.

Nutritional and textural properties of doughs and breads produced from oat flour and oat bran flour

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This study investigated the effect of oat flour (OF) or oat bran (OB) substitution of wheat flour (WF) on both the physical and nutritional quality characteristics of bread. Bread formulations were developed to contain with 30, 50 and 70% WF substitution with OF and/or OB respectively. A significant decrease in specific volume, number of cells and crumb brightness was observed with increasing WF substitution levels with OF or OB. A significant increase in crumb hardness was observed for OF and or OB-based bread. OF based breads showed higher specific volume, number of cells and lower crumb hardness with improved crumb brightness compared to OB for all substitution levels studied. Crumb hardness was observed to be negatively correlated with specific volume of OF ($r = –0.90$, $P < 0.0001$) and OB ($r = –0.84$, $P < 0.0001$) bread. A significant reduction of 37.8–42.9% in dough β-glucan was observed during 45 min fermentation time. The β-glucan content of OF and OB bread was found to increase from 0.13 g/100 g bread (db) (control) to 1.35 and 3.61 g β-glucan /100 g bread (db) for 70% WF substitution with OF and OB, respectively. This study shows that a bread of acceptable quality can be prepared by substituting WF by up to 50% for OF and up to 30% by OB.

Antioxidant active anthocyanins in Blue Wheat (UC66049 *Triticum aestivum*)

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Several studies demonstrated greater in vitro antioxidant activity of extracts from colored grains compared to the activity of the same extracts obtained from non-colored grains. Blue Wheat is one example of a colored grain variety and its color is attributable to anthocyanins. These compounds are known antioxidants that are absent in red or white wheat, and are assumed to be responsible for the observed increased antioxidant activity of Blue Wheat extracts. However, little is known about the anthocyanin composition of Blue Wheat varieties and the contribution of individual anthocyanins to the overall antioxidant activity. The aim of this study was to determine the structure and antioxidant contribution of individual Blue Wheat anthocyanins. Isolating individual anthocyanins from Blue Wheat in high purities (>95%) is complicated by co-extracted phenolic compounds. We developed a protocol for the separation of anthocyanins from non-anthocyanin phenolic compounds. Blue Wheat extracts were purified by solid phase extraction and RP-HPLC and structure characterization was performed by HPLC-MS and 1D- and 2D-NMR. The antioxidant activity of the overall extract and individual fractions was assessed with the Folin-Ciocalteu assay, the TEAC assay, and the leucomethylene blue assay.

Proteases activity in wheat flour and barley flour

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Endogenous proteases in flour can soften dough during fermentation. There are four classes of peptidases (serine peptidases, cysteine peptidases, metallopeptiadases, and aspartic peptidases). A study of identifying the magnitude of peptidases activity in wheat flour and barley flour was undertaken. Gelatin and azogelatin, were used as substrates to measure the enzymatic activities of the four classes of peptidases. After the nonhydrolyzed substrate was precipitated by isopropanol or trichloroacetic acid, it was centrifuged. A spectrophotometer was used to measure the absorption of the supernatant solution to determine the breakdown of the protein. The absorbance of the supernatant from the hydrolysis reaction with gelatin was read at 280nm, while reaction with azogelatin was read at 440nm. This quantitative in-solution assay is simple yet accurate for industrial settings when compared with other assays, such as gelatin films, polyacrylamide gels, viscosity analyses, or radioactive techniques. The initial velocity of the hydrolytic reaction was studied. Varying concentrations of peptidases with 1% gelatin were measured at 280nm every ten minutes for two hours. Gelatin was hydrolyzed by peptidases in both wheat flour and barley, and the initial velocity occurred within the first ten minutes of the reaction. Known inhibitors of all four classes of proteases were used to estimate the relative concentrations of each class of protease present in wheat flour and barley. The results of this study will facilitate system adjustments, in bakery manufacturing environment, to improve system performance and finished product attributes.

White corn hybrids as a source for starch production

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Twenty-five commercial white corn hybrids from different seed companies were screened for wet milling properties using a laboratory level procedure in order to evaluate processing characteristics and potential for the starch industry. Wide ranges in test weight (79.3 to 86.0 Kg/hL), thousand kernel weight (349.6-452.4 g), kernel density (1.26-1.32 g/cm3) and protein content (9.7-12.9%) were observed, indicating great differences in the characteristics of white corn hybrids that affected wet milling properties. Starch yields ranged from 54.6% in hybrid Noro 847 to 66.0% in hybrid Logos, that also presented the maximum value of starch recovery observed (93.3%). Protein levels in the starches recovered were low, with a mean value of 0.41%. Starches obtained from white corn hybrids presented high whiteness. Gluten yields ranged from 7.2% in hybrid TG 8990 to 11.1% in hybrid H-375. Relationship between physical and chemical properties and wet milling properties showed that commercial white corn hybrids yielded more starch when lower values of protein content ($r = –0.516$) and test weight ($r = –0.547$) were observed. Results showed that due to the variability in their physical and chemical properties, it is possible to find and select commercial white corn hybrids that could show good wet milling performance.

Evaluation of wet milling performance of commercial yellow corn hybrids and relations with grain physical and chemical properties

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Sixteen commercial yellow corn hybrids from seven seed companies, cultivated in the same location, were evaluated for chemical composition, physical and wet-milling properties. Great ranges for protein content (8.5-12.3%), test weight (78.6-86.2 Kg/hL), thousand kernel weight (349.0-432.5 g) and kernel density (1.23-1.32 g/cm3) were observed. Variation was also found in other characteristics evaluated such as percentage of kernel components, kernel size, color, pH and water absorption properties. Starch yields ranged from 45.0% to 69.5% indicating differences in millability of corn hybrids, suggesting that not all commercial yellow corn hybrids are suitable for wet milling. The relations of proximate composition and physical properties indicated that hybrids with low protein content ($r = 0.636$), test weight ($r = 0.662$), kernel density ($r = –0.741$), pH ($r = –0.535$), and high water absorption properties [IWAR ($r = 0.529$), WAI ($r = 0.769$), WAI2 ($r = 0.670$) and MSP ($r = 0.760$)] yield more starch. Different models to predict starch yield were obtained, and the preferred model for starch yield [Starch yield(%) = 244–2.19 (protein content)–125 (kernel density)] accounted for 65% of the variation, opposite to the 55% of kernel density alone [Starch yield(%) = 270–164 (kernel density)]. Results suggest that kernel density is a good indicator of starch yield and could be useful in the identification of commercial yellow corn hybrids suitable for wet milling, which is highly convenient, since kernel density determination is easy, rapid and inexpensive.

Development and validation of a methodology to determine different ferulic acid populations in cereal products

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Cereal Foods World 56:A66

Bioavailability of ferulic acid is dependent on its form present in the food matrix. This necessitates a methodology to quantify different ferulic acid

populations in food products, especially cereal based products. The aim of the proposed methodology is to separate and quantify ferulic acid ester-linked to mono-/oligosaccharides, soluble polysaccharides, and insoluble polysaccharides, respectively, as well as the free form. This method is widely based on liquid/liquid extraction and precipitation steps. Development and validation was performed by using isolated and characterized compounds from corn bran for each of the mentioned populations. Following separation and extraction of ferulic acid derivatives, the recovery was analyzed by using RP-HPLC and external calibration. Recovery rates were generally between 70–80% except for ferulic acid linked to insoluble polysaccharides where a recovery of >90% was observed. As we are mainly interested in the determination of ferulic acid linked to mono-/ oligosaccharides, this method was validated with three different ferulic acid mono-/ oligosaccharides having their origin from corn arabinoxylans. Following validation, the applicability of the method on actual samples was demonstrated.

Segmental mobility of polymers in hydrothermally treated maize starches varying in amylose content

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Annealing (ANN) and heat-moisture treatment (HMT) are physical modification techniques that modify starch structure and properties without destroying its granular structure. The type and extent of modifications are influenced by polymer chain mobility. However, the exact molecular mechanisms of these hydrothermal treatments still remains poorly understood. The objective of this study was to investigate polymer chain mobility during HMT and ANN of maize starches of different amylose content by differential scanning calorimetry, wide angle X-ray scattering and iodine binding. Waxy maize, normal maize, Hylon V and Hylon VII starches were subjected to heat-moisture treatment (100°C, 16 h, 23% moisture) and one step ANN (starch:water 1:3, at 5°C below the onset temperature of gelatinization for 72 h). The results showed that ANN increased the gelatinization transition temperature and decreased the gelatinization temperature range of all starches. Gelatinization enthalpy of normal and waxy starches increased and those of Hylon V and Hylon VII remained unchanged on ANN. HMT increased the peak (Tp) and conclusion (Tc) temperatures and broadened the gelatinization temperature range of normal and waxy maize starches. Native Hylon V and Hylon VII exhibited a broad dual endotherm (overlapping endotherms of amylopectin & amylose-lipid). Amylopectin endotherm of these starches increased on ANN and decreased on HMT. A-type X-ray pattern of normal and waxy maize starches remained unchanged after HMT and ANN; however, in both Hylon V and Hylon VII starches X-ray pattern changed on HMT and ANN. Iodine-binding ability of normal and Hylon V starches increased on HMT and ANN. However, Hylon VII and waxy maize exhibited lower iodine binding ability after HMT and ANN. The mechanism behind variations in the above properties will be discussed.

The impact of internal unit chain structure of amylopectin on thermal properties of starches

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The amylopectin chains are distinguished as external chains, which build up the crystalline lamellae and internal chains found among the clusters of branches in the amorphous lamellae. The internal unit chain profiles, obtained from Ø, β-limit dextrins of 17 amylopectin samples, represented a broad range of different starch sources with regards to the type of plant and crystalline structure, and were divided into four structural groups reflecting the interconnection of clusters as well as the internal structure of the clusters (Bertoft et al.:, Carbohydr. Polym. 2008, 74, 527–543). Group 1 (e.g., barley and oat) possessed very high number and broad size-distribution of short chains. Group 4 (B-type crystalline starches) had typically higher number of long chains whereas groups 2 (e.g., rice, waxy maize) and 3 (e.g., tapioca and arrowroot) were intermediate in chain distribution. The objective of this study was to determine the relationship between the internal unit chain structure and thermal properties of the same starches with emphasis on gelatinization and retrogradation properties. Lowest gelatinization temperature was observed in group 1 starches with the general trend of group 3 > group 2 > group 4 > group 1. Gelatinization enthalpy was also low for group 1 starches. Group 2 starches exhibited broader gelatinization temperature range compared to other groups. Gelatinization enthalpy (ΔH) was higher in group 4 starches. The result thus suggests a correlation between starch functionality and amylopectin internal structure, an association not previously highlighted.

Effects of a shear-induced separation process on the resulting gluten yield and composition

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Cereal Foods World 56:A67

Wheat flour can be separated into its constituents starch and gluten using the concept of shear-induced separation. In a cone-cone shearing device, a gluten enriched part was obtained in the apex of the cones, while a gluten-depleted phase was obtained at the outer part of the device. This presentation shows how the composition of the glutenphase changed, thereby answering the question whether the gluten proteins behaves similarly or that fractionation of the various proteineous components occurs during and after separation of wheat flour. SDS PAGE and SE HPLC were used to study the changes in protein composition. We observed fractionation, but we also concluded that all protein fractions took part in the aggregation and migration of gluten phase. In this presentation, we will couple the changes in protein composition to the rheology of the gluten phase. This provides a better understanding of mechanism behind shear induced separation.

β-Glucan degradation by endogenous enzymes in wheat flour doughs with different moisture contents

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The health benefits of soluble fibers such as cereal β-glucan are well documented. The bioactivity of β-glucan is thought to be dependent on its molecular weight (MW) and the consequent viscosity development in the gut. Several studies reported degradation of β-glucan in baked products. Our previous work demonstrated different levels of endogenous β-glucanase activity in wheat varieties and the levels were affected by genotype and environmental conditions. The objective of this study was to investigate the effect of endogenous β-glucanase activity on MW of β-glucan in doughs with different moisture contents. A high MW β-glucan isolate (1000 kDa) was used to fortify whole wheat flour with two different levels of β-glucanase activity (164 or 82 Units/kg). A low moisture (cookie) and higher moisture (bread) dough were prepared by using the AACC standard formulation. Dough moisture contents were 11% and 60% for cookie and bread dough, respectively. The doughs were allowed to rest for up to 90 min and depolymerization of β-glucan in dough samples was followed using high-performance size-exclusion chromatography with post-column calcofluor detection after 15, 30, 60 and 90 min. The β-glucan MW decreased in both dough systems within 15 min. However, in cookie dough the MW was 230 kDa while in bread dough it was 30 kDa. Furthermore, after 90 min, the MW in cookie dough was 189 kDa while in bread dough MW had decreased to 25 kDa. MW of β-glucan was higher when flour contained lower levels of β-glucanase; and the values were again higher in cookie dough compared to bread dough. These studies highlight that, depending on the product type, strategies can be developed to preserve high MWs of β-glucan. Furthermore, novel strategies need to be developed in dough containing higher moisture contents to maintain high MW β-glucan.

Effect of the addition of three different types of resistant starch to instant noodles obtained by atmospheric and vacuum frying

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Nowadays there is considerable concern related to health and the consumption of high fat content products, and there is a need to develop healthier products with functional appeal. The objective was to develop instant noodles (IN) with functional properties obtained by atmospheric and vacuum frying processes with the addition of 10% of three different types of resistant starch such as RS2 obtained from high amilose corn starch, RS3 obtained from gelatinized-retrogradated high amilose corn starch and green banana flour (GBF). For the atmospheric process a conventional fryer was used (Gastromaq, Brazil) and 50 g of sample were immersed in hot oil (150 ± 3°C). Vacuum frying was carried out in an electric vacuum cooker (Gastrovac, Spain) and 15 g of sample were immersed in hot oil (110 ± 3°C), when the vacuum reached the target value (–0.8 bars). According to the Tukey test ($p < 0.05$), there were significant differences in the moisture and fat contents of the IN obtained by atmospheric and vacuum frying. The IN obtained by atmospheric frying lost the water faster and absorbed more fat (around 3–4% more fat per total mass) than those obtained by vacuum frying. The highest loss of resistant starch occurred during the steam cooking stage. The noodles made of RS2 and GBF presented losses of resistant starch of about 30%, while the noodles made of RS3 lost approximately 18% during steam cooking. RS3 noodles presented the best technological properties with the lowest fat absorption and the highest firmness value and resistant starch content. The vacuum frying process shows

advantages in the production of IN, due to the lower fat absorption, lighter color of the noodles and lower resistant starch degradation, when compared to atmospheric frying.

Lamellae structure of developing wheat starch granules
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Cereal Foods World 56:A68

The lamellae structure of mature starch granules is well established. However, the development of the lamellae structure of starch granules throughout the maturation is still not known. Knowledge about the development of lamellae structure of starch granule is important in understanding the organization of glucan polymers throughout the growth of the granule. Therefore, the objective of this study was to use the combined application of iodine binding ability of granular starches with small angle X-ray scattering (SAXS) technique to understand the development of lamellae structure of starch granules throughout their growth. Starches were isolated from wheat grains harvested at seven different stages of maturation as 7, 14, 21, 28, 35, 42, and 49 days after anthesis (DAA), equilibrated to 0.97 water activity (a_w), and exposed to iodine vapour for 24 hrs at the same a_w. Then, the hydrated control and iodine exposed starches were measured with SAXS for the lamellae structure. Lamellae structure of starch granules were established even at 7 DAA. Lamellae distances of starches were changed throughout the maturation, while the 7DAA and 14 DAA starches had the shortest and the longest lamellae distances, respectively. The exposure of starches to iodine vapour decreased the lamellae distance at all phases of maturation, except 28 DAA starch, which demonstrated no change. The 14 DAA starch showed the highest decrease among others. Furthermore, iodine caused the peak to be broader and smaller in all starches, except 21 DAA, demonstrating a loss in the degree of ordering in the semicrystalline region. These results indicate that the lamellae structure of starch granules is established even at early stages of maturation, but has changes in the lamellae thickness and the degree of order throughout the growth. These changes are most likely to be mainly in the amorphous lamellae region of the granule.

Atomic force microscopic imaging of the surface of developing wheat starch granules
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Cereal Foods World 56:A68

Atomic force microscopy (AFM) can be used to visualize the surface morphology, especially the blocklet structure, of starch granules. In this study, AFM is used to picture the surface of developing wheat starch granules. Starches were isolated from wheat grains harvested at seven different stages of maturity (7, 14, 21, 28, 35, 42, and 49 DAA; DAA-days after anthesis), imaged, and compared for the effect of granule development and the difference between large and small granules. However, only large granules of 7, 28, and 49 DAA starches were imaged before and after exposing to iodine vapour in-situ at 100% humidity. Starches from all stages of maturity exhibited blocklet structures. However, the surface of 7 DAA and small granules of 14 and 21 DAA starches were composed of larger (~80 nm, ~30-80 nm, and ~30-80 nm, respectively) less resolved blocklets than that of the other starches (~20-50 nm). Surface roughness of 7 DAA and small granules of 14 DAA starches were higher than that of the other starches. Except for the blocklet sizes of 14 and 21 DAA starches and the surface roughness of 14 DAA starch, there were no other differences between large and small granules of starches from other maturities. Exposure to 100% humidity caused blocklets of large granules to be less resolved. Further exposure to iodine vapour increased the surface roughness of these starches. These observations demonstrate that the blocklets at the center of starch granules are most likely to be larger and less resolved than the periphery and are not growing as rings with specific height. In situ imaging with iodine exposure further supports the concept of hairy billiard ball structure of starch granules.

Characterization of physicochemical changes in cookies baked in a commercial oven
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Cereal Foods World 56:A68

The objective of this research is to understand the effects of baking in an industrial tunnel oven on physicochemical properties of commercially formulated short-dough cookies. Quality parameters of the cookie, including moisture content, dimensions and colour were tracked throughout baking. Instrumental evaluations of compression and fracturability, acrylamide concentration and proton mobility were conducted and their data used to explain changes that occurred. Peak acrylamide values were observed after L* values dropped, suggesting there may be a point at which colour development and low acrylamide values overlap, allowing optimization of baking for colour and lower acrylamide content. Pasting properties of fully baked cookies as measured by RVA were shown to differ from dough and partially baked cookies. Baking resulted in a loss of birefringence in a subset of A-type starch granules providing some evidence of starch granule damage. Proton mobility decreased during baking as moisture loss progressed and interactions between starch and water increased. Isolation of starch from the treatments however demonstrated few differences in crystallinity, pasting behaviour or gelatinization enthalpy. Characterization of these product parameters and process variables could suggest strategies for altering a commercial process to modulate quality and also develop strategies to reduce energy consumption.

New insights into distribution of amylose in pea starch
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The relative location of amylose and amylopectin in native starch granules continues to be a matter of debate. Acid hydrolysis has been used extensively as an approach to reveal the structure of starch granules. The objective of the research was to investigate the degradation mode of amylose and amylopectin and reveal the distribution of amylose in starch. The acid hydrolysis of pea starch granules was investigated through measuring changes in amylose content by both iodine binding and concanavalin A methods, along with small- and wide-angle X-ray scattering, and scanning electron microscopy (SEM). The relative crystallinity, intensity of the lamellar peak and the low-*q* scattering increased during the initial stages of hydrolysis, indicating that the amorphous regions were degraded preferentially. A rapid decline in amylose content and a concomitant loss of precipitability of amylopectin by concanavalin A were observed, which were more evident after two days of hydrolysis than one day. Correspondingly, etching from the surface to internal parts of the granules was observed between days one and two of hydrolysis. Taken together, these observations indicated that both amylose and amylopectin are located on the surface of the granules and attacked simultaneously in the early stages of acid hydrolysis, and that amylose was more concentrated at the core of the granules. More extensive hydrolysis resulted in the concomitant disruption of amorphous and crystalline regions, which was indicated by the decrease in the lamellar peak intensity and no further increases in crystallinity. SEM observation showed that the semi-crystalline growth rings decreased in width from centre to periphery, while no significant changes were observed in the width of amorphous growth rings. On the basis of these results, a new model of starch granule organization is proposed.

A comparative study of physicochemical properties in mature and immature seeds of yellow pea
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Cereal Foods World 56:A68

Yellow field peas (*Pisum sativum*) are commonly consumed after cooking both in the form of whole seeds and decorticated splits in various types of food. The seeds are usually harvested when completely mature (dry field peas). Immature seeds in yellow peas are caused by cool and wet conditions during the growing season delaying development of the crop. Information is scare on how immature seeds in yellow peas affect the quality characteristics. The present study was undertaken to investigate the effect of immature seeds of yellow pea on physicochemical properties. Three yellow pea varieties were used in this study. Mature and immature seeds in the samples were manually picked. The physicochemical properties of mature and immature seeds of yellow pea were evaluated according to published methods. Results indicated that when compared to mature seeds, immature seeds of yellow peas exhibited significantly lower seed weight (17.9 and 21.7 g/100 seeds, respectively) and smaller seed size (6.2 mm and 6.6 mm, respectively) but higher water hydration capacity (1.06 and 0.98 g H_2O/g seeds). Significant shorter cooking time but higher firmness value of cooked seeds was observed for immature seeds than for mature seeds. Immature seeds contained significantly higher protein (254.2 and 234.6 g/kg DM, respectively) and ash content (31.5 and 29.4 g/kg DM, respectively) whereas lower starch content (432.5 and 451.3 g/kg DM, respectively) as compared to mature seeds. Sucrose content was higher in immature seeds than in mature seeds, however, stachyose and verbascose contents were higher in mature seeds than in immature seeds. Preliminary results demonstrated that immature seeds displayed a significant effect on certain quality properties of yellow pea.

Modifying wheat bran by microfluidization process
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Cereal Foods World 56:A68

Wheat bran was processed by the microfluidization technology in order to improve its physicochemical and antioxidant properties. In the process, bran

particles underwent extremely high shear stress and hydrodynamic cavitation as high pressure (172.4 MPa) forced aqueous bran suspension through a microchannel (200 microns in diameter). The results demonstrated that microfluidization could effectively reduce bran's particle size and increase its specific surface area. Because a larger surface area and more active binding sites were exposed to the surrounding environment, its swelling capacity, water holding capacity, and oil holding capacity were significantly increased. The ferrous ion (Fe^{2+}) chelating capacity of the treated wheat bran decreased slightly with an unclear reason. In addition, the treatment substantially improved free radical scavenging activity of wheat bran as indicated by the measured values of Trolox equivalent antioxidant capacity (TEAC) and DPPH scavenging activity. TEAC value (mmol Trolox/kg dry mass) increased from 13.6 (control) to 28.0, 36.9, and 42.0 for one, two, and three processing passes, respectively. This might be explained by microfluidization induced microstructure disruption of bran fiber that exposed more phenolic compounds which were originally cross-linked or embedded in the fiber matrix. These findings suggested that microfluidization treatment would provide an effective way to improve physicochemical and antioxidant properties of wheat bran and potentially other high fiber containing ingredients in food applications.

Effect of osmotic pressure and simultaneous heat-moisture and phosphorylation treatment on structure and physicochemical properties of five starches

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Cereal Foods World 56:A69

The structure and physicochemical properties of starch can be altered depending upon the modification methods and starch sources. Heat-moisture and pressure treatments cause a physical modification of starch without a damage of the starch granules. The objectives of this study were to compare the osmotic pressure treatment (OPT) with the simultaneous heat-moisture and phosphorylation treatment (HMPT) on the structure and physicochemical properties of starches. Five high-amylose (34–71%) starches including mung bean, water caltrop, yam (TN1 & TN2) and corn (Hylon VII) starches were modified by using OPT and HMPT methods. The morphology, degree of crystallinity, thermal and pasting properties, swelling power and solubility, and resistant starch content of the modified starches were investigated. The results indicated that OPT and HMPT methods increased the degree of crystallinity of all starches. The X-ray diffraction patterns were altered from B-type to A-type for the OPT starches. The gelatinization temperature of starch increased with treated time while gelatinization enthalpy decreased. According to the RVA viscograms, the peak, breakdown and final viscosity of OPT starches decreased, resulting in the decrease of swelling power and solubility of starches. The results also evidenced the resistant starch content increased with the progress of treated time in 0–180 min in both OPT and HMPT treatments. These findings suggest that OPT and HMPT methods significantly change the physicochemical properties of starch and increase the resistant starch content, which can provide the availability for food development.

Effect of genotype and environment on the refrigerated dough quality and arabinoxylan content of hard red spring wheat

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Cereal Foods World 56:A69

Arabinoxylans (AXs) are the main non-starch polysaccharides found in wheat flour. Structural changes of AXs in refrigerated dough are linked to deleterious effects on refrigerated dough quality during storage. The purpose of this research was to evaluate the effect of cultivar and environment on dough syruping during refrigerated storage in relation to xylanase activity and AX chemistry in HRS wheat. Eight HRS cultivars grown at six locations in North Dakota over two years were evaluated for dough syruping during 15 days of refrigerated storage. Environment had a stronger effect on xylanase activity and dough syruping than wheat cultivar. Average xylanase activity from Langdon-2008 was 63 times higher than that of in Dickinson-2007. The total AX content in the flour ranged from 1.27 – 1.76%. Environments with dry conditions, such as Williston, had lower dough syruping of 2.53% and 1.59% in 2007 and 2008 respectively. Environments with wet conditions such as Langdon, (wetter environment) had higher dough syruping of 14.78% and 21.02% in 2007 and 2008 respectively. There were very highly significant ($P < 0.001$) phenotypic and environment correlations between the percent dough syruping on days 5 and 15 and apparent xylanase activity. There was also highly significant ($P < 0.01$) phenotypic correlations between the percent dough syruping on day 0 and the total AX in the flour and water extractable solids. Glenn, RB07 and Traverse showed lower W_i and σ_i^2 for xylanase activity and dough syruping; indicating these cultivars have more stability over growing locations than other cultivars. Though environment had a stronger effect, the genotype did have an effect and results show certain cultivars from relatively dry environments can be used in refrigerated dough formulations.

Effects of fibre and baking conditions on digestive biscuit properties

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Cereal Foods World 56:A69

Increasing fibre content of biscuits by greater inclusion of bran or other ingredients is desirable for nutritional purposes, but may compromise sensory characteristics. A model product was developed based on a digestive biscuit, which is a short dough product containing wholemeal flour. This was used to study effects of fibre-rich ingredient inclusion on biscuit quality and to model colour and moisture changes during baking. The model product includes a defined recipe, production method and specification. It was shown that the specification could be achieved using a pilot plant or smaller scale processing equipment. This approach enabled recipe and process effects to be studied on a small scale and validated at pilot scale. For fibre experiments, the proportions of white and wholemeal flour were varied, and further bran or soluble fibre was added. Effects of ingredient quantities and the type and particle size of the added fibre on biscuit properties were studied. Measurements included biscuit mass, dimensions, colour, moisture content and texture. Comparisons were made with corresponding dough measurements. For studies of baking, a travelling oven was used with variations in the temperatures and baffle settings for each zone. Temperature and heat flux profiles were measured, and moisture and colour distribution were measured for cross-sections of biscuits in each zone. Moisture distribution was measured by hyperspectral NIR imaging and colour distribution was measured with a DigiEye system. A model was developed for the effect of the conditions in each zone on the change in colour and moisture distribution and for the overall effect on biscuit characteristics. This study is financially supported by the European Community's 7th Framework Programme, Project "Design and development of realistic food models with well characterised micro- and macro-structure and composition", DREAM (222654-2).

Application of chemometrics to prediction of some wheat quality factors by near-infrared spectroscopy (NIRS)

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Cereal Foods World 56:A69

Recent advances in NIRS prediction of functionality parameters in whole kernels have paved the way for selection for quality factors in early generations. Testing is nondestructive, so that seed can be planted after testing and selection. Dependable predictions of gluten strength (GS) in whole grains by NIRS, in terms of physico-chemical dough properties, have so far proved to be elusive. The paper describes results of application of several chemometric approaches to the prediction of wheat quality in whole grain by NIRS. The objective was to see how advanced chemometrics in experienced hands would be able to develop comprehensive NIRS models, based on 7 years of data, that would predict data for an eighth year reliably. Growing season affects both the quality and spectral characteristics of wheat. The calibration sample set (N = 775) was compiled from samples drawn from growing seasons 1998–2005, excluding the 1999 season. The validation set (N = 107) consisted of the 1999 Plant Breeders' samples. Quality factors were protein content, test weight, kernel texture (particle size index, or PSI), and Farinograph water absorption, dough development time (DDT) and mixing tolerance index (MTI). Each participant applied their own versions of chemometrics to the development of calibration models. No outliers were eliminated. For water absorption r-squared values ranged from 0.84 – 0.94, for DDT r-squared values ranged from 0.24 – 0.59, and for MTI r-squared values ranged from 0.57 – 0.87. The Random Forest approach appeared to have the best potential for prediction of physico-chemical properties. Results for protein content, test weight, water absorption and PSI ranged from excellent, to acceptable for screening purposes, but other Farinograph factors were not reliably predictable.

The effect of cover cropping systems and nitrogen fertilization on sorghum grain characteristics

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Cereal Foods World 56:A70

No-till farming has become an increasing popular cropping practice, due to increased water and soil conservation. Recently, cover cropping has been added to the system to aid in weed prevention and also increase soil fertility. The objective of this study was to determine the effect of cropping system as well as nitrogen fertilization on sorghum grain. The experimental design was a 3×4 factorial with three cover crop treatments (none, soybean, and Sunn hemp) crossed with four nitrogen rates (0, 33.6, 67.2, and 100.8 kg/ha) in plots following the harvest of wheat. A sorghum hybrid was then planted the following spring in each plot. Grain was harvested and cleaned for analysis including kernel, protein and starch characteristics. The hardness and size of kernels was measured by the Single kernel characterization system (SKCS). The average kernel hardness across all nitrogen rates was 74.7, 74.6, and 69.7 for soybean, Sunn hemp, and none, respectively. The kernel weight and diameter was also significantly larger for the cover crop treatments compared to no cover crop. The soybean cover crop had the highest protein content at 9.2% followed by Sunn hemp at 8.8% and no cover crop at 8.2%. The 0 and 33.6 kg/ha nitrogen rates had significantly lower hardness values (68.7 and 70.0) than the 67.2 and 100.8 kg/ha (76.2 and 77.3) treatments. The protein content of the grains ranged from 8.1% in the 0 kg/ha rate to 9.5% in the 100.8 kg/ha rate. Protein digestibility values and starch granule size distributions were not affected by nitrogen level or cover cropping treatments. The utilization of cover crops appears to increase the protein content without causing a deleterious effect on protein digestibility. The end-product quality is not hampered by the use of beneficial cropping systems necessary for sustainable agriculture.

Correlation between molecular and intragranular structural parameters in waxy starch

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Cereal Foods World 56:A70

There is a limited understanding of the influence that the molecular properties of starch, such as the branch frequency and branch length distribution, have on the intra-granular properties of starch, such as degree of crystallinity and lamella spacing. Both the molecular and intra-granular structures have an influence on the physical properties of starch so understanding the extent of correlation between these factors is desirable. We have therefore sought to compare the characteristics of a series of waxy starches using a range of complementary methods. The properties compared include: β (rate ratio of starch branching enzyme : starch synthase), γ (rate ratio of starch debranching enzyme : starch synthase) and X_{min} (The minimum length that starch branching enzyme acts upon) which accurately describes the starch branch length of different lamellae as found by fluorophore assisted capillary electrophoresis; degree of branching via nuclear magnetic resonance; molecular density determined via size exclusion chromatography; lamella repeat distance and thickness distribution as measured by small angle x-ray scattering; and the extent and type of crystallinity by x-ray diffraction. A multivariate analysis of the results from these experiments has been used to determine the extent of inter-parameter correlation and a hypothesis as to their associated relations will be presented.

Designing starch for better nutrition

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Cereal Foods World 56:A70

The complex branched structure of starch determines its nutritional end–use properties. The structure of starch is controlled by the biosynthetic pathways in living plants. Current methods to alter these pathways to give different starch structures usually involve mutations based on empirical knowledge where specific enzyme(s) is knocked out. A mathematical model of the chain-length distributions (CLDs) of starch is developed to gain mechanistic understanding of the relations between the structure of starch and the underlying genetics. This model uses the fact that the CLD is controlled by the actions of multiple enzymes, which can be grouped into three classes: starch synthases (propagation), starch branching enzymes, and starch debranching enzymes. The model provides quantitative fits to a large number of CLD data found in the literature. Physically possible conditions as predicted by the model show that the CLD for native amylopectin is highly constrained in a viable plant. This explains the difficulty in creating different CLDs through genetic modification. Mutations which do not obey these constraints will result in plants with severe phenotypes, such as producing starch without the semicrystalline structure of amylopectin required for effective energy storage. This modeling approach also suggests novel ways of designing starch with desired molecular structures by altering the biosynthetic pathways without compromising the viability of a plant. In particular, one way to obtain starch with longer amylopectin branches (which is nutritionally desirable) is to use single-nucleotide polymorphism (a standard technique in molecular biotechnology) to change binding site of a starch branching enzyme. This would produce cereal grains containing unique starch structures and properties that may contribute to a healthier diet.

In-house validation of a microbiological method to determine natural occurring folates in cereals and cereal products

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Cereal Foods World 56:A70

The water-soluble vitamin folate can be divided in different derivates of folic acid, which play altogether an important role in C1 transfer reactions in the human body. The requirement of folate can either be covered by folic acid fortified food or food rich in natural occurring folate. In consideration of increasing interest on natural occurring folates in food, the determination with valid analytical methods is crucial. It was therefore the aim to compare a microbiological assay (MA), which is useful in determining the total folate content, and a HPLC method, for characterisation of the amount of different vitamers. The MA method contains mainly two steps, i.e., extraction and measurement, which have been both validated with a certificated reference material (CRM 121, EC). The extraction was carried out involving a three enzyme treatment (α-Amylase, Peptidase and Conjugase). The growth of *Lactobacillus rhamnosus* (ATCC 7469) is dependent on the supply of the vitamin. The growth in relation to the extracted folates is measured as turbidity and compared to a folic acid standard curve. The standard curve was linear within the concentration range of 0.06 to 0.6 ng folic acid/mL and gave the equation $y = 0.05 + 1.816*x$ ($R^2 = 0.9811$, $P < 0.0001$). By non-linear regression the sigmoidal 4-parameter logistic equation was obtained: $y = (0.1175+1.1591)/[1 + (x/0.3325)^{-2.6978}]$ ($R^2 = 0.9964$, $P < 0.0001$). The limit of detection using this function was 0.35 µg/100 g sample and the limit of quantification was 0.57 µg/100 g. The validation of the HPLC method used the extraction procedure as seen at MA. In addition, solid phase extraction (SPE) was performed to eliminate interfering polymers. The different folates were separated with different RP-columns and detected by DAD. The results show that the three enzyme treatment is a suitable method to determine the total folate in food matrices.

Gluten-free breadmaking using sorghum flour and carob flour

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Cereal Foods World 56:A70

Celiac disease is an auto immune response to the gliadin fraction of wheat and the prolamins of rye and barley. It is a serious chronic disease that affects approximately 1% of the population in the US. The market for gluten-free foods currently stands approximately $1.7 billion per year. Sorghum is a healthy choice for celiac patients as it does not contain gluten. US is the largest producer and exporter, and Kansas is the number one producer (41% of total sorghum production) in the US. Caroubin protein from carob germ flour (CGF) has been known to have similar viscoelastic properties with wheat gluten. Objectives of this research were to study the rheological properties of dough consisting of sorghum flour and CGF, and compare the baking quality and textural properties of sorghum and carob breads with wheat bread. Two dough formulations (50% sorghum+50% CGF, and 70% sorghum+30% CGF) were developed. Mixing and pasting properties of doughs were tested against that of wheat flour using Mixolab (Chopin Technologies). Water absorption of sorghum dough samples increased with the addition of CGF (84.2 and 88.2% at 30 and 50% addition). Although CGF did not affect the mixing times, it caused slight decrease in dough stability. Gelatinization temperature and the peak viscosity values, however, have changed significantly. Adding CGF to sorghum flour improved dough formation. Sorghum flour dough containing 30% CGF was as strong as the dough consisting 50% CGF, which were both stronger than wheat flour dough. Dough samples were baked at 355°F for 55 min. 50% CGF containing sorghum formula resulted in the highest bread volume, followed by wheat bread and 70% sorghum flour+30% CGF. Both sorghum bread formulations resulted in higher hardness values (2500, 1400 and 900 g) as determined through compression test.

New mixing technology and applications for the Farinograph-E

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Cereal Foods World 56:A70

The Brabender Farinograph is widely used by the milling, baking, and wheat breeding industries for standard testing and quality control of a variety of flour and flour mix characteristics. It would be a more powerful analytical instrument if new applications, including variable mixing intensities, controllable temperature, and flexible software were available. The objectives of this work were to assess dough rheological properties under a variety of temperature profiles; to study flour-water dough behavior during mixing using constraining lids of varying lid profile; to modify the current AACC method to accommodate the changes required by the use of lids and temperature profiles; and to assess the ability of the new method and profile to differentiate flours of different classes and qualities. Studies were conducted by two independent operators on different days by using the same Farinograph-E, bowl lids, flours, and operation procedures. All tests were done in triplicate by each operator. The results showed that the relationship between dough consistency and temperature was well fitted by a 4th order regression equation over the range of 30 to 90°C. Lid shape affected dough mixing characteristics. A double-concave lid profile was most sensitive and easily differentiated a series of flours of different classes and qualities using both ambient and programmed temperature profiles. The use of the solid lid gives the Farinograph-E the potential to measure the torque associated with dough during mixing, heating, and cooling. It could be used to characterize the rheological behavior of dough when the dough is subjected to the combined effects of higher energy inputs and elevated temperatures.

Digital imaging of freefalling cereal grains for defect and damage assessment

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High-speed optical inspection of cereal grains typically involve monochromatic or bichromatic sensor systems that are responsive to white light that is reflected from each kernel in freefall and dispersed by interference filters or dichroic mirrors before reaching the sensor. Although these devices are very fast, damage and defect conditions within localized regions of the kernel are limited. Digital imaging has stood as a potential alternative, but with a limitation the greater time needed to acquire and process an image. General advances in camera arrays and computer processors have vastly reduced this shortcoming, with now potential application to cereals for assessment of quality. We are currently developing an imaging system capable of acquiring 640 × 480 10-bit images at 1/30,000 s exposure time along with the image processing algorithms for kernel morphology and texture analysis. This system will be used to recognize conditions of wheat kernel damage (scab, frost, black point, insect) and defects in real time, with a target kernel-to-kernel sampling rate of 20 ms or less, thus providing the design criteria for a rapid (i.e., < 1 minute per sample) instrument for grading and classification. Aspects of hardware, optics, image processing and pattern recognition will be discussed.

Characterization of waxy corn starch for ethanol production

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Fuel ethanol is produced almost exclusively from corn in the United States. Thus, it is important to understand the relationship between corn starch structures/properties and the fermentation efficiency. The objective of this study was to compare ethanol yield between waxy and normal corn lines developed by the USDA Germplasm Enhancement of Maize (GEM) project. The starch of the selected line was isolated for characterization, including the molecular weight and gyration radii of starch molecules, branch chain length distribution of amylopectin, thermal and pasting properties, and the hydrolysis rate of raw starch. The ethanol yield obtained from waxy corn was up to 37.3 g/100 g dry matter (line 08GEM05036), which was greater than that of normal corn (e.g., line 08GEM04702, 36.4 g/100 g dry matter). The average starch-to-ethanol conversion efficiency of the waxy corn (92.7%) was substantially higher than that of the normal corn (87.3%). Strong correlations were found between the ethanol yield and the total starch content ($R = 0.96$, $p < 0.01$) and the protein content ($R = –0.77$, $p = 0.07$) of the waxy corn. There was no correlation, however, between the initial starch-hydrolysis rate of either dry-grind corn or isolated starch and the ethanol yield. The enzymatic hydrolysis of isolated starch showed different kinetics from that of starch in the dry-grind corn, likely resulting from effects of cell wall structure and protein matrix in the dry-grind corn. Starch physicochemical properties, including the enzyme hydrolysis rate, and thermal and pasting properties, of certain lines planted in 2010 crop season showed significant differences from that of the 2009 crop season. The differences could be attributed to the effects of climate change on the structure and properties of the starch.

Evaluation of α-amylase accumulation and falling numbers in soft red and soft white wheat adapted to Michigan

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Cereal Foods World 56:A71

Michigan has experienced severe pre-harvest sprouting (PHS) in wheat. α-amylase is an important component of PHS and the falling number (FN) test is used by industry to identify sprouted wheat. The objective of this study was to evaluate wheat cultivars adapted to Michigan for the quantity of α-amylase and the corresponding FN values at three time-points around physiological maturity (PM) in the absence and presence of PHS inducing conditions. In 2009 and 2010, twenty and twenty-four soft winter wheat genotypes with varying levels of susceptibility to PHS were planted in a three-replication alpha lattice design in two and three locations in Michigan, respectively. Spikes were collected three days before PM, at PM, and three days post PM. In 2010 a subsample from each plot was artificially misted, while a second subsample was non-misted as a control. Immediately following collection, samples were frozen. Frozen samples were freeze-dried, threshed, milled and evaluated for α-amylase activity and FN values. Genetic differences existed for both traits at all time points and treatments. A clear trend was observed in the reduction of α-amylase and the increase in FN during the maturation in non-misted conditions. Comparisons between treatment groups showed significantly different α-amylase quantities and FN values. However, significant differences were not identified between misted and non-misted samples, but only between immediately frozen vs. misted and non-misted (ambient temperature) samples. Further investigations are being made of misted and non-misted samples to determine if other components have changed even though α-amylase and FN values did not. This study has been planted for a third year of investigation.

A new family of healthy, safe, and convenient food products based on partial germination of pulses

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Cereal Foods World 56:A71

Urbanization and malnutrition set new requirements to the food market, particularly in the developing countries such as India. Pulses, one of the staples in India, are a precious food since they are an excellent source of proteins, have a high concentration of essential micronutrients - such as iron - and have low fat. Unfortunately this high nutritional value is limited by the presence of antinutrients that reduce protein digestibility and micronutrients bioavailability, and by the presence of raffinose family oligosaccharides (ROF) which cause digestive discomfort. Germination is the natural way traditionally used in household to improve the nutritional value of pulses but this domestic process is very cumbersome and hygienically unsafe. A new industrial process for partial germination has been developed and its effect on the nutritive value has been evaluated on brown chickpeas at laboratory scale. These pulses were partially germinated, stabilized through gentle drying and then splitted. The resulting daal were assessed in respect to main chemical compounds, sugars such as fructose and ROF, antinutrients, dialyzable minerals and vitamins. It has been verified that this novel process has a remarkable effect in reducing antinutrients and in improving the bio-availability of micronutrients. ROF have in fact decreased by more than 50% and the antinutrients have reduced up to –35%. This increases the mineral bioavailability, as indicated for instance by an improvement of dialyzable iron by +150%. Also, the concentration of several vitamins increases remarkably, as shown for instance by a 500% higher thiamine content. Moreover, fructose has greatly increased providing a sweet note to the daal taste. These experimental results show that partially germinated pulses have a great potential as novel food product with properties of high nutritional value and convenience.

Influence of novel partial germination process onto nutritional and functional properties of different types of pulses

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Cereal Foods World 56:A71

Pulses are a major source of proteins in the diet of populations who are dependent mainly on cereals as staple foods and have limited access to animal

protein. Economically, they in fact provide good quality protein at only a fraction of the cost of animal proteins. In addition, they supplement certain amino acids that are deficient in the cereal proteins. Despite the efforts in increasing the production of pulses, a gap is still present between the availability and the demand for these grains, particularly in developing countries like India. Therefore, every effort is needed to improve their nutritional value and the yield of industrial processing (dehulling), for example reducing the amount of antinutrients naturally present in the pulses and reducing the processing losses in form of brokens. In India, pulses are traditionally consumed either as whole or in the daal form (dehusked and split) as soft-cooked products. From a processing point of view, pulses are categorized in two types: easy-to-dehull (i.e., chickpeas) and difficult (hard)-to-dehull (i.e., pigeon peas and mung beans). A novel process that comprises partial germination and stabilization through gentle drying was developed and its effect on the improvement of nutritive and functional properties was studied on different types of pulses, including easy- and hard-to-dehull. Namely, the processed pulses were evaluated in terms of milling yield, antinutrients content, vitamin and minerals content, aspect, colour, hardness, cooking properties and were assessed by a trained panel for their sensory properties after cooking. This study shows that partial germination not only enhances the milling yield of the analyzed pulses, but also remarkably improves the nutritional value of the resulting daal without affecting in a prohibitive way its cooking and the sensory properties.

Effects of wheat flour quality and making process on cooking losses of Chinese white noodle

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Cereal Foods World 56:A72

Noodle cooking losses are influenced by wheat flour quality and making process. Nine types of wheat flours with different quality were chosen for the test. Relationships between noodle cooking losses and water addition, mixing time, resting time and the sheeting ratio, of every type of flour, were studied using quadratic orthogonal rotation combination design. Effects of wheat flour types on the relationship between noodle cooking losses and making process were investigated. When cooking losses of nine types of wheat flours noodles were relatively low, the optimal making process parameters were discussed. The results showed that there were significant regression relationships (α = 0.05) between making process and noodle cooking losses in seven out of nine flour samples. Water addition was the most important factor influencing the unit cooking losses, followed by resting time, sheeting ratio, and mixing time. The effects of making process on the unit cooking losses had three different trends. It is concluded that the effects of the making process on the unit cooking losses of noodle were significant. The extent and trends of the effects were influenced by wheat flour quality. The unit cooking losses of 9 types wheat flour noodles were relatively low in the case of 34%–35% for water addition, 4 min for mixing time, 30 min for resting time, and 25% for sheeting ratio.

Effect of kernal heating treatment time on the physicochemical properties of oat flour

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There are more than 80% oats being used for the milling in Chinese food industry. Kernal heating treatment is necessary before milling in order to increase milling yield of flour, extend the shelf life and enhance flovor of oat foods. Effect of kernal heating treatment time on the physico-chemical properties of oat flour was investigated. Oats kernal samples were prepared with a laboratory scale Far-infrared heating instrument. The results showed that with heating treatment time extending, kernal surface temperature increased, while moisture decreased gradually. Kernal test weight, L* of kernal surface, milling yield, crude fat content and peak viscosity of oat flour increased and then decreased. However, the total fat content kept consistent. It is concluded that the effect of heating treament on the fat existing form in oat flour is significant. Fat existing form changing bound into free may improve the fluidity of oat flour, and then increase the milling yield after moderation heating treatment of oat kernals.

MISSED ABSTRACT

Measurement of beta-glucan viscosity using Rapid Visco Analyzer (RVA)

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The viscosity of cereal β-glucans is an important physiochemical characteristic correlated with the cholesterol and glycemic response lowering effects. A simple direct method for viscosity measurement using RVA has been developed to overcome the complexity of the common protocols based on in vitro digestion methods. The effects of several parameters including β-glucan content, enzyme types and concentration, buffer pH and particles size, on the viscosity and solubility were considered in the development of this method. Oat cereal products showed different RVA viscosity profiles depending on their physiochemical characteristics and their β-glucan contents. Products high in starch gave a high initial viscosity which dissipated as the α-amylase worked, whereas products with low amounts of starch gave a slow increase in viscosity. The viscosity of all samples reached a plateau for the viscosity curve after 1 to 2 hr, which is a key for obtaining reproducible results in this new method. Extraction conditions using sodium phosphate buffer (20 mM + 10 mM NaCl, pH 6.9), 1% β-glucan dispersion and 0.6 mm sample particle size showed the optimum viscosity without affecting the solubility of β-glucan. Pancreatin and α-amylase had major impacts on the digestion rate of protein and starch in the samples, but pepsin has limited influence. Highly significant Pearson correlation between the β-glucan viscosity (r^2 = 0.963) and solubility (r^2 = 0.954) obtained by the RVA method and the in vitro digestion method based on 1% β-glucan content was achieved for a variety of oat cereal products. These products cover a wide range of β-glucan content, solubility and molecular weight. The proposed method could be used as an effective alternative for measurement of β-glucan viscosity in a variety of cereal products.

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