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ABSTRACTS

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AACC INTERNATIONAL
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2010

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2010 Annual Meeting
Abstracts of Hot Topic Session

Abstracts submitted for presentation at the 2010 annual meeting in Savannah, Georgia, October 24–27. The abstracts are listed in the time order of the presentation. Abstracts are published as submitted. They were formatted but not edited at the AACC International headquarters office.

Cereals: Challenges in the Oriental World

Status and trends for the development of science and industry of cereal-based foods in China

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Cereal Foods World 55:A1

China has become one of the five most important economies in the world. China's agriculture has achieved a historic breakthrough, feeding now 23% of the world's population with 8% of the world's arable land. The total production of main farm products has risen to the top of the world and the output of food grain has reached 500 million tons. For the past five years, total industrial processing of agricultural products has had a yearly average increase rate of 10.8%, of which food processing accounts for 42% with an average yearly increase rate of 15%. There are over 600,000 farm product-processing enterprises, employing 16.08 million people. In particular, the grain processing industry which is the mainstream food industry in China, plays a critical role in this booming market. Besides production, China is a major country in terms of consumption. Wide varieties of ethnic, frozen, bakery, convenient, and other cereal-based foods are consumed annually. Significant changes have taken place since the reform and opening up to the world in consumption patterns and market trends, for example, chain-store operations, which has stimulated the development of food processing technology. This presentation will show how the application of underpinning science and technology is used to understand the contribution of new ingredients and processing methods in the industrialization, standardization, and optimization of quality for a range of traditional food products, such as steamed bread, baozi, you-tiao, oriental noodle and dumpling, etc. Development trend in the use of filling-containing frozen dough technology and sourdough technology in China will be presented using specific examples. From the international trade standpoint, China's current grain situation, and her practices of stabilizing grain prices, gaining the balance between supply and demand, and ensuring domestic grain security will be discussed. This presentation will indicate that while the underpinning grain science may be global, its application requires a sound knowledge of local products and their associated manufacturing and consumer preference bases for millers, bakers or traders to remain successful in the era of economic globalization.

Grain research and potential new opportunities for Asian markets

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Cereal Foods World 55:A1

Australia has been a traditional supplier of cereal grain for Asian markets. About one-third of Australia's major cereal, wheat, is regularly purchased for use in the manufacture of a wide range of Asian foods, such as noodles, steamed bread and other bread types, and dumplings. Other cereal and grain crops are also produced, including barley, lupins and sorghum. In 2008, total production included 13.6 million tonnes of wheat, 7.2 million tonnes of barley, 3.7 million tonnes of sorghum, 1.5 million tonnes of oats and 0.6 million tonnes of lupins. The primary use of lupin and sorghum in Australia has been for animal feed but the value of these crops as human food is now being investigated. Varietal screening, optimising processing and formulation for acceptability in various Asian foods including noodles and chapatis, have been a focus of new research. A whole-of-value-chain food science research approach has led to the study of the physical characteristics of grain-based foods with added health benefits and their effects on, digestibility, appetite, food intake, blood glucose and cholesterol levels and other biomarkers of chronic disease risk.

Potential ways to improve the nutritional and health benefits of Asian noodles

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Cereal Foods World 55:A1

All across Asia, the number of people age 65 and above is expected to grow dramatically over the next 50 years. For the region as a whole, the population in this age group will increase by 314 percent—from 207 million in 2000 to 857 million in 2050. Today, nearly one in five Japanese is age 65 or older, and the figure will jump to more than one in three in the next three decades according to government data. The increasingly aging population has created opportunities for food manufacturers to develop nutritional and healthy food products in Asia. Staple foods in Asia include rice- and wheat-based products. Of the total wheat flour consumed, over 40% is in the form of various types of Asian noodles. Improving the nutritional value and health benefits of Asian noodles would provide a viable option to serve the needs of aging consumers. This presentation will give an overview of the research results of fortification

of Asian noodles with whey protein concentrates (WPC), dairy mineral complexes, dietary fiber, and medicinal herbs. Fortifying Asian noodles with WPC80 alone or in combination with dairy minerals not only significantly improved the nutritional profile of the noodles, but also resulted in improvement in noodle color and texture. The incorporation of cross-linked resistant wheat starch as a source of dietary fiber into instant fried noodles proved to be an efficient way to increase dietary fiber and decrease calorie levels, while maintaining an acceptable texture profile (hardness, springiness, cohesiveness and chewiness), appearance (color and shape), and taste. Adding rehmannia (Rehmannia glutinosa), also known as Chinese foxglove or Jiwhang in Korea, to noodle formulations up to 4% (w/w) not only yielded noodles more acceptable than or comparable to the control wheat flour noodles, it also offers potential health benefits.

Sourdough fermentation processing of Chinese Northern-style steamed breads and their volatile compounds

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Cereal Foods World 55:A2

Chinese steamed bread is a widely consumed breakfast item, representing about 40% of the wheat consumption in China. It is produced using wheat flour, water, and yeast. Studies on Chinese steamed bread have explored the relationship of quality to different types of flour, formulation, and processing factors. Sourdough bread has been produced for thousands of years using natural or spontaneous fermentation, and the traditional formulation of sourdough steamed bread also utilized sourdough technology before yeast was commercially available. The objective of this study was to evaluate the effect of processing parameters such as amount of flour in sourdough starter, fermentation time of sourdough starter and amount of yeast on the quality of Chinese sourdough steamed breads with spontaneous sours using all purpose and whole wheat flours. The effect of amount of flour in the pre-fermented form (10%, 20%, and 30% flour in the pre-fermented form), fermentation time (12, 24, and 36 h), and amount of yeast (0.5%, 1.0%, and 1.5%) on acidity, specific volume, and crumb texture of Chinese Northern-style sourdough steamed breads were studied. Volatile compounds of the sourdough and non-sourdough steamed breads were also determined. The preferments were produced from spontaneous fermentation using all purpose (APF) and whole wheat flours (WWF). Specific volume was the highest at 20% preferment for APF sourdough steamed bread (ASSB) and 30% preferment for WWF sourdough steamed bread (WSSB). The softest texture was obtained with 20% preferment while at 30% preferment there was excessive gluten weakening due to high acidification. A total of 89 volatile compounds were identified in steamed breads with ethanol and 3-methyl-1-butanol being the most abundant compounds.

A health-conscious approach to developing rice-based products

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Cereal Foods World 55:A2

Rice is the staple food in Taiwan. Rice bran is a byproduct generated in the polishing of rice, and accounts for 10% of brown rice. It is rich in nutrients, including dietary fiber, vitamins, minerals, proteins, and lipids. The lipid fraction contains physiologically active substances, such as α-tocopherol, tocotrienols, phytosterols, γ-oryzanol and other anti-oxidants. Fermentation has been used to produce γ-aminobutyric acid (GABA) from rice bran extract. GABA is health-enhancing and known to be able to lower blood pressure, improve menopause symptoms, regulate the central nervous system, prevent obesity, avoid arteriosclerosis, and suppress anxiety and insomnia. The production of GABA was carried out in a 2.5 L fermentation medium containing heat-stabilized rice bran, glutamate and milk powder, and a mixed culture of commercially available lactic acid bacteria. The results showed that the production of GABA reached the highest amount (1236 mg/100g) after 24 hours and its pH was 4.45. Results of analysis showed that the amounts of total polyphenols, total tocopherol and γ-oryzanol were 537 mg/100g, 18.8 mg/100g and 0.95 mg/100g, respectively in upscale level. The resulting GABA-rich rice bran product was used for making biscuits. the process was found to lower the amount of GABA by only 10%, indicating that the product may be useful as an ingredient for bakery goods.

Effect of frying conditions and yeast fermentation on the acrylamide content in you-tiao, a traditional Chinese fried twisted dough-roll

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Cereal Foods World 55:A2

You-tiao is a traditional wheat-based twisted dough roll with origins that date to the Sung Dynasty (960-1279 AD). A very popular breakfast item in Chinese cuisine, you-tiao is deep-fried at temperatures that exceed 200°C, resulting in a golden brown crispy exterior and chewy interior containing large holes. The high frying temperatures used to produce you-tiao have been shown to promote acrylamide formation ranging from 250 - >300 ug/kg. In order to develop strategies to reduce acrylamide, the effects of frying temperature, frying time and dough pH on the formation of acrylamide in the processing of you-tiao were analyzed. The results obtained showed that the frying temperature and time had a notable impact on the formation of acrylamide. Dough pH also had a significant effect on the amount of acrylamide resulting in the products. It was demonstrated that lowering the frying temperature to 175°C, prolonging the frying time to 86 seconds, and adjusting the dough pH to 6.0 with citric acid reduced the acrylamide content by 71% in the finished products. The addition of different levels of yeast ranging from 0.1% to 1.2% to the traditional formulation was examined. We found that dough with the addition of 0.8% yeast fermented for one h could significantly reduce the amount of acrylamide formed in the fried twisted dough-roll by 66.7%. An examination of the influence of yeast fermentation on the free asparagine and reducing sugars levels, revealed that when the reducing sugars reach the maximum content, the acrylamide content was reduced, and free asparagine was decreased. Asparagine reduction by yeast fermentation proved critical in the reduction of acrylamide content in you tiao.

Changes in wheat products consumption in Japan: Trends, new products and quality

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Cereal Foods World 55:A2

Total annual wheat flour consumption in Japan is 5 million metric tons, with 26% of that being for bread and 28% for noodles. As the population has declined in the past decade, the downswing is seen in all carbohydrate rich foods. Rice is the main source of carbohydrate, with 7.5 million metric tons being consumed, mainly in the simple boiled form, which is a reduction of 6.7% in the past decade. This is in direct comparison with bread and noodles which are eaten in many different ways. The latter is especially true for noodles, which are traditional foods, and come in many different categories: boiled Udon, fresh ramen, frozen noodles, instant noodles, cooking noodles, dried noodles and noodles eaten in restaurants. The consumption trends are different in each of these categories. In this presentation, the quality demands for these wheat products through recent consumption trends, and new products and technology development in Japan, which may also be relevant for the other East Asian situations, will be discussed.

Effects of transglutaminase on the rheological and noodlemaking characteristics of oat dough

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Cereal Foods World 55:A2

Although perhaps not as popular a breakfast food as many manufactured cereal alternatives, oats have received increased interest recently due to their nutritional value (e.g., high in soluble dietary fibre, proteins, unsaturated fatty acids, vitamins, minerals and other nutrients). Utilisation of oats in baked products is limited due to the inability of oat flour to form cohesive, viscoelastic dough, such as the gluten network of wheat dough. In addition to the goal of enhancing food's nutritional properties, incorporating exogenous proteins into food production is a common practice for improving processing characteristics. In the present study, oat dough containing 15% (w/w, blends of protein-oat flour basis [POB]) vital wheat gluten (VWG) and 15% (w/w, POB) egg albumin (EA) were used to produce noodles with or without gluten (i.e., gluten-free), respectively. To enhance the noodle-making characteristics of the oat dough and improve the quality of noodles, transglutaminase (TGase) was added. The effects of various amounts of TGase on the rheological properties of oat dough with different proteins were investigated using Mixolab and rheometer. The modifications of TGase on different protein fractions from oat dough were also studied with SDS-PAGE and free-amino-group quantification. The results indicated that the extent of TGase's modification of the thermomechanical and dynamic rheological characteristics (G' and G", respectively) are dependent on the source of exogenous proteins in the oat dough. By adding 1.0% (w/w, POB) TGase, the cooking qualities of the resulting noodles (i.e., those containing VWG and EA) were elevated with lower cooking loss; the elasticity of both types of noodles increased. In the oat dough that had been prepared with VWG, TGase was shown to catalyse the cross-linking of both oat protein and gluten protein; however, oat protein acted as the only substrate of TGase in the noodles that had been prepared with EA.

2010 Annual Meeting
Abstracts of Pre-Meeting Workshops

Abstracts submitted for presentation at the 2010 annual meeting in Savannah, Georgia, October 24–27. The abstracts are listed in alphabetical order by title of workshop and time order of presentation within each workshop. Abstracts are published as submitted. They were formatted but not edited at the AACC International headquarters office.

Green Technology and Carbon Footprint—Impact on Food and Feed Processing

The business of trading carbon
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Cereal Foods World 55:A3

The presentation will cover trading of soil carbon and how this may affect the way we farm in the future. The basics of carbon trading will be explained with an introduction of the some of the concerns and requirements for trading in this relatively new market. Novecta has been involved with the carbon industry for over two years developing a standardized system for validation the methodologies for carbon trading and verification of soil based offsets. Basic understanding will be provided on how the 'carbon market' could be used under a proposed Cap and Trade system that agriculture can take part in.

Climate, carbon and energy policy impacts on sustainable livestock production
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Cereal Foods World 55:A3

As the U.S. Congress continues to debate a variety of offerings related to carbon sequestration programs, energy policy and overall climate change legislation, the long term impact on the livestock and feed industries that very often operate on razor thin margins remains a concern. This presentation reviews the operations and supply chain participants to see the impact of early adopters of systems that allow industry to operate within a new proposed framework, and evaluates some of the most critical economic tools used in the public policy development process to determine the information needs of both political leaders and producers. Additionally, insight will be provided into the political dynamics in the U.S. as to the future of climate, energy, and related legislation. Early interest from the agriculture community in climate change legislation was based on early estimates of income potential from sale of carbon credits, but this was eroded by estimates of inflated energy costs for crop and livestock production sectors. A number of individuals in the food and feed sector made plans to "hedge" against a potential onslaught of regulations and began adopting production standards that might be required under the new law. Many of these operations also worked to find income streams from carbon sequestration and these new management practices. Sustainability has numerous meanings. To be successful each of the operations would need to conquer sustainability on numerous fronts; economically, environmentally, and operationally. Additionally, changes in operations would affect all the participants of the chain many of which were now being forced to serve "both sides" of the proposed operational models. In some cases one would believe that the fragmentation of the chain would present challenges to sustainability as well.

Sustainability and the pulse industry
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Cereal Foods World 55:A3

Most global food companies now have programs underway to improve sustainability. While many initial programs have focused on reduced/recyclable packaging and reduced energy use in processing, these are gradually giving way to efforts aimed at more substantive change. Leading organizations have used life cycle analysis to examine their supply chains and identify opportunities for reducing impacts. Among the interesting conclusions reached are that roughly 90 per cent of their products' "footprints" come from the agricultural component of their supply chains, and that transportation energy use and greenhouse gas emissions tend to be dwarfed by field emissions, even when products are crossing oceans. Pulse Canada, a trade association of bean, pea, chickpea and lentil producers, has recognized the growing importance of sustainability metrics as an issue likely to affect markets in North America and the EU. While there is opportunity in these changes, different approaches to measuring the sustainability of agriculture are being advocated by different interest groups, and potentially competing methodologies and views of sustainability are emerging. Pulse Canada has a strong commitment to sustainability, to promoting sustainable practices amongst its members and to securing the position of Canadian-grown pulses in markets which are becoming increasingly sustainability-conscious. Sustainability metrics like carbon footprinting—provided it is properly understood and fairly implemented—have the potential to incentivize the adoption of even higher standards in future. Pulse Canada has international and Canadian projects and partnerships underway in the areas of carbon footprinting, soil organic carbon measurement, life cycle analysis, water footprinting, and harmonization potential in carbon offsets and food industry sustainability metrics.

Sustainability and life cycle principles for food products
C. BALDWIN (1)
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Cereal Foods World 55:A4

Sustainability for the food industry means that food is produced and consumed in a way that supports the wellbeing of generations. With the food supply responsible for an estimated 20–30% of total greenhouse gas emissions and with more than a third of child deaths worldwide attributed to undernutrition, there remain significant challenges ahead for the food industry. Sustainability has been a growing topic in the food industry, with parallel successes in practice. Much of the successes has been with improvements in the environmental performance in manufacturing operations or packaging of products. It is time to expand the successes to the rest of the supply chain and begin taking a life cycle approach to sustainability. The life cycle approach to sustainability will be discussed with 10 sustainability principles for the food industry along with best practices to illustrate the principles and provide ideas and inspiration for more sustainable development in the food industry.

Sustainability in the ethanol and feed processing industry
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Cereal Foods World 55:A4

Together, the feed and ethanol industries are the first users of about 70% of U.S. corn. Feed consumes nearly 80% of U.S. soybean meal, which in turn is 70% by weight of soybean production. This presentation will review the sources of energy and other natural resource consumption in the feed and ethanol industries. The impact of corn and soybean production trends on the efficiency and output of these industries will be projected. Technology improvements in the ethanol industry will improve energy and water use efficiency substantially. New products created by ethanol process technology will improve the usage of ethanol coproducts in swine and poultry diets, and could double the oil feedstock available of biodiesel. Increased trendline slopes for grain yields potentially increase total biofuel production with less external input per unit. Possible outcomes for biofuel generation, share of U.S. transportation fuel use and grain availability for feed/food uses will be presented. The feed, corn-to-ethanol, and soybean crush industries are synergistic in the ability to achieve systemwide reductions inputs per unit of output.

Healthy Grains: Implications of the Rheology of Digestive Processes

Hydration and mixing of cereal foods during eating and digestion
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Cereal Foods World 55:A4

The role of dietary fiber within a healthy diet is widely recognized and with this heightened awareness comes the requirement for the definition and assessment of this category of material. However, like many food materials, chemical composition alone will not convey the fibers' functional performance and therefore, along with forms of compositional analyses, there should be physicochemical characterization. This leads to the question "What physicochemical test/s should be undertaken?" Viscosity is one parameter generally considered to have an effect on digestion and absorption of nutrients, with the non-starch polysaccharides often considered the main materials implicated in changing the rheology of foods. In the last few years there has been marked progress in following foods as they pass through the digestive tract using techniques such as Magnetic Resonance Imaging for example. From such studies and from investigations of the content of the digestive tract, it is clear that foods eaten and undergoing digestion will be continually changing due to mastication, acid and enzyme hydrolysis or microbial degradation. The impact on the digesta's physicochemical properties is marked; as mixing, hydration, size reduction, dilution and phase inversion occurs. These changes will influence the efficiency of digestion as the absorption process is partly determined by the mixing ability of the gut (it should be remembered that the digesta is a mix of particulates and solutions) and transit time of ingested food. Therefore simple relationships between viscosity (however measured) and fiber performance are unlikely. A greater understanding, jointly undertaken between physiologists and food scientists, of the behavior of foods within the gastrointestinal system is necessary and only then can suitable tests on fibers be developed as useful predictors of functionality.

Dynamic Gastric Model: A realistic model of the human stomach
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Cereal Foods World 55:A4

Investigation of the human digestive process normally involves a feeding study and the acquisition of serial samples of digesta from the stomach and upper small intestine via naso-gastric/ naso-duodenal aspiration, the rest of the small intestine being inaccessible. However aspirated samples taken from the upper GI tract need to be fluid so only fluid foods can be tested. This technique therefore cannot be used for the direct study of real foods where functionality is dependent on macro structures. Terminal ileal samples can be collected at regular intervals from ileostomy patients but only reveal the end point of upper GI tract processes while faeces are heavily degraded by the colonic microflora. Animal studies may offer an alternative but in addition to ethical considerations, concerns are frequently raised regarding their relevance to human. Studies of the complex process of digestion are therefore ethically and technically difficult, expensive to perform and make large numbers of studies impractical. There is therefore a strong case for the development and application of in vitro models of digestion which closely mirror the conditions and processes that actually occur in vivo. The abundance of different techniques and protocols available reflects the need for reliable in vitro methods to assess gastro-intestinal digestion of real food materials. Within the last two decades our understanding of the human gut has evolved with the development of non-invasive investigative techniques that allow real time measurement of the key processes that take place in the gut. Such data has made it possible to under take in vitro modelling that is predictive of in vivo performance within the human gastro-intestinal tract allowing the process of digestion of real foods and meals to be followed in some detail. This presentation will give an overview of the current state of this innovative sector.

Future trends of artificial mouth: Generation of food particle sizes similar to orally processed foods to help the comprehension of digestive processes
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Cereal Foods World 55:A4

In the field of sensory and physiologically studies, developing of instrumental techniques that reproduce oral functions could be an interesting topic. Indeed, the major goal of mastication and salivation is to transform the food in a bolus suitable for swallowing, and to prepare and initiate digestion reactions. Thus, we designed an "artificial mouth" that reproduces oral functions, such as mouth temperature, saliva, mastication and volatiles transportation by respiration. Boluses generated by this artificial mouth were studied. We first characterised boluses obtained from foods with different structures and textures. They were collected in vivo just before swallowing, or obtained after artificial crushing. Different artificial mouth settings were studied in order to find those that better mimic the human mastication of food samples. Several volunteers were involved in the study, to take into account the inter-individual variability. Foods chewed in vivo and crushed in vitro were compared by granulometry and an image analysis method. We screened different foodstuffs, and particularly cereal foods. The objective was to check if the conditions that best reproduced human mastication effects were the same for different kind of structure and texture. For cereal products, the concomitant actions of saliva and artificial mastication were necessary to obtain a bolus similar to that obtained in the human mouth. The artificial mouth was shown to reliably mimic the human mastication of food samples, since it generates food particle size similar to those of orally processed foods. This tool was used to study volatile odorant compounds responsible for aroma perception. Indeed, it is necessary to extract these compounds under conditions that reproduce their release from foods. As it was done for aroma study, this apparatus could also be used to study digestive processes.

Rheological challenges in modelling digestive processes
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Cereal Foods World 55:A4

Digestion is a complex rheological phenomenon involving chewing, swallowing and peristalsis through the digestive tract. Modeling the rheology of these processes has been difficult for a number of reasons. Chewing involves a lateral as well as vertical motion and shearing in several directions. Modeling of swallowing has received more attention recently because of the prevalence of dysphagia in an aging population, but more research is needed. Peristalsis is the contraction of smooth muscle surrounding the stomach and

intestines providing a squeezing motion which is difficult to mimic in a batch situation. Model systems are necessary to study the digestion of food ingredients designed for health benefits, because most ingredients need to be in a hydrated form or at least dispersed to be functional. In the case of solid food forms, the ingredient must be hydrated *in-vivo* and the extent of hydration and dispersion *in-vivo* will determine the effectiveness of the ingredient. The shear forces of the gut are very important in hydration and dispersion and modeling these forces is required for effective *in-vitro* screening assays. Several *in-vitro* models have been developed, but none incorporate all of the digestive processes. Most models focus on only one aspect of digestion, such as the stomach or large intestine. Many of these models use a "batch" system and slow stirring to mimic peristalsis. Batch systems have difficulties in mimicking chewing to create small boluses, the saliva/amylase interaction, and accurately simulating peristalsis. Measuring the viscosity of digesta contents can be problematic as well because digesta is not uniform in solution. More sophisticated models account for these failings, but sophistication increases the expense. The challenge is to find realistic models that are not cost prohibitive and yet are representative of actual digestion so as to better screen ingredients and foods for defined health benefits.

Surface architecture, lubrication and nanorheological properties of mucins and mucosal biofluids

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Cereal Foods World 55:A5

Nature provides a whole variety of solutions for interfacial design; it uses proteins, lipids, carbohydrates and glycoproteins to create self-assembled structures, like multilayers, lamellar structures, 3D phases, gel and fibrous networks. Some of these structures are kinetically or even thermodynamically stable, whilst others are extremely dynamic and their long term stability depends on effective repair mechanisms. Structural and rheomechanical properties of these structures ultimately determine their end functionalities. These include barrier properties, encapsulation, tensegrity, structural integrity, as well as transport, motion and adaptive dynamics. For example the integrity of cells in a tissue is determined by intercellular adhesion, whilst motion relies on a combination of friction and fluid dynamics. Here we focus on the structural and nano-rheological properties of proteinaceous films, and examine how these properties translate into their functionality as lubricants and surfaces modifiers. Firstly we look at the natural lubricant – saliva – which has evolved to form an extremely robust boundary layer, which for hydrophobic surfaces yields in a boundary friction coefficient two orders of magnitude lower than that for water or e.g. an adsorbed layer of serum albumin. We use AFM imaging and force spectroscopy, in combination with other techniques, to characterise the structural properties of adsorbed salivary films, and discuss scenarios by which these lead to emergent phenomena such as biolubrication. Further we analyse in more detail the interfacial and lubricating properties of adsorbed films of mucin, a key component of saliva, and demonstrate that mucin alone is not responsible for superior lubrication, but has a number of key structural elements and dynamic properties that uniquely differentiate salivary film from simpler layers of adsorbed globular of fibrous proteins. Finally we bring some examples of how some common proteins, such as lactoferrin or lysozyme, can be used together with mucins in interfacial design, enabling surface modification with tuneable surface interactions, adhesion and bulk aggregation. Using this biomimetic approach we are seeking to utilise these insights in the design of superior aqueous lubricants that potentially can be used in prosthetic devices, foods, packaging etc.

2010 Annual Meeting
Abstracts of Symposia Presentations

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A Statistical Smorgasbord for Cereal Chemistry

What is the meaning of statistics?
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Cereal Foods World 55:A6

There are six basic statistics that can be used to evaluate most of the basic or applied research that has to be carried out by cereal technologists. These are: the mean; the standard deviation (SD); the coefficients of correlation and determination (r and r2); the coefficient of regression (b); and the analysis of variance (ANOVA). If the application of these fails to arrive at a conclusion, either the experiments have not been well-designed, or the hypothesis needs re-visiting! Any software package, such as Excel, will include the first four of these statistics. The ANOVA is available in SAS. A sixth statistic is the coefficient of variance or variability, which relates the SD to the mean, and is a useful adjunct to the SD. The paper attempts to explain these statistics in easy to understand terms. For example, of the first five, the standard deviation (SD) is probably the least understood. It expresses the variance in a set of data. The variance is the heterogeneity, or degree to which the data are distributed above and below the mean. The term SDx is used to denote the SD of the independent variable and SDy is used to denote the SD of the dependent variable. What is often not understood is that the value of e.g. ± 0.2 for the SD of protein check sample testing, represents only about 68% of the total population. The value of +1.96 times the SD represents 95% of the population and is sometimes referred to as the 95% Confidence Limit. This is a rather better way to describe the variance in a population. To describe the variance in full the SD should be multiplied by 3. This expands the SD to ± 0.6, which implies a range of 1.2% in the possible results obtained for a protein test carried out on the same sample.

Effective presentation of statistical analyses
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Cereal Foods World 55:A6

Tables and graphs are essential both as aids in analysis of your data and also for presentation of your results. Use frequency, box, and scatter plots as guides to identify outliers, check distributions, and to determine the proper analyses of your data. Many of these exploratory plots can then be used for presentation of results. After analysis, scientists tend to present results in tables and these tables can be enhanced when accompanied by effective graphics. For example, correlation tables are useful to show which variables are related but should be accompanied by scatter plots to show the whole story. Linear and non-linear relationships are effectively shown by X and Y plots. A variety of plots and procedures will be presented and discussed.

Avoiding common pitfalls in designing experiments
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Cereal Foods World 55:A6

Obtaining meaningful statistical results requires asking appropriate questions before beginning an experiment. Guidelines will be shared for choosing the appropriate experimental design. Participants will leave this session with a better understanding of the range of experimental design types available and how to leverage them appropriately. Presentation will focus on the differences between factorial and response surface designs.

CV, RSD, and the HorRat - applications and limitations
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Cereal Foods World 55:A6

Relative Standard Deviation, or RSD, (sometimes referred to as CV), is a combination of 2 other statistics: mean and standard deviation. When combining statistics, it is important to be sure that the combination results in a metric which adds additional understanding to the interpretation of the data set. Additionally, all reported statistics should be understood by the audience, and the audience should have a contextual framework to interpret the magnitude of the statistics. RSD was originally used as a way to aid the interpretation of the observed standard deviation of a test method. Subsequently, William Horwitz and Richard Albert developed the Horwitz equation relating RSD of the method to analyte mean concentration. This function has greatly aided the interpretation of validation data, as it gives a prediction of RSD for a given analyte concentration. Calculation of a Horwitz Ratio, or "HorRat" from multi-lab validation studies has been used effectively as a metric to guide interpretation of collab results. Since the Horwitz equation is only applicable to measures of concentration in mass ratio units, the HorRat would not be applicable for non-concentration-based methods, such as pH or color tests. In recent years, biochemical assays have shown

startlingly high HorRat values for some analytes. The cause of this is likely due to the fact that the chemical species being detected by these methods are a very small fraction of the total mass of the analyte being quantified. The expected RSD for such analytes would be higher than anticipated by the Horwitz function. Application of the HorRat to these types of analyses should be done with caution.

Assessment of Grain Quality: From Breeding to Store Shelf

Assessment of genetic and molecular approaches for the prediction of wheat quality
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Cereal Foods World 55:A7

Over the past four decades, the field of plant breeding and genetics has been revolutionized by technological advances in the areas of DNA manipulation and evaluation. For some crops, these approaches have brought new products to market via genetic transformation, and have vastly improved the efficiency of selection in breeding programs. Marker-assisted selection also has improved the efficiency of selection of disease resistant lines, thereby indirectly impacting crop quality. At the same time, technological advances in the fields of immunology and spectroscopy have improved the ability of breeders to rapidly phenotype selections. This presentation will examine some of the advances in genetic manipulation, DNA marker assisted selection, and rapid phenotyping that have impacted breeding efforts to improve or alter wheat quality and disease resistance. Attention will be focused on efforts to alter grain polyphenol oxidase activities, starch composition, gluten strength, tolerance to pre-harvest sprouting and selection of lines carrying resistance to wheat streak mosaic virus. The relative merits of these various approaches for selection or improvement of each trait will be discussed.

The quest for knowledge: Dealing with the continuum of defining quality parameters through the market channels
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Cereal Foods World 55:A7

The quest for knowledge is a goal of every person in today's business and scientific environment. This is especially true when defining what the term "quality" means in the channels dealing with a vast range starting with the inception of a variety to the consumer searching what is on the shelves of retailers today. Please join me as we explore the range of what "quality" means in channels today. We might even explore virtual integregation as the next frontier of refining what "quality" means in the entire supply chain regarding the implications to business growth aligning with consumer satisfaction.

Experimental milling for wheat and flour quality assessment
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Cereal Foods World 55:A7

Wheat variety development has historically been focused on agronomic traits, and flour millers were resigned to opt for consistency in the absence of quality. Wheat growers, exporters, flour mills and bakeries all have a common interest in wheat quality, but not a common definition of wheat quality. To define wheat quality each user must rely on data that may not be suited for their needs. In experimental milling, the tool used for variety development, there are two basic considerations. First (which certainly exists), is an experimental method that minimizes variability due to milling, so we can evaluate the differences in wheat performance. Second (which doesn't necessarily exist), reflects commercial mill performance, where a flour mill sets the extraction based on a budgeted amount for maximum economical gain. Mills, as customers, use data from experimental milling to make decisions about which wheat to buy. However the milling yield and rheological/end-use data are based on wheat and flour from a standardized experimental method. Commercial and experimental milling data are undoubtedly correlated, but do these data meaningfully reflect rheological and end-use performance at the bakery? In this talk I will discuss wheat quality needs from a millers perspective, and the need for standardized tests that reflect commercial milling conditions.

Please use the tradesman's entrance: The back door to flour quality
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Cereal Foods World 55:A7

Traditional methods of measuring flour quality require significant amounts of material, time and the availability of appropriate (and usually expensive) equipment. While the amount of material is not often an issue in the commercial world, time and equipment are not always on hand. Sometimes the equipment is present but not the amount of material required for testing (such as in a breeding situation). There are many predictive tests for flour quality that can be applied in appropriate situations. Some of these require high-tech equipment such as HPLC, and others are much more basic. They all give the possibility of allowing selection of samples of suitable quality for the purpose in mind. A number of these will be discussed and results for actual commercial samples will be presented.

(Bio)active compounds in flours and cereal products: What does it take to get reliable data?
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Cereal Foods World 55:A7

Phytochemicals are made responsible for a range of health beneficial effects related to whole grain consumption. Recently, a lot of data for concentrations of phytochemicals in different cereal grains and in cereal based products were published, often presenting conflicting results. While several publications aimed to report contents for individual compounds the use of sum parameters (e.g. total phenolics, etc.) is very common, too. Sum parameters are usually obtained from procedures which can be performed fast and easily. In general, only very few papers report details on the methodologies used, validation data are hardly ever reported. The use of non-validated and/or unspecific methodologies, however, leads to severe problems in comparing results from different studies/laboratories. When using sum parameters, it is most critical to realize that other compounds in the matrix can influence these parameters as these tests are often less specific. Thus, the chemical principals of the tests must be known and the effects of matrix components must be critically evaluated. Also, methodologies used (regardless of determining sum parameters or individual compounds) should be validated for other parameters next to selectivity. Minimum validation parameters for analytical methodologies used to analyze phytochemicals from cereal grains in research include selectivity, precision, accuracy, limit of detection, and limit of quantitation. A complete validation (as required for industrial quality assurance purposes) of methods used for research purposes seems not doable due to time restraints and the large number of methods which often change very quickly. However, testing of the minimum validation parameters should be performed to secure that the methodologies meet the researcher's acceptance criteria, and these criteria have to be clearly communicated in scientific publications.

Incorporating important biochemical attributes into breeding programs
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Cereal Foods World 55:A7

Biochemical attributes of quality can be manipulated by breeding when they can be measured inexpensively and genetic variation exists for trait that is expressed consistently across environments. This is true of all cereal crops but the examples for this presentation will be taken from wheat. Simple direct selection is effective for attributes such as wheat seed color because it meets all three of these criteria. Arabinoxylan content of flour as measured by solvent retention capacity and polyphenyl oxidase activity also fits this model as they are readily manipulated biochemical traits with relatively small genotype x environment interaction. When traits are difficult to measure directly or environmental conditions obscure the phenotype selection, using genetic markers can improve the selection efficiency. High-molecular-weight glutenins are the classic example of marker assisted selection. Selection for waxy (low amylose starch) wheat also was initially developed using markers. Although final stages of selection for the waxy trait typically uses inexpensive phenotyping methods. Traits that have limited variation may require the introduction of traits through inter-species hybridization. Gpc1 for grain content represents this type of introduction. Mutagenesis is another method to introduce new variation. This was used for the Lpa1 gene in wheat for low phytic acid concentration. TILLING is a relatively new method to direct the selection of the mutagenesis that may be appropriate for biochemical traits where the reduction of activity for a gene will enhance the biochemical profile of the grain.

Best Student Research Paper Competition

Development of consumer acceptable and nutritious Teff (*Eragrostis tef*) bread using enzyme combination treatments

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Cereal Foods World 55:A8

Bread has been an important part of daily diet for many years. It is one of the main staple foods and provides important nutrients. Recently, there has been a great interest in incorporating less-utilized and nutritious grains in order to improve nutritional value of bread. This can provide a challenge in producing an acceptable baked product. Teff is a small-grained and nutrient-rich cereal, which has good potential to be used in developing healthy cereal products. This research aimed to determine effects of incorporation of Teff grain on bread characteristics and nutritional properties and the effects of enzymes on product quality and acceptability. Teff flour replaced white wheat flour at the level of 30% in breadmaking formulation. A combination of four enzymes (xylanase, α-amylase, glucose oxidase and lipase) were used to develop Teff breads. Breads were tested for nutritional properties, quality parameters and sensory attributes. The results showed that Teff bread contained significantly more iron and had higher total antioxidant capacity compared to wheat bread but had lower loaf volume and increased crumb firmness. Sensory evaluation showed significant decrease in overall acceptability due to bitter flavour and aftertaste. This problem was overcome by addition of different enzymes, which resulted in significant improvements in loaf volume and crumb firmness. Image analysis showed that addition of enzymes improved crumb structure parameters. Teff breads with enzymes had more uniform and fine crumb structure with a larger slice area and smaller cells. Sensory evaluation revealed that addition of enzymes significantly reduced bitter flavour, aftertaste and improved overall acceptability. In conclusion, a number of enzymes can be used to produce nutritious Teff bread, which texture and sensory attributes could be comparable with wheat bread, and which would provide additional health benefits.

Changes in oat beta-glucan properties by heat induced oxidation

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Cereal Foods World 55:A8

Thermal degradation of oat β-glucan (β- (1→3)(1→4)-D-glucan) and role of oxidation were studied with and without an oxidation catalyst, ferrous ions. Native extracts from oat bran concentrates and solutions of commercially purified oat β-glucan were heated at 120°C up to 30 minutes. Viscosity change was determined by a rheometer and polymeric parameters by SEC-MALLS-RI. Carbonyl content was determined by a carbonyl-selective fluorescence labelling method (CCOA method), since carbonyl groups are introduced in the polysaccharide backbone in oxidation processes. Radical formation was studied by an ESR spectroscopy. The heat treatment caused a clear decrease in the viscosity of the extracts (75%-90%, depending on the source of the extract), and a 10% loss in viscosity in the solution of purified β-glucan. Molar mass (MW) of β-glucan decreased in solutions mainly following the trend of viscosity decrease and thus suggesting chain scission. The scission was related to oxidation, since radicals were detected during heating and the formation accelerated in the presence of ferrous ions in line with viscosity loss and MW decrease. In addition, carbonyl content increased as a result of heating at 120°C. Addition of ferrous ions resulted in two MW populations of which the first population had significantly smaller and the second population significantly higher MW compared to that of untreated β-glucan. Formation of the compact high molar mass population may be explained by new linkages, such as hemiacetal crosslinks, between chemical groups formed in oxidative cleavage and hydroxyl groups of glucan chain. Results obtained with several independent methods suggest β-glucan to be sensitive to oxidative cleavage and functional changes in food processing such as heating.

Reaction kinetics of amylose and amylopectin branch chains in a model derivatization system

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Cereal Foods World 55:A8

Starch chemical modification is not fully understood, due in part to the complexity of the starch granule structure, which impacts the distribution of substituent groups on starch chains (impacting modified starch properties). This work investigated the relative reactivities (reaction kinetics) of amylose (AM) and amylopectin (AP) branch chains, in relation to reaction time. Relative reactivities of AM and AP branch chains of normal wheat starch were monitored over a 24 h period, utilizing a fluorescent reagent [DTAF, 5-(4,6-dichlorotriazinyl)aminofluorescein]. At various intervals (0, 0.5, 4, 12, and 24 h), molecular reaction patterns of debranched starch derivatives were assessed via size-exclusion chromatography equipped with refractive index (RI) and fluorescence (FL) detection. Extent of reaction was measured by fluorescence density (FD), calculated as the ratio of the FL and RI peak areas for each starch chain fraction. For all starch chain fractions, a rapid rate of derivatization was observed in early reaction stages (< 4 h), after which reaction rate decreased (4 to 24 h). For all reaction stages, AP long branch chains (DP >36) were most densely derivatized (even more so than AM), while short AP branch chains (DP <13) were least derivatized, due to their participation in the granule crystalline structure. In later reaction stages, the proportion of FD attributable to AP intermediate and short branch chains continued to increase relative to that of AM and AP long branch chains, suggesting that granule crystalline regions gradually became more available to reagent as reaction progressed. These findings represent the first report of molecular-level reaction kinetics for AM and AP branch chains, and will aid modeling of molecular reaction patterns in relation to modified starch properties to facilitate more precise control of starch reactions and functionality.

Single pass drying of rough rice using glass transition principles

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Cereal Foods World 55:A8

As a kernel of rice is subjected to high temperatures, the starch in the kernel transitions from a 'glassy' to a 'rubbery' state. This transformation from a glassy to rubbery material is referred to as glass transition and the temperature at which the transition initiates is known as glass transition temperature. During high temperature drying, the core of the rice kernel may be in a rubbery state while the surface transitions back into a glassy state: this results in tensile and compressive stress differentials within the kernel, which if sufficiently large, provoke kernel fissuring and subsequent breakage. A recently developed approach to high temperature drying of rough rice uses controlled relative humidity of the drying air such that the kernel periphery remains in a rubbery state, just as would the kernel core. Such drying would allow single-pass drying without fissure occurrence. A series of drying trials were conducted in which rough rice samples from Wells cultivar (long-grain) were dried in a single pass from an initial moisture content of approximately 19.6% to a desired 12.5% moisture content using air at 60 – 90°C and 13 – 83% relative humidity. The milling quality of the dried samples, evaluated in terms of head rice yield, showed no significant differences between dried samples and controls when the relative humidity of the drying air was equal to or greater than 63, 73, and 83% at 70, 80, and 90°C, respectively. Therefore, better milling quality, along with potential drying time reductions afforded by single-pass drying, may be possible by controlling air relative humidity and thus the kernel matter state.

Effect of dietary fibre enrichment in spaghetti - An enzymatic and structural study

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Cereal Foods World 55:A8

Initiatives have been taken to develop food products with special health-enhancing attributes. We have developed pasta incorporating inulin and resistant starch (RS II and RS III) with durum semolina over a range of concentrations and made into pasta. Structural changes in the dried, cooked and in vitro digested pasta using Scanning Electron Microscopy (SEM), Confocal scanning laser microscopy (CSLM), X-ray Diffraction (XRD) and Small Angle X-ray scattering (SAXS) to provide a picture of the morphological changes in the starch/protein matrix over a broad range, μm to nm range). RSII and RSIII were effective in lowering starch hydrolysis compared to durum pasta. CSLM showed an increase in starch granule (SG) concentration with an increase in RS content. SEM of digested 20% RS pasta showed clusters of intact SG in the disrupted matrix. XRD suggests digestion results in an increase in crystallinity and molecular order and a transformation from A to B+V type crystallinity. The starch hydrolysis of inulin pasta reached a minimum at 5% inulin content then increased at 20% inulin. SEM and CSLM of cooked inulin pasta support the hypothesis that up to 5% inulin encapsulates the SG in a protective coat, while higher inulin content disrupts the starch/protein matrix. XRD and SAXS of digested inulin samples indicate that crystallinity was highest at 5% substitution. Application of these characterisation methods with in vitro starch digestion enabled a clearer understanding of the digestion process.

Starch-granule development in high-amylose maize
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Cereal Foods World 55:A9

GEMS-0067 is a new line of high-amylose maize developed by the USDA-ARS Germplasm Enhancement of Maize Project, which is a homozygous mutant of *amylose-extender* (*ae*) and high-amylose modifier gene(s). GEMS-0067 starch had greater amylose content (~85%) than did maize *ae* single-mutant starch (~65%) and normal-maize starch (~30%). GEMS-0067 starch consisted of up to 32% elongated starch granules, much higher than maize *ae* single-mutant starch (~7%) and normal-maize starch (0%). The elongated starch granules were highly resistant to enzymatic hydrolysis at 95–100°C (AOAC Method 991.43) and functioned as resistant starch (RS). The objective of this study was to understand internal structures of the elongated starch granules and how the elongated starch granules formed during kernel development. Polarized-light and confocal laser-scanning microscopy (CLSM) were used to reveal internal structures of physiologically matured elongated starch granules. Endosperm tissues harvested at an early stage of kernel development were examined using transmission electron microscopy (TEM). Under the polarized-light microscope, the elongated starch granules showed various birefringence patterns, including multiple Maltese-crosses overlapping in one granule, a single granule displaying one Maltese-cross or more on one side of the granule but no birefringence on the remainder of the granule, and starch granule showing weak or no birefringence. The CLSM images showed the elongated granules having multiple regions with intense fluorescence. The TEM images showed multiple small granules in the amyloplast fusing into an elongated granule during development. The results suggested that the elongated starch granules were developed by fusion of small granules initiated at the early stage of granule development through amylose interaction. This study provided an understanding of the formation of the elongated starch granules and the RS in high-amylose maize.

Bioengineering for Human Health

Improving the content and composition of wheat dietary fiber
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Cereal Foods World 55:A9

Wheat is an important source of dietary fiber for human health, accounting for about 12% of whole grain and 2.5% of white flour. The major component is arabinoxylan with smaller amounts of beta-glucan and both polymers occur in soluble and insoluble forms which may differ in their health benefits. Work within the EU FP6 HEALTHGRAIN program has focused on identifying sources of variation in the content and composition of dietary fiber in whole grain and white flour. Analytical tools and molecular markers have also been developed to allow this variation to be exploited by plant breeders and the content of fiber in grain samples and food products to be determined. Fundamental studies are also being carried out to identify genes that control fiber content and composition to allow specific modifications to be made in order to optimise the health benefits.

Crop development for improved nutrition and downstream value-added products
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Cereal Foods World 55:A9

Monsanto is committed to our sustainable agriculture initiative, producing more while conserving precious resources, and improving the lives of farmers and their families. A disproportionate percentage of the people who go to bed hungry at night are farmers who are unable to produce sufficient food to feed themselves and their families. Two billion people suffer from malnutrition each year, a number that will continue to increase if we don't find solutions. Monsanto's breeding, biotechnology and agronomical practice platforms are all geared towards establishing a solid foundation from which to create solutions for a growing global community. The farmer benefits of biotechnology traits are clear – for example, increasing productivity through increasing yield or through increasing the flexibility with which farmers are able to manage weed and insect pressure. We have also made progress in developing crop products that have processor and consumer benefits, with an emphasis on products that match a healthier lifestyle. The current paper will highlight some of Monsanto's efforts to utilize biotechnology approaches to generate maize with enhanced lysine content and soybean with heart-healthy fatty acid content. Time-permitting, the paper will also address some of Monsanto's conventional breeding approaches which are directed towards generating products with consumer benefits.

Enhanced levels of B-carotene in oilseed crops
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Cereal Foods World 55:A9

Carotenoids belong to a class of C40 isoprenoids and are well known lipid-soluble natural pigments. There are nearly 600 carotenoids in nature with biochemical pathways interrelated and very complex. We have genetically manipulated the carotenoid biosynthetic pathway in soybean seeds by strongly expressing crtB as a means to increase the amount of carotenoids in seeds. Developing green soybean seeds produce some carotenoids, presumably to play a role as a phytoprotective agent. This indicates that the initial steps in the carotenoid pathway are present and functional in soybean seeds so only the necessary genes for the seed-specific production of the carotenoid of interest need to be added. By engineering a seed-specific expression of a chloroplast targeted soybean codon optimized bacterial phytoene synthase gene, the initial gene product necessary to shuttle the substrate geranylgeranyl diphosphate to B-carotene, we have obtained levels near 870 ug/g B-carotene in soybean seeds, an enrichment of 1,700-fold over wildtype levels. As a pro-vitamin A source this level is over 20-fold greater than the enhanced golden rice and twice the level of B-carotene measured in most carrots. Once shown that soybean seeds can produce and accumulate such an enriched level of B-carotene, we are now using it as a precursor to the red colored carotenoid, astaxanthin, since it is a desirable additive in salmon farm-raised feed and a lucrative commodity due to its extreme difficulty in chemical manufacturing.

Plant-made vaccines and biopharmaceuticals
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Cereal Foods World 55:A9

Plant cells are ideal bioreactors for the production and oral delivery of vaccines and biopharmaceuticals, eliminating the need for expensive fermentation and purification processes. Plant-made vaccines have been developed for the past two decades and two plant-made biopharmaceuticals are advancing through Phase II and Phase III human clinical trials. Therapeutic proteins are stably expressed via the nuclear or chloroplast genome in plant cells or transiently using the plant viral systems. Chloroplasts are ideal bioreactors for expression and oral delivery of vaccines or biopharmaceuticals eliminate the need for expensive fermentation, purification, cold storage, transportation and sterile delivery. Twenty four vaccine antigens against 16 different diseases and fifteen biopharmaceuticals have been expressed in chloroplasts and are shown to be functional. An optimized lettuce chloroplast transformation system (Plant Phys Feb 2010) facilitates expression of several vaccines and biopharmaceuticals. Orally delivered cholera/malaria vaccine antigens developed both mucosal and systemic immunity (PBJ 8: 223-242, 2010) and conferred greater protection than injectable vaccines against plague challenge (Infection & Immunity 76: 3640-3650, 2008). Oral delivery of blood clotting factor IX expressed in chloroplasts prevented life threatening inhibitors and fatal anaphylaxis in hemophilia B mice (PNAS 107: 7101-7106, 2010). In order to further advance this valuable concept for clinical applications greater research emphasis is needed on large scale production, purification, functional characterization, oral delivery and preclinical evaluation. Recent advancement in this field will be presented.

Celiac Disease: A Multidisciplinary Point of View

Biochemistry of celiac disease
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Cereal Foods World 55:A9

Celiac disease (CD) is an inflammatory disorder of the upper small intestine triggered by the ingestion of wheat, rye, barley, and possibly oat products. The clinical feature of CD is characterized by a flat intestinal mucosa with the absence of normal villi, resulting in a generalized malabsorption of nutrients. The prevalence of CD is now thought to be in a range of 1:100–300. There is a strong genetic association with human leukocyte antigens (HLA-)DQ2 and DQ8 and currently unknown non-HLA genes. The precipitating factors of

toxic cereals are the storage proteins, termed gluten in the field of CD (gliadins and glutenins of wheat, secalins of rye, and hordeins of barley). There is still disagreement about the toxicity of oat avenins. The structural features unique to all CD toxic proteins are sequence domains rich in Gln and Pro. The high Pro content renders these proteins resistant to complete proteolytic digestion by gastrointestinal enzymes. Consequently, large Pro- and Gln-rich peptides are cumulated in the small intestine and reach the subepithelial lymphatic tissue. Depending on the amino acid sequences, these peptides can induce two different immune responses (innate and adaptive), which result in mucosal destruction and epithelial apoptosis. Additionally, stimulated T-cells activate B-cells that produce serum IgA and IgG antibodies against gluten proteins (antigen) and tissue transglutaminase (autoantigen). These antibodies can be used for noninvasive screening tests to diagnose CD. The current essential therapy of CD is a strict lifelong adherence to gluten-free diet. Dietetic gluten-free foods produced for CD patients underlie the regulations of the Codex Alimentarius Standard for Gluten-Free Foods. The "Draft Revised Codex Standard" edited in 2008 proposes a maximum level of 20 mg of gluten/kg for gluten-free foods.

Improved gliadin quantitation - second generation of a competitive ELISA in compliance with Codex Alimentatius

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Cereal Foods World 55:A10

The Codex Alimentarius recommends the R5-antibody for gluten analysis. The R-Biopharm RIDASCREEN® product line for gluten analysis fulfils this demand. One of the ready to use assays is the RIDASCREEN® Gliadin, a sandwich ELISA which quantifies wheat, rye and barley prolamins. It detects intact prolamin molecules and large fragments which contain at least two binding sites. Smaller fragments of these prolamins, known as peptides, occur e.g. during the hydrolisation process of commodities like syrups and starches or during the brewery process. These small fragments bear a risk for coeliacs as they are potentially toxic. In processed samples a mixture of intact gliadin molecules, large and small fragments are present. When using the sandwich assay format for the detection of hydrolysed samples the risk to miss the small potentially toxic fragments is very high. Therefore, the competitive assay format should be used as this is designed especially for the detection of smaller molecules due to the fact that the assay needs only one binding site of the antigen. The RIDASCREEN® Gliadin competitive is a test system to quantify intact prolamins, peptides and small fragments thereof. This assay was calibrated on the toxic peptide QQPFP even knowing that the result could not be recalculated in mg/kg gliadin. Theoretically, such a recalculation is possible by comparing the standard curves of the pure peptide and high purified gliadin, but it does not reflect the normal matrix situation in a sample. The 2nd generation RIDASCREEN® Gliadin competitive will use a mixed hydrolysed standard made out of hydrolysed wheat, rye and barley to enable quantification as mg/kg gliadin according to the Codex Alimentarius level. At present, the use of this "pure" hydrolysed standard to measure peptide levels in food seems to be the most promising compromise for quantification of gluten levels.

Next generation of gluten antibodies—What's after R5?

E. HALBMAYR (1), J. Coutts (2), R. Fielder (2), A. Rogers (2)
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Cereal Foods World 55:A10

Celiac disease (CD) is an immune-mediated enteropathy caused by the ingestion of gluten, a protein fraction found in certain cereals. Immunotoxic gluten peptides that are resistant to degradation of digestive enzymes appear to trigger celiac syndrome. Celiac disease occurs in genetically predisposed persons and leads to the destruction of the microscopic finger-like projections of the small intestine, called villi. The disease is triggered by the ingestion of peptides from wheat, barley, rye, and in some cases oats. It currently affects roughly 1% of the world's population, primarily adults. This presentation is showing the results of a new monoclonal antibody, called G12, which specifically recognises the toxic fragment of the gliadin protein present in gluten. This fragment is called 33-mer and triggers the auto-immune reaction in celiac patients. Homologues of this peptide were found in every food grain (except oats) that is toxic to CD patients, but were absent in all nontoxic food grains. The antibody was specially developed to determine the toxic fractions present in gluten. When food and drinks are hydrolysed, the gliadin protein is degraded in small fragments which are difficult to detect with classic antibodies because their epitopes may be destroyed. The newly developed monoclonal antibody can reliably detect toxic fragments of gluten in hydrolysed food. The outstanding advantage of this new antibody is the possibility to detect the actual toxic fragment of gluten with a very high sensitivity. A test kit using this monoclonal antibody was developed to detect the toxic fractions of gluten from wheat and other cereals such as barley, rye and, with a much lower level of sensitivity, oats.

Proteolytic elimination of gluten

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Cereal Foods World 55:A10

The primary trigger of celiac disease (CD) is gluten, which in the context of CD comprises prolamin proteins of wheat, rye, and barley. Prolamins contain prolamine/glutamine rich peptide structures that resist gastrointestinal digestion. These undigested polypeptides of prolamins are considered as the immunodominant molecules that trigger CD. An extensive enzymatic hydrolysis of prolamins, and especially their immunoreactive parts, is a potential way to detoxify gluten. Two main approaches to commit the proteolytc gluten elimination are the medicinal gluten elimination, that takes place after ingestion in stomach, and the food technological approach where gluten elimination occurs during food processing. A gluten detoxification approach relying on a papaya extract, containing a pool of peptidases, was introduced already in 1964, but more recently new approaches have emerged. It has been noted that an efficient hydrolysis of prolamins requires specific enzymes that can cleave proline containing protein structures. A proline oligopeptidase and a proline endopeptidase, both of microbial origin, were shown to cleave toxic prolamin structures. The endogenous cereal enzymes have also paid attention with this respect, and a recombinant barley cysteine endopeptidase and a pool of germination-induced cereal enzymes hydrolyzed the toxic prolamin fragments as well. A prerequisite for medicinal peptidase preparations is that they must detoxify gluten in acidic conditions of stomach. Acidic conditions also favor the hydrolysis of gluten in food processing, because the solubility of gluten increases at low pH which, in turn, increases its susceptibility to proteolysis. This has raised sourdoughs as potential candidates to commit gluten detoxification. Recently, we showed that more than 99.5% of rye prolamins got extensively hydrolyzed in sourdoughs prepared of germinated rye grains with high peptidase activities.

ALV003, a mixture of two oral proteases, degrades immunogenic gluten epitopes in a complex food environment

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Cereal Foods World 55:A10

Celiac disease is a common autoimmune disorder triggered in susceptible individuals by dietary exposure to gluten proteins found in wheat, barley and rye. ALV003 is a protease therapy being developed for celiac disease, designed to degrade the immunogenic gluten epitopes within a typical human meal containing fats, carbohydrates, and non-gluten proteins. In vitro methods to simulate and quantify the ability of ALV003 to degrade gluten in complex food environments need to be developed and compared to human clinical data. The ability of ALV003 to degrade baked wheat bread gluten was analyzed in three prototypical meals: 1) simple [ice cream and chocolate soymilk], 2) complex homogenized [hamburger, potatoes, butter, juice, ice cream], and 3) complex chewed [gluten-free mac and cheese, Indian Paneer, peas, rice, gluten-free bread, banana]. In vitro modeling consisted of food, resting gastric fluid, simulated gastric secretions, continuous mixing, and ALV003 (100 or 300 mg) in gastric volumes commonly observed. Simulated gluten digests were assessed at 30 minutes and the results were compared to in vivo data obtained from a phase 1 clinical study (ALV003-0812), in which fasted subjects were administered a meal and ALV003 (100 and 300 mg) via a nasogastric tube. In these patients, gluten digestion was assessed from the entire gastric volume after 30 minutes. Competitive ELISAs using antibodies directed against several known immunogenic gluten epitopes were used to quantify gluten degradation. In vitro ALV003 showed robust gluten elimination (average = 91% for 300 mg; 77% for 100 mg ALV003, 30 minute reaction) in all three meals tested, and the magnitudes of the dose response between in vitro simulations and in vivo phase 1 clinical results were similar (92% gluten elimination for 300 mg ALV003; 79% for 100 mg ALV003). In vitro gastric digestion models were built to simulate gluten degradation in the human stomach. ALV003 degraded gluten effectively in several complex food environments typical of the human diet. In vitro data derived from the gastric simulation model were consistent with in vivo data from a phase 1 study with comparable degrees of gluten degradation. Taken together, data from the simulated gastric environment and phase 1 clinical trials suggest that ALV003 will degrade at least 1 gram ingested gluten in patients with celiac disease. In vitro simulations can be used to inform human clinical trial design. The therapeutic hypothesis being tested in phase 2a clinical trials currently underway is that ALV003 administered to patients with celiac disease will prevent small intestinal mucosal injury induced by a gluten challenge.

Renovation to innovation: Developing a portfolio of gluten-free offerings
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Cereal Foods World 55:A11

Consumers are seeking gluten free foods for a variety of reasons, from general health beliefs to specific medical conditions such as celiac disease. A significant portion of the population (12%) watches and avoids gluten in their diet – 3 times as many as those avoiding nuts. General Mills offers over 200 gluten free products across several mainstream trusted brands. Development efforts in building this portfolio ranged from assuring a gluten free label claim, to replacing a single ingredient, to formulating traditionally wheat based products from the ground up This presentation will address key consumer and technical considerations taken into the development of this gluten free product portfolio.

Emerging and Persisting Food Hazards: Analytical Challenges and Socioeconomic Impact

Multi-criteria analysis for impact assessment of food safety regulations: An application to T-2 and HT-2 toxins in cereals in the EU
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Cereal Foods World 55:A11

In the EU, all major draft laws must be subject to a regulatory impact assessment. The objective of socio-economic research in the EC-funded MoniQA Network of Excellence is to develop a toolbox for impact assessment of food safety regulatory proposals. The aim of this contribution is to present a draft of such toolbox with its application to a case study, regarding a proposal on setting maximum levels of T-2 and HT-2 toxins in cereals and cereal products. Such toolbox is based on multi-criteria analysis rather than cost-benefit analysis, which cannot be complete and reliable in most situations due to major difficulties. A multi-criteria approach dealing with both fuzzy linguistic and stochastic quantitative variables - which take into account uncertainty – appears to be the best way forward to an ex ante comparison of alternative policy options, especially in the food safety area, where the effect on public health is the most important impact as giving the rationale for a regulatory proposal. The alternative policy options considered for the case study are: 1) maintaining the status quo; 2) setting 'soft' maximum levels; 3) setting 'strict' maximum levels. Cereals considered in the analysis as susceptible to T2/HT2 contamination are wheat, oats, barley, maize, and rye. From the qualitative and quantitative assessment, impacts on public health, conduct of businesses, public authorities, and SMEs emerge as the most prominent. Multi-criteria analysis shows a preference for the status quo option. All data used for this application are based on expert consultation and statistical databases, but, due to time constraints and the main aim of the research, the outcome of the analysis should not be taken as relevant for a real policy decision process. This case study shows the potential of the toolbox, which will be improved and tested with additional case studies in the remaining years of the MoniQA project.

Emerging multiscreening methods and new reference materials for food allergen analysis
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Cereal Foods World 55:A11

Food allergy is the result of abnormal responses of the immune system to some proteins naturally present in foods, which are considered nutritious for healthy individuals. Not all proteins are allergenic and it is not well understood why only some proteins are allergenic. Although only a few allergenic ingredients (milk, egg, peanut, tree nuts, wheat, soy) are responsible for more than 90% of the reactions, over 150 foods are known to cause allergies. Analytical methods for food allergens can be incorporated as part of the industry safety control activities (Hazard Analysis & Critical Control Points and Good Manufacturing Practices) to monitor and identify unexpected contamination during food production. This ultimately leads to comply with regulations by ensuring the safety and accuracy of food labels. Also these methods serve the governments for enforcement purposes. The difficulties in complying and enforcing labelling regulations are based on the fact that there are not target thresholds or action levels although several approaches to establish these values have been suggested. The detection of food allergens is possible by targeting the proteins of the allergenic product (ELISA, LFD, MS) or their marker DNA (PCR, RT-PCR, LPA). These assays are tools available to comply and enforce existing food allergen labelling regulations. Current assays are, to a large extend, neither standardized nor validated, and obtaining the correct value greatly depends on the type and complexity of food samples. This presentation will discuss the pro's and con's of existing and emerging technologies as well as the currently ongoing activities for the production of appropriate reference materials to harmonise calibration of allergen ELISA assays. Here, the presentation will focus on the activities of the EC-fundes MoniQA project and its casein ringtrial.

Chemical contaminants in food: A snapshot of selected events and associated costs
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Cereal Foods World 55:A11

Chemical contaminants in food may include pesticide and veterinary drug residues, fungal toxins (mycotoxins), food additives and environmental contaminants like dioxins, polycyclic biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and the heavy metals, arsenic, cadmium, lead and mercury. The cost of chemical contaminants in food and feeds may range from a few thousand dollars or euros, to meet the direct cost of compliance or monitoring analysis, to many millions of dollars for court prosecutions, bankruptcy, product disposal, monitoring and surveillance, damage to brand or reputation of the product or country, decline in tourist income or loss of life. A snapshot of selected events of chemical contamination of food ranging from mercury in fish in Japan in the 1950s to melamine in Chinese milk powder in 2008 will be presented, with consideration of the outcomes and associated costs.

Pyrrolizidin alkaloids – Plant toxins of growing concern in food and feed safety
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Cereal Foods World 55:A11

Alkaloids are naturally occurring compounds containing basic nitrogen atoms produced by plants and fungi. Pyrrolizidin alkaloids (PA), which are plant toxins, are attracting increasing attention due to several worldwide intoxications of humans and animals. One of the initial purposes of PA toxin production is to act as a repellent and protect plants against insects. PA's themselves are usually not toxic for humans and animals, but through the metabolic process (e.g. in the liver) toxic compounds will be formed. One of the first organs affected by this toxicity is the liver resulting in hepatic veno-occlusive disease (VOD) and liver cancer. Several food products like milk, honey, eggs and herbal teas as well as medicinal products and animal feed such as hay and silage can be contaminated by PAs. We are currently lacking adequate regulations for those substances in food and feed which could also be due to the fact that there are no established reference methods for PAs. First commercially available reference materials are provided by Romer Labs®. This presentation will focus on the occurrence and nature of PAs highlighting the necessity of further investigations and worldwide regulations for this group of substances.

Safety assessment of engineered nanoparticles in food: The importance of detection and characterization
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Cereal Foods World 55:A11

Nanotechnology is a fast growing market and engineered nanoparticles (ENPs) are finding widespread applications including use in consumer products, medical applications, packaging materials, processing technologies and novel or functional foods. During their manufacture and use, human exposure and the releases of ENPs to the environment are inevitable. The proliferation of nanotechnology has therefore prompted concerns over the risks of adverse effects of ENPs on organisms in the environment and humans. However, research to address these concerns is still in the fledgling stages and the development and application of adequate analytical techniques for the detection and characterization of ENPs in food and natural samples is challenging. This presentation will give an overview of the challenges faced during engineered nanoparticle risk assessment. Current testing approaches and available analytical methods for the measurement, characterization,

detection and chemical analysis of engineered nanoparticles in comlex matrices will be illustrated using real world examples and advantages and limitations of the approaches will be discussed. The implications for food safety and regulation and priorities for future research will be highlighted.

Grain-Based Food and Ingredient Safety in the Supply Chain

Theory and experience with traceability of bulk commodities in grain handling systems
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Cereal Foods World 55:A12

Bulk commodity grains and their products present unique challenges for conventional food chain traceability strategies. Typical traceability schema and software begin tracking at a point where the lot identity is created and monitored through future operations. In contrast, grains are constantly commingled, aggregated by overall consistent quality, and then disaggregated to buyers, all to achieve efficiency of bulk distribution systems. This presentation will summarize four years of theoretical development and on site case studies of traceability in U.S. bulk grains handling systems, and will present the needs for new science in modeling, uniform terminology, and cost-benefit analysis. In our studies, traceability was embedded in a formalized quality management system framework that simultaneously improved inventory management, provided increased compliance with multiple process-based regulatory programs, supported risk management and worker safety programs, and ultimately enhanced operational efficiency. Bulk material traceability is a probability-based activity, not likely to be absolute. However, documentation was steadily improved, supported by upgraded elevator management practices, creating improved tracking/tracking accuracy, as measured by an index developed at Iowa State, Documentable reductions in operating costs were also found. Database theory and uniform data lists were developed to support practical operating needs. Several case studies allowed for the development of database theory, and improvement in process mapping strategies, and initial development of a uniform system of terminology. A novel methodology for modeling the traceability information using event management approach in bulk food production was also developed and applied to grain and pelagic fish industries.

Industry collaboration for food safety – third party audit initiative
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Cereal Foods World 55:A12

The presentation will provide an update on industry collaboration focused in the area of food safety. Working groups have been focused in 3 key areas: development of a Common Survey, GFSI Audit gap identification, and Communication across the Food & Beverage Industry. Through collaboration the team hopes to influence accepted food safety auditing practices, securing related documentation, as well as improve the safety of the overall food supply chain.

Challenges for "gluten-free" foods
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Cereal Foods World 55:A12

Many foods and food ingredients can be used to formulate gluten-free food products. Certification, auditing, and analytical verification are advisable to assure the gluten-free status of all components of a formulation. ELISA methods are generally useful in verifying gluten-free status. Some grains e.g. rice, corn, buckwheat, etc. do not contain gluten but care must be taken to assure that no contamination occurs with gluten-containing cereals. This question is particularly profound for oats. Contamination with grass seed can also produce positive results in gluten ELISAs. Questions especially surround ingredients that are derived from gluten-containing cereals. Levels of gluten in some wheat- and barley-derived ingredients including wheat starch, wheat starch hydrolysates (glucose syrups), wheat protein hydrolysates, soy sauce, vinegar, ethanol/alcohol, wheat germ oil, caramel, sorbitol and other sugar alcohols, fermentation products such as enzymes, bacterial cultures, and xanthan gum, malt ingredients, and β-glucans require careful consideration. The suitability of the ELISA methods for assessment of gluten levels in such ingredients can be problematic.

Mapping your food safety program: An integrated approach
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Cereal Foods World 55:A12

The safety of food products is both morally and legally top of mind with food producer worldwide. As with any activity, the food industry has its share of bad players that bring into question dedication and commitment to ensuring production and distribution of safe food. However, with adequate information and direction on the how-to's of food safety systems, the vast majority of food producers around the globe strive to 'do the right thing'. Ensuring the safety of food, from farm to fork, is on one hand, not rocket science; on the other hand, not simple, or necessarily self evident. What is required is an extensive knowledge of suppliers, production systems, and the distribution of the food. There are many forces pressuring the safety of foods. External pressures include the ability to track and report outbreaks based on more rapid analytical testing, improved reporting systems, and proliferation of media outlets, whereas internal pressures may include economic criteria as well as a variety of etiological influences. Many factors can affect food safety, therefore, the approach to identifying, controlling and eliminating (ICE) these factors is key to any food safety system. Implementation of the ICE approach provides a means to manage risk in a way that will provide a risk reduction program for each potential threat in a systematic and integrated manner. The basis of this approach provides the tool needed to identify those program challenges, points of intersection and the basis for designing a fully integrated process from incoming raw materials through final sales.

The future of biotech wheat
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Cereal Foods World 55:A12

Mr. Bair will present the North American Millers' Association's perspective on the development of biotech wheat. He will describe why he believes the industry needs biotech wheat, the consequences of not having it and what U.S. millers are doing to encourage it.

The Impact of Climate Change on the Production and Utilization of Wheat and Rice

Identifying future threats: Impacts of climate change on wheat
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Cereal Foods World 55:A12

Global warming is causing changes in temperature at an unprecedented rate. Crop cultivars have been selected for optimal performance under the current climatic conditions. With global warming, characterised by shifts in weather patterns and increases in frequency and magnitude of extreme weather events, new ideotypes will be required with a different set of physiological traits. Severe pressure has been placed on breeders to produce new crop cultivars for a future, rapidly-changing environment that can only be predicted with a great degree of uncertainty and is not available in the present day for direct experiments or field trails. Modelling, therefore, represents a powerful tool to identify future threats for wheat production. In this study, we consider drought and high temperature as key stress factors with high potential impact on crop yield that are associated with global warming, focussing on their effects on wheat. In our predictions, we used a wheat simulation model combined with climate scenarios for the future based on fifteen global climate models from the IPCC AR4 multi-model ensemble at several locations in Europe. Despite lower summer precipitation predicted in Europe, the impact of drought stress on simulated wheat yield is predicted to be smaller than at present, because wheat will mature earlier in a warmer climate and avoid severe summer drought. However, the probability of heat stress around flowering is predicted to increase significantly that is likely to result in considerable yield losses for heat sensitive wheat cultivars which are common in north Europe. Breeding strategies for the future climate might need to focus on wheat varieties tolerant to high temperature, rather than to drought.

Ecophysiological, biochemical and molecular effects of heat stress on wheat grain development and end use quality
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Cereal Foods World 55:A12

High temperature during grain filling can dramatically modify several grain characteristics determining wheat and rice grain end-use quality. Under moderately high temperature, grain protein concentration, on a dry mass basis, increases with the temperature, because of its negative effect on starch synthesis. Most other grain quality traits are negatively impacted by high temperature. This includes starch composition (amylose-to-amylopectine ratio, starch granule size distribution, etc.) and physicochemical characteristics, storage protein aggregation, the proportion of small grains, pre-harvest sprouting. These changes have dramatic effects on flour functionality and may render the harvest improper to its commercialisation and industrial use. In the field, variations in grain end-use quality induced by variations in temperature are usually much larger than variations due to the genotype. The difference in stability between carbon and nitrogen metabolisms appears as a central aspect of grain responses to temperature. Starch and protein depositions in the grain are relatively independent from each other and are controlled differently. The synthesis of grain starch mostly relies on the current photosynthesis of the plant, while grain nitrogen accumulation results from the transfer of nitrogen stored in the vegetative tissues before anthesis. Several enzymes of the starch biosynthesis pathway have been shown to be highly sensitive to the temperature. Over the last decade, grain biochemical modifications in response to high temperature have been studied in details and their physiological and ecophysiological causes are now better understood. The molecular mechanisms driving these changes and the interactions between these mechanisms also start to be unravelled. These different aspects of wheat and rice response to high temperature and climate change will be discussed.

Developing new wheats with increased resistance to abiotic stress
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Cereal Foods World 55:A13

In comparison to model organisms, wheat has the advantages of extensive monitoring and archiving of genotypes and associated phenotypic data and the availability of unique populations adapted to specific environments and end-uses that have resulted from a long history of selective breeding. These advantages are becoming increasing significant as analytic tools improve. However, application of markers and genomics research in wheat still faces a number of serious issues. In particular, many of the key traits influencing yield are poorly understood at the physiological level, hard to reliably phenotype and the genetic control is frequently poorly understood. However, advances in phenotyping techniques, whole genome approaches and systemic analysis of the molecular basis of stress tolerance responses are starting to reveal key pathways and process involved in maintaining yield in difficult environments. Results now coming out of genomics studies are providing new insights into stress responses and provide novel strategies to improve stress tolerance. A broad approach to using genomics techniques to tackle abiotic stress tolerance in wheat will be presented with some specific examples of how these results can influence practical crop improvement.

Maintaining sufficient stocks of rice in a warming world
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Cereal Foods World 55:A13

Two sets of reciprocal introgression line (IL) populations derived from Teqing (TQ) and Lemont (LMT) were evaluated for chalkiness in grain, including percent of grain with chalkiness (PGWC), area of chalky endosperm (ACE) and degree of endosperm chalkiness (DEC) from field (2007DS, 2007WS, 2008DS) and phytotron (two temperatures) experiments. Six lines were observed with low PGWC (<10%) and low DEC (<3%) across all 5 environments, that is, there was high heritability for chalkiness. There was one stable QTL for ACE identified on Chr 4 in all 5 seasons in the TQ set, 3 QTLs for PGWC on Chr 1, 4 and 10 and 1 QTL for DEC on Chr 10 mapped across 4 seasons in the TQ set. QTL for percentage of grain with less 10% chalky area (PCAL10), 10–25% chalky area (PCAL25) and 25–50% chalky area (PCAL50) was analyzed on TQ set on 2008DS and phytotrons. *qPCAL10-5* and *qPCAL10-10* with positive additive effects were detected on chromosome 5 and 10, while *qPCAL50-5* and *qPCAL50-10* with negative effects were mapped on the same regions across all environments respectively, that is, the alleles from LMT on two regions are responsible for low chalkiness area. Sixteen of 17 epistatic interactions performed same direction effects as main QTLs, and 64 of 97 (68.04%) QTLs were located on marker interval of RM104-RI05813, RM252-RM470, RI00399-RI01948, RM163-RI01877, RI03180-RI03489 and RI01015-RI02123 respectively. Several genes located on these regions regulating substrate supply to the endosperm may have important roles in chalkiness formation.

Identifying high temperature-sensitive processes during grain filling of rice
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Cereal Foods World 55:A13

With the influence of global warming, high temperature (HT) has become a major challenge for rice production. Our study has been focusing on the physiological pathway of HT effects on rice grain quality formation during grain-filling stage. Physiological responses including energy metabolism, peroxidation, cell death, C/N balance, and ethylene/polyamines fluctuation were analyzed. Gene expressions were also determined by a designed primers set and proteomic approaches. Results showed that HT accelerated the aging of flag leaf, induced rapid growth of caryopsis, but also enhanced chlorophyll degradation of the caryopsis. Contents of H_2O_2 and MDA in caryopsis were elevated but the ATP content was reduced by HT treatment. High temperature stimulated a rapid evolving of ethylene, enhanced DNA degradation and cell death of caryopsis. At transcription level genes involved in glycolysis, fermentation, DNA degradation, and cell death were stimulated by HT. Expressions of genes conferring to degradation of H_2O_2, such as *SOD* and *CATB*, were enhanced in response to HT. High temperature also regulated the expression of some stress-related gene, including up-regulated *GLOI*, *RAB24*, and *OsSAMDC*. Regarding C/N balance, HT increased GABA shunt related metabolites. These results suggest that HT may induced a hypoxia, low ATP, and peroxidative status within caryopsis, and then stimulate H_2O_2 production, lipid peroxidation, DNA degradation, and cell death. Enhancement of expression of genes involved in glycolysis, fermentation, GABA shunt, and H_2O_2 degradation may be related to the amelioration of internal low energy and peroxidative stresses induced by HT. Evolution of ethylene further implies the involvement of hormones in the processes. A schematic rationale is proposed to depict the possible relationship between these physiological processes and grain quality under HT.

New Milling and Pretreatment Technologies for Changing Functionality and Nutritional Profiles of Flours

Understanding how wheat pretreatment and milling relate to flour functionality: Innovations from a process engineering approach
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Cereal Foods World 55:A13

The relationships between wheat characteristics and end-use quality in bread are separated by two complex and interacting processes: milling and breadmaking. The relationship starts with breakage of the wheat; quantifying this breakage based on kernel characteristics and roller mill design and operation is the first step to understanding routes of flour streams through the process and hence the differing characteristics of these streams. Pearling (or debranning) is a new technology that alters this initial breakage and that results in better bread, for reasons not yet fully understood. Wheat flour is distinctive in its ability, when mixed with water, to form a dough that can expand to retain fermentation gases to produce the aerated structure of bread; the Dynamic Dough Density test allows this expansion capacity to be quantified in order to understand the origins of flour quality within the milling process.

New ways to control wheat product composition through dry fractionation
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Cereal Foods World 55:A13

Wheat grain tissue behaviour along fractionation appears as a determinant factor to control the composition and properties of the flours. These last years, new more appropriate methods have been developed in order to track each of the grain tissues along fractionation. Indeed, detection and quantification of biochemical markers, such as a trimeric form of ferulic acid, alkylresorcinols, phytic acid, starch and the wheat germ agglutinin were found useful to monitor the outer pericarp, testa, aleurone layer, starchy endosperm and the embryo respectively and to better understand tissue behaviour along process. Tissue fate was also found to really depends on its mechanical properties which could be measured with classical mechanical assays. Furthermore,

these mechanical properties appear to be related to the nature of the tissue cell wall biochemical compounds and their interactions. Thus, it appears possible to act on the mechanical properties using chemical, physical or enzymatical tools that are able to modify the cell wall compounds' structure. In this talk, results of grain pre-treatment using these tools and consequences on grain milling will be shown, as well as characteristics of the obtained fractions. Potential differences between the wheat cultivars will be discussed. At last, perspectives of these studies and development of new methodologies in order to better control wheat grain tissue behaviour along process and the fraction properties will be presented.

Technological improvement of wheat flour through enzymatic treatment during tempering

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Cereal Foods World 55:A14

Traditionally, wheat tempering has been conducted to plasticize the bran layers by increasing the moisture content from 11–12% to 16–18%. This process facilitates the removal of the bran as large pieces and, in consequence, it increases the milling yield. During the tempering process, water is initially adhered to the kernel surface followed by its diffusion through the external layers to the endosperm. Enzymes are widely used as processing aids in numerous processes of food technology owing to their clean label consideration and because they are the best and safest alternative to chemical compounds due to their protein nature. These properties are also important for the baking industry. Enzymes are able to modify rheological properties of wheat doughs, the quality of fresh bread and also their significance on the shelf-life of cereal-based products. Enzymes as processing aids are usually added to flour, during the mixing step of the bread-making, but this could sometimes cause some problems due to over-dosage and non-uniform mixing. Water diffusion during the tempering process could be an alternative way to incorporate the enzymes for modifying flour technological functionality or even for improving milling yields. This presentation will provide information about the impact of adding different enzymes (non-starch hydrolysing enzymes, glucose oxidase, transglutaminase, lipase, and so on) to the tempering solution on wheat kernel and the technological functionality of the resulting flour.

New processing ways for dry fractionation of wheat bran

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Cereal Foods World 55:A14

Wheat bran is a by-product of the conventional milling used for animal feeding. But nowadays wheat bran is also considered as a source of bio-active compounds (fibres, minerals, vitamins, antioxidants). However, these bioactives compounds are poorly bio-accessible as they are trapped in resistant cell-walls. A general study on dry fractionation processes was developed with the aim to recover separately the different layers of the bran and to produce fractions rich in the different bran tissues, like pericarp-rich fractions (rich in fibers) or aleurone-rich fractions (rich in vitamins, minerals, antioxidants). Two processes were more particularly studied: cryogenic grinding and electrostatic separation. The mechanical properties of the different bran layers were studied to define the conditions in which these bran layers were the most brittle. Grinding tests were then carried out to evaluate the effect of milling temperature on particle size reduction. In cryogenic conditions most of the bran layers and cellular structures were found to be disrupted. In a second time, the sorting of ultra-fine bran particles according to their origin (aleurone, pericarp…) was studied, using electrostatic separation. This new separative technic allows to obtain bran fractions with different biochemical compositions and with different bran tissues proportions. The different fractions obtained by ultra-fine grinding and electrostatic separation were incorporated into white flour. In vitro digestion studies of these enriched breads have shown that the bio-accessibility of phenolic acids and minerals increases with decreasing particle size as well as with increasing the concentration of aleurone particles. This study has shown that wheat bran and bran fractions might have a good potential for food ingredients.

Process and opportunities for 100% whole grain and nutrient enhancement with wheat bran and germ flour

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Cereal Foods World 55:A14

Wheat millfeed contains the bran and germ and provides fiber, protein, lipids, antioxidants, vitamins and minerals. Wheat millfeed can be used to replace a portion of the flour in bakery and snack foods to increase the fiber and other nutrients; however, traditional millfeed imparts a coarse texture, dark color and visible bran specks. To broaden the potential uses in food applications, wheat millfeed was further processed to reduce particle size and increase shelf stability to create stabilized wheat bran and germ flour. Stabilized wheat bran and germ flour also has a reduced microbial content. To determine the potential scope of use, stabilized wheat bran and germ flour was used to replace varying portions of refined or whole wheat flour in foods including breads, muffins, cookies, tortillas, cereal and pasta and the resulting sensory and physical attributes were determined. Stabilized wheat bran and germ flour can be blended with refined wheat flour to create flour that is nutritionally equivalent to whole wheat flour or even more nutrient dense than whole wheat flour. Stabilized wheat bran and germ flour is a value-added ingredient that can be used to improve the nutritional profile of popular bakery and snack foods.

Recent Advances in Knowledge Related to Starch Synthesis and Structure

Genetic modification of adenosine diphosphate glucose pyrophosphorylase causes unexpected, but beneficial, effects in cereals

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Cereal Foods World 55:A14

The enzyme ADP-glucose pyrophosphorylase (AGPase) synthesizes ADP-glucose and represents the first committed step in starch biosynthesis. We focus on an understanding of the maize endosperm AGPase, the synthesis of "enhanced" AGPases and tests of them in cereals, particularly maize. Emphasis is placed on enhanced heat stability and allosteric properties. Two variants gave rise to unexpected changes in maize. Both increase seed number without a decrease in individual seed weight. One variant has also been expressed in wheat and rice and increased seed number in both cereals. Increased seed number in maize occurs only when temperatures during early seed set are elevated (>92 F or 33C) and is background dependent. Extant studies point to protein expression occurring only in the endosperm; however, seeds lacking the transgene but developing on ears with kernels harboring the transgene also increase in number.

Suppression of the Glucan Water Dikinase (GWD) by RNAi increases yield in wheat

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Cereal Foods World 55:A14

With a total production of over half a billion tons of per annum, wheat, along with maize and rice, provides a significant proportion of the energy and nutrients required to sustain the global population. Wheat is particularly valued for its utility in a diverse range of food, feed and industrial applications. Given the economic and social importance of wheat, considerable focus has been applied to identifying mechanism for increasing yield. This need has been highlighted by the contributions that genetic engineering technology has made to increasing yield in maize, to the point where in the U.S., there has been a trend towards converting acres previously devoted to wheat production to the production of disease, pest and herbicide resistant maize. Approaches to defining genetic mechanisms for increasing wheat yields through QTL analysis and the identification and pyramiding of physiological traits contributing to yield have been employed. Recently, a number of mechanisms for increasing the yield have been reported including increasing starch synthesis in grain through increasing ADP-glucose pyrophosphorylase activity, modifying the levels of brassinosteroids or modifying inflorescence architecture (DEP1 in Rice). To investigate the potential consequence of a phosphoglucan reduction on cereal starch metabolism and on its effect on storage carbohydrate accumulation, we have utilised RNAi to suppress expression of Glucan-Water-Dikinase (GWD), the major enzyme involved in starch phosphorylation, in and endosperm specific manner. This work provides evidence not only of the involvement of the GWD in reserve starch metabolism, but also has identified a novel mechanism for increasing yield.

The complexities of starch synthesis
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Cereal Foods World 55:A15

The structural features of higher plant-derived starches underpin their many and varied end uses in food and industrial applications. Starch is synthesized through the coordinated actions of three major groups of enzymes, starch synthases, starch branching enzymes, and starch debranching enzymes, for which multiple isozymes operate inside storage starch-synthesizing plastids termed amyloplasts. Posttranslational regulatory mechanisms such as protein phosphorylation and protein complex assembly govern the activities of many amylopectin synthesizing enzymes. Regulatory protein kinases and protein phosphatases present in amyloplasts control protein complex assembly and disassembly, and preliminary characterization of some of these proteins will be discussed. Analysis of various starch mutants in maize reveals novel protein complexes are responsible for altered starch phenotypes, such as the "high-amylose" starch in the *amylose extender* mutation.

The function of starch synthase isozymes in rice developing endosperm
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Cereal Foods World 55:A15

Starch synthase (SS) I and IIIa are the first and second major SS isozymes, respectively, accounting for amylopectin biosynthesis in developing rice endosperm. We previously clarified the functions of these SS isozymes using the respective mutant lines (Fujita et al., (2006), Plant Physiol. 140: 1070-1084; Fujita et al., (2007), Plant Physiol. 144: 2009-2023). To get the double mutant of these major SS isozymes, the *SSI* null mutant was crossed with the *SSIIIa* null mutant. Two types of opaque seeds having *ss1ss1/SS3ass3a* and *SS1ss1/ss3ass3a* genotypes appeared in F_2 generation, and the developing endosperms had extremely low SS activity. On the other hand, the double-recessive mutant was sterile. The two types of opaque seeds had a unique starch structure, round-shaped starch granules, and high amylose content and showed specific physicochemical properties. The seed weight was ca. 80% of those of the wild type. The amount of GBSSI protein and activity of AGPase were higher than those of the wild type and the parent mutant lines. The double-recessive homozygous mutant between the leaky *SSI* mutant and the null *SSIIIa* mutant was fertile, suggesting that active SSI or SSIIIa is mandatory to allow the synthesis of starch in rice endosperm.

Eating starch: How to fight crystalline starch energy deposits
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Cereal Foods World 55:A15

The enormous impact of starch stems from its hyper-efficient deposition of pure glucose combined with its ability to be made bioavailable upon cellular demand. Cellular starch degradation involving amylases, dikinases and phosphatases having low-affinity starch binding domains. Starch phosphate amorphisises starch in the cell to increase bioavailability and degradation. For food and environmental starch, different crystalline forms of starch affect degradation. Microorganisms feeding on starch excrete enzymes with high affinity SBD. Fusarium feeds on starch during infection and the growth behavior and amylolytic activity of differs with starch type. B-type starches are quite resistant towards degradation and excretion of amylolytic activity is stimulated by starch. We found higher stimulation with native starch granules as compared to soluble starch. Malto-oligosacharides efficiently induced amylases indicating that starch breakdown products induce expression and excretion of amylolytic enzymes.

Small-Grain Biorefining—Agronomy and Grain Supply, Biorefining Technology, Environmental Sustainability, and Commercial Development

Development of new winter barley lines for production of advanced biofuels and coproducts: Yields, composition, and other agronomic factors
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Cereal Foods World 55:A15

Concerns over climate change and high energy prices have resulted in a growing interest in renewable energy, especially transportation fuels. In the United States, a majority of fuel ethanol is currently produced from corn (Zea mays L.), but grain supplies are insufficient to meet anticipated demands. Recent efforts to expand biofuel markets in the mid-Atlantic region have focused on the use of barley (Hordeum vulgare L.) for ethanol production. During production of ethanol, several high value co-products are produced including Carbon Dioxide and Distillers Dried Grains with Solubles (DDGS), which can be used in food and feed industries. Conventional and molecular breeding, including marker assisted selection, are being used to identify and improve critical and desirable traits in barley. Traits such as disease resistance, grain yield, quality, and composition including starch, protein, fiber, beta glucan, and lipid concentrations are being altered to meet diverse and specific end use markets. The Virginia Tech winter barley breeding program continues to improve and develop traditional hulled cultivars, but also is making a concerted effort to develop hulless cultivars that will provide growers and end users with a higher value winter cereal crop for production in the eastern U.S. As a result, two winter hulled (Thoroughbred and Price) and three hulless (Dan, Doyce and Eve) barley cultivars were released from our program. The aim of the breeding program is to develop high yielding, high quality and disease resistance winter barley cultivars designed for specific end uses and having desirable combinations of high value traits, such as hulless seed, higher protein, starch and energy content. Through breeding and selection the quality and value of winter barley has been greatly improved and the area of production in Virginia more than doubled in 2010.

Conversion of barley to ethanol and DDGS: Technical challenges and advancements
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Cereal Foods World 55:A15

Barley has a great potential as an alternative feedstock for ethanol production, especially in the Mid-Atlantic and other states, where it is a winter crop, allowing double cropping with soybean. It is estimated that barley can provide at least one billion gallons of ethanol per year. However, using barley as a feedstock is not common yet in the U.S. since barley has some technical challenges to overcome before it can be processed in a conventional corn-to-ethanol plant. Barley mash has very high viscosity due to its high content of beta-glucans. In addition, the low starch content (50–55%) of barley would result in lower ethanol yield compared to corn requiring larger barley plants to run the same capacity. The DDGS co-product from barley can contain high levels of beta-glucan which limits the value of the co-product in poultry and swine production areas. This lecture will focus on solutions to overcome the above described technical challenges and advancements in current enzyme technologies.

Value-added coproducts from barley refining
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Cereal Foods World 55:A15

Barley kernels contain 50–65% starch and 3–8% beta glucans, which can both be fermented to ethanol using an enzymatic process, jointly developed by our laboratory and Genencor, a Danisco Division. The remaining kernel components have traditionally been combined into an animal feed product called DDGS (distillers dried grains and solubles) and more recently into barley protein meal (BPM). The non-fermentable components in barley kernels have also been reported to have value as other types of coproducts. Barley oil is an example of a higher value coproduct from barley refining. Barley kernels only contain about 2% oil, but when barley hulls or pericarp are removed by abrasive methods such as pearling or scarification, the resulting fines contains 5–12% oil. Like commercial wheat germ oil, barley oil contains high levels of vitamin E. However, unlike wheat germ oil, barley oil contains very high levels of an unusual form of vitamin E called alpha tocotrienol. Tocotrienols in the diet have been shown to lower the levels of serum LDL cholesterol, to be active against some types of cancer cells, and to have other health-promoting properties. Barley oil also contains higher levels (about 2%) of health promoting plant sterols than most other oils. In addition to barley oil, other types of potential coproducts in barley include beta glucans which are a valuable type of dietary soluble fiber, silica from barley hulls which has unique properties as a valuable form of amorphous silica, and arabinoxylans. Barley arabinoxylans can potentially be used emulsifiers in foods and may be useful as a domestic replacement for imported gum Arabic. Barley straw, hulls, and non-feed grade DDGS can be converted to valuable pyrolytic oil (bio-oil) and bio-char by fast pyrolysis. The bio-oil can be upgraded to "green" gasoline and "green" diesel. Bio-char can be applied to soils for increasing fertility and for sequestering carbon.

Life cycle assessment of greenhouse gas emissions for winter barley ethanol—Status as an advanced biofuel

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Cereal Foods World 55:A16

Winter crops are gaining attention as domestic, renewable and low-carbon feedstocks for biofuel production because potentially they do not upset food grain cycles and prices, and are readily implemented at commercial scale. If grown on land that would be fallow in winter, and if the winter growing season does not affect the yield productivity of summer crops, winter crops would likely not contribute to induced land clearing and indirect CO_2 emissions. We use life cycle assessment (LCA) to test whether ethanol produced from winter barley grown in the Mid-Atlantic States (North Carolina, Virginia, and Maryland) could meet the advanced fuel category of the Renewable Fuel Standard 2 (RFS-2), by demonstrating with 95% confidence that its life cycle greenhouse gas (GHG) intensity is 50% lower than a baseline gasoline fuel, whose GHG-intensity is set to 96 g CO_2e/MJ. Using public and industry data, we constructed a LCA model of winter barley-to-ethanol and investigate cases with co-product crediting of barley hulls used for process steam and electricity recovery. Results show that the GHG intensity of winter barley derived ethanol is approximately 38 g CO_2e/MJ, a 60% reduction in the carbon intensity relative to gasoline, based on average feedstock growing conditions, preliminary refinery process data, and credits for avoided products. These results signify that ethanol derived from winter barley would satisfy national renewable fuel policy, would not disrupt agricultural land practices, and could be commercially competitive with today's technology as an advanced biofuel.

Commercialization of the first U.S. winter barley ethanol-production facility

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Cereal Foods World 55:A16

Based on work accomplished at Virginia Tech and at the ARS ERRC labs, plus discussions with key growers in the Mid-Atlantic region, the founders of Osage Bio Energy, LLC ("OBE") became convinced that new winter barley varietals grown ahead of soybeans in the region could result in an attractive business opportunity, as well as provide real positives for the regional environment. For years, the bulk of cultivated land in the region has been left fallow over the winter for lack of a profitable crop opportunity. Putting a significant percentage of this fallow acreage to work by growing a winter cover crop will provide the grain to produce profitable local ethanol for this ethanol-deficit region, a winning strategy for all involved. OBE utilizes advanced technology for production of ethanol and co-products from barley or other small grains. OBE's methodology starts with a core process designed by KATZEN International specifically for efficient processing and fermentation of small grains. As a further enhancement, OBE technologists incorporated an innovative dehulling process. OBE then coupled both the KATZEN and dehulling processes with the latest enzyme technologies validated at ARS ERRC and Genencor labs. Finally, OBE incorporated superior flash drying technology for production of a "barley protein meal" co-product, which preserves essential amino acids and provides a high value animal feed product. OBE's first plant, Appomattox Bio Energy, located in Hopewell, VA, will ultimately produce more than 65MM gpy of fuel ethanol, along with a premium barley meal, a renewable fuel pellet, and CO2 which will be marketed to an onsite beverage LCO2 supplier. ABE's financing is derived 100% from private equity.

Whole Grains Unraveled

Keynote speech: Whole grain health benefits - components and mechanisms

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Cereal Foods World 55:A16

Health claims in various regions support the protective effects of whole grain foods against heart disease and other chronic diseases. The evidence underlying these claims comes mainly from epidemiological studies. Nevertheless, substantial data from intervention studies show that whole grain oats, and in particular the soluble fiber in oats and other cereals, can lower plasma LDL-cholesterol, a risk factor for heart disease. However, oats together with whole grain rye, corn and rice products contribute modestly to dietary intakes in most western regions where wheat is the major dietary cereal. As with other cereals, whole grain wheat contains numerous components that may exert beneficial effects. The identification, quantification and characterization of these components in grain, in milling fractions, and in whole grain consumer foods present major challenges. Candidate components include fiber and fiber fractions, phenolic and other antioxidants, and physiological methyl donors (folate, choline, betaine). Chronic diseases, such as heart disease, have complex pathologies, whose onset and progression may be mediated by a wide range of risk factors. These risk factors can be influenced by other dietary components, and by demographic, genetic and lifestyle factors of subjects. Thus, intervention studies are constrained by the choice of whole grain foods, which need to be provided in palatable forms, and by the endpoints assessed, which may be influenced by other dietary factors, and by variations in subject characteristics. Recent human intervention and mechanistic studies will be reviewed with the aim of assessing the contribution to health benefits of a range of components and mechanisms. It is too early to draw firm conclusions, but evidence is increasing that the health benefits of whole grain foods are attributable to a number of components and mechanisms.

Health benefits of insoluble dietary fibers from whole grains

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Cereal Foods World 55:A16

In general, whole grains contain a greater ratio of insoluble dietary fiber to soluble dietary fiber than fruits and vegetables. Surprisingly, while many of the recognized benefits of dietary fibers, such as slower gastric emptying, reduction in postprandial glucose response, reduction in low-density lipoprotein cholesterol levels, and enhanced colonic fermentation are more applicable to soluble dietary fibers than insoluble, a number of prospective cohort studies have reported greater reductions in the relative risks of diabetes, heart disease, and obesity with higher intakes of whole grains compared to fruits and vegetables. Furthermore, in many instances when soluble and insoluble dietary fiber intakes are reported, the protection against the above mentioned diseases is at least as strong for insoluble dietary fibers compared with soluble dietary fibers. Therefore, more emphasis on describing the benefits of insoluble dietary fibers from whole grains is needed. Benefits may include improved whole-body insulin sensitivity, distal gut fermentation, unique effects on the gut microbiota, and others.

Hydroxycinnamic acids in whole grains and their potential health benefits

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Cereal Foods World 55:A16

Whole grains contain a vast number of phenolic compounds including hydroxycinnamates. The most abundant hydroxycinnamate in cereal grains is ferulic acid (and its derivatives) either free or conjugated. Due to its antioxidant activity ferulic acid may be beneficial in the prevention of diseases linked to oxidative stress and inflammation. Free ferulic acid and ferulic acid bound to low-molecular weight mono-/oligosaccharides can be absorbed from the small intestine; the participation of a Na+-dependent co-transporter or monocarboxylic acid transporters in the absorption is discussed. However, as early as 1973 it was demonstrated that ferulic acid is bound to insoluble wheat arabinoxylans. In the 1980s/90s structural details were discovered and it was shown that most ferulic acid is actually bound to insoluble arabinoxylans vs. soluble arabinoxylans. As most ferulic acid derivatives are not directly available for absorption in the small intestine they reach the colon. In the colon, the gut microflora can liberate ferulic acid and its derivatives, but can also metabolize the liberated phenolic acids themselves. Whether these compounds are substantially re-absorbed from the colon is not known yet; considering available information on comparable phenolic compounds, it seems likely that they are at least partially re-absorbed and reach the blood stream. As information about these microbial metabolites is still limited, it is not possible to judge their significance for health beneficial effects yet. Because ferulic acid is linked to arabinoxylans and can form ferulate oligomers acting as cross-links, it can also have an influence on the physicochemical properties of grain fiber components, thus having a more indirect influence on the health beneficial effects of whole grains and products thereof.

Relationships between solubility and molecular weight of oat β-glucan and cholesterol lowering effect

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Cereal Foods World 55:A16

Early clinical studies which demonstrated that attenuation of postprandial blood glucose levels was correlated with viscosity have since been amply confirmed for cereal β-glucan, by modifying both the molecular weight (MW) and solubility of the β-glucan. In contrast, the literature on the role of viscosity of β-glucan in lowering serum cholesterol levels has been limited and inconsistent. Both oat and barley β-glucan have been studied. Overall, results and interpretation of clinical trials of the effect of β-glucan on serum cholesterol levels have been confounded by lack of information about solubility, MW and viscosity of the β-glucan in the food as consumed. In a study designed to correct this deficiency 345 subjects (LDL-cholesterol ≥3.0 and ≤5.0 mmol/L) were fed oat bran ready to eat (rte) cereals in which solubility (S) and MW had been modified by the energy input of an extrusion process. S ranged from 67 – 100% of the total β-glucan and MW from 251,000 to 2,213,000 g/mol. There was a 20 fold difference in the viscosity of extracts from these foods. Across 5 centres in a randomized, controlled, double-blind, parallel design, test groups consumed cereal containing either 3 or 4 g high, medium high, medium low, or low MW β-glucan per day and a control group consumed an equivalent wheat bran cereal. After 4 weeks, LDL-cholesterol levels of those consuming 3 g high MW β-glucan was lower than the control group by 0.21 mmol/L ($P = 0.0023$). Analysis of covariance revealed a significant regression ($P = 0.003$) of LDL-cholesterol levels against log(MW×S), demonstrating that efficacy progressively declined in the rte cereal test foods as solubility and MW of the β-glucan was reduced. The study confirmed, as allowed in health claims, that serum LDL-cholesterol is lowered by daily consumption of 3 g of high MW β-glucan in rte cereal.

Betaine and other bioactives in whole grains

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Cereal Foods World 55:A17

Epidemiological studies show that whole grain and dietary fiber consumption are associated with reduced risk of several chronic diseases. Whole grains and fiber are sources of a wide variety of bioactive phytochemicals, such as polyphenols/phenolics, vitamins, minerals, carotenoids, methyl donors, etc. In vitro, animal, and human intervention studies show the physiological benefits for many of these bioactives. However, understanding their relative importance and how they work together to reduce disease risk is not well understood. This presentation focuses on recent research on the role of betaine in whole grain and fiber health benefits. In particular, content in various cereals and fractions, disease risk reduction from epidemiology, physiological effects from human intervention, and protective mechanisms in animal or in vitro models.

2010 Annual Meeting
Abstracts of Oral Presentations

Abstracts submitted for oral presentations at the 2010 annual meeting in Savannah, Georgia, October 24–27. 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.

Optimization of anthocyanin extraction from black rice, blue wheat and purple corn by accelerated solvent and microwave-assisted extractors

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Cereal Foods World 55:A18

Anthocyanins are promising dietary compounds that have demonstrated significant functions in human health due to their anti-oxidative, anti-diabetic, anti-carcinogentic and ocular effects. The current study was designed to optimize extraction of anthocyanins from black rice, blue wheat and purple corn using accelerated solvent extraction (ASE) and microwave-assisted extraction (MAE) in comparison with a standard manual extraction method. Several operating variables in ASE and MAE extraction methods were investigated and optimized using factorial experimental analyses. Extraction of anthocyanins was carried out on the whole grain flours obtained by a cyclone mill, and quantification of anthocyanins in the extracts was performed by spectrophotometric and liquid chromatographic analyses. For ASE the greatest anthocyanin recovery was obtained at operating conditions of 50°C, 2500 psi, 150% flush and 10 min static time using 5 cycles. In the case of MAE method a combination treatment of 50°C, 1200W and 20 min was effective in extracting anthocyanins from black rice compared with 70°C, 300W and 10 min for blue wheat and purple corn. Under these conditions a mixture of acetone and water at ratios 2:3, 3:2 and 2:3 was optimal for extracting anthocyanins from black rice, blue wheat and purple corn, respectively. Either ASE or MAE extraction method was comparable with the standard manual method but they were more efficient in using less solvent volume and faster. Research is underway to look into effects of ASE or MAE extraction on bioactivity and composition of anthocyanins.

Impact on the pasting properties of wheat starch with the addition of emulsifiers

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Cereal Foods World 55:A18

Increasing the shelf life of baked products is a goal of cereal science research. One approach to improve specific properties of interest to baked food manufacturers is the use of emulsifiers. Two of which, oleyl lactylic acid (OLA) and sodium stearoyl lactylate (SSL), are similar in structure, with the difference being the acid moeity:(oleic versus stearic acid). Widely researched, SSL has found many uses in baked products. It is not well understood how OLA interacts with starch in baked products and how that interaction affects quality of the finished goods. The objective of this project is to study the interactions between wheat starch and emulsifiers and understand the differences between SSL and OLA. The effects of OLA and SSL on pasting properties of wheat starch and wheat flour were studied by using a MicroViscoAmylograph. At the heating rate of 6°C/min, the peak viscosities of the starch pastes increased with increased emulsifier concentration for OLA and SSL. Solid contents of the starch paste also effected the maximum and end viscosity. SSL and OLA demonstrated a delay in starch gelatinization at all solid levels. In the presence of OLA, the peak and final viscosities increased with the increase of starch and/or emulsifier concentration. When tested in high concentrations of wheat flour, a higher concentration of SSL decreased the peak and final viscosities. OLA demonstrated a different interaction with wheat flour; at lower concentrations of flour, a higher concentration of OLA decreased its peak viscosity. The interactions between SSL and starch were also affected by rate of heating and cooling. At a faster heating rate, both emulsifiers decreased viscosities of flour pastes. Hot stage microscopic analysis revealed additional emulsifiers inhibited the swelling of the starch granules, normally occurring at 60°C. Both emulsifiers proved inhibiting, but OLA inhibited more prominently.

Extrusion processing – Research and engagement for addressing nutritional challenges worldwide

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Cereal Foods World 55:A18

Young Research Scientist Award

Extrusion processing is a versatile, continuous and highly efficient technology for the production of a variety of food products ranging from breakfast cereal and snacks, to texturized vegetable protein and pasta. It is also widely used in the manufacture of pet food, aquatic feed, and value-added industrial products. In recent years, research has been focused on use of extrusion in novel areas like fabricated grains; delivery of fiber and antioxidants; and development of continuous reactor technology for food and non-food applications. Efforts are ongoing at Kansas State University in these cutting-edge topics. Fabricated and pre-cooked rice and lentil analog products provide a unique opportunity for meeting caloric, protein and micronutrient deficiencies for the rapidly expanding global population. Challenges exist related to elimination of water and heating for preparation of these products for easy consumption. Incorporation of fruit and vegetable by-products in ready-to-eat snacks can provide healthier options to consumers and help in addressing the obesity epidemic. Adverse effects on product microstructure,

texture and overall consumer acceptability have to be addressed for commercial viability. Overcoming such obstacles, through ongoing fundamental research, active collaboration with industry partners and engagement with stakeholders, is vital for success. As an example of reactive extrusion, a high throughput process for production of sorghum protein concentrates will also be described. This technology promises to be a significant advancement towards functional ingredients that can be used in foods for the gluten-intolerant population. Reactive extrusion is also being utilized in non-food applications such as development of biopolymer nanocomposites for sustainable packaging applications and thermo-mechanical pre-treatment for cellulosic ethanol.

High temperature exposure affects rice physiochemical properties

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Cereal Foods World 55:A19

Exposure of rice kernels at elevated temperatures (60° to 90°C) as proposed in some fluidized bed drying applications may cause undesirable quality changes. However, few studies have quantified the effects of high temperature exposure on kernel quality. The objective of this study is to evaluate the response of physical and chemical properties of rice kernels at two moisture content levels exposed to three temperatures (40°, 60° and 80°C) over a range of durations. Two cultivars of long-grain rice, a pureline (Wells) and a hybrid (XL729) were exposed at 17% and 18% w.b. harvest moisture contents (HMC), respectively. Additionally, samples of both cultivars were dried to 12% moisture content and exposed to same temperatures and durations. Controls were not exposed. Exposure tests were conducted in air-evacuated plastic bags to minimize drying and tempered for 8 h after exposure. Samples were milled to determine head rice yield (HRY). Head rice color was measured immediately after milling and at intervals of 7 d for 28 d at 25°C. Exposure to high temperatures did not affect HRY. Kernels at HMC failed to germinate after being exposed to 80°C in both cultivars. A combination of heat and moisture inhibited germination which could minimize the biochemical processes of respiration. Darkening (L*) and yellowing (b*) of HMC kernels increased at 60° and 80°C in both cultivars. Although, overall discoloration increased in Wells, XL745 showed greater yellowing at 80°C and longer exposure durations. High exposure temperatures and durations along with presence of moisture content seemed to have induced discoloration. Peak and final viscosities, and pasting temperatures, increased in both cultivars after being exposed to high temperatures and longer exposure durations. Exposure at high temperature and longer durations influenced quality parameters in HMC kernels in both cultivars.

Evaluation of different agricultural feedstocks for bioethanol production

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Cereal Foods World 55:A19

The composition of bioenergy crops vary and thereby have an effect on saccharification and final ethanol concentration. In our study, five different bioenergy crops: wheat straw (*Triticum aestivem*), forage sorghum stover (sorghum bicolor), switchgrass (*Panicum virgatum*), miscanthus (*Miscanthus giganteus*) and sweet sorghum baggase were evaluated for bio-ethanol production at 20% (w/v) initial substrate concentration. The substrates were ground to less than 600 mesh size and treated with 2% (w/v) NaOH at 121°C for 30 minutes. The washed and neutralized pretreated residues were subjected to saccharification using cellulase and β-glucosidase enzymes (ratio 1:1.25) at concentrations of 25 fpu/g and 31.25 fpu/g, respectively, in pH 5.0 citrate buffer in an orbital incubator shaker at 150 rpm for 48 h. The fermentation was performed in shake flasks using Saccharomyces cerevisiae at 10% (w/v) inoculum concentration at 100 rpm for 24 hrs. Alkali treatment was effective in delignification of all the biomass feedstocks; highest percent removal on raw biomass basis was attained for sorghum stover BMR-DP (81.70%, w/w) followed by miscanthus (80.39%, w/w), sorghum stover BMR-RL (69.83%, w/w), wheat straw (67.45%, w/w), switchgrass (65.43%, w/w) and sorghum baggase (65.07%, w/w). The highest glucose yield was obtained from sorghum baggase (0.51 g/g treated biomass) and the lowest was obtained with miscanthus (0.32 g/g), which suggests significant difference in glucose yield for different biomass sources considered in our study. A maximum final ethanol concentration of 3.85% (w/v) was observed for sorghum baggase followed by wheat straw (3.27%), switch grass (3.26%), miscanthus (2.76%), sorghum DP-BMR (2.71%), and sorghum RL-BMR (2.56%). The results clearly shows the final ethanol concentration varies with biomass source, and the quality and quantity of lignin present in the biomass plays a significant role in the saccharification and fermentation processes.

Molecular cloning and expression analysis of multiple polyphenol oxidase genes in developing wheat (*Triticum aestivum*) kernels

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Polyphenol oxidase (PPO, EC 1.10.31) is a major cause of discoloring in raw dough containing wheat flour. PPO is a ubiquitous enzyme that occurs in the outer layers of wheat kernels. High levels of flour PPO have been associated with diminished end-product color and brightness in a variety of products, particularly Asian noodles. PPO catalyzes the oxidation of endogenous phenolic substrates in flour, resulting in the formation of dark pigmented products that diminish product quality. Minimization of PPO activity is therefore desirable. This has proven difficult because bread wheat is genetically complex, composed of the genomes of three grass species. The PPOA1 and PPOD1 genes, on chromosomes 2A and 2D, respectively, have been implicated in PPO activity. However, much remains to be understood regarding the genetic basis for kernel PPO activity. Recently we found that in addition to PPOA1 and PPOD1, wheat contains multiple paralogous PPO genes. The goal of this study was to determine which if any of these genes were expressed in developing wheat kernels. We also wished to quantify expression levels of all the expressed PPO sequences in wheat kernel development. RNA was isolated from developing wheat kernels, reversed transcribed, and amplified using degenerate oligonucleotide primers designed against conserved PPO regions. Four distinct PPO sequences were detected. Full length clones were isolated from cDNA and genomic DNA. An additional related sequence was detected in genomic DNA. Of the five sequences, two were the previously described PPOA1 and PPOD1 genes. The three new sequences were found to be homeologus to one another, and parologous to the PPOA1/PPOD1 group. We propose naming these new genes PPOA2, PPOB2, and PPOD2. Real-time PCR analysis determined that PPOA1, PPOA2, PPOD1 and PPOD2 were all expressed in substantial amounts in developing wheat kernels.

TIM-Carbo: Validated *in vitro* technology to accurately predict the glycemic response on carbohydrates

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Glycemic response curves are measured in humans. Besides ethical constrains, the Glycemic Carbohydrate Definition Committee has expressed concern about this approach, because of considerable intra-and inter-individual variability. They expressed the need for a rapid and accurate *in vitro* technology that overcomes these drawbacks. Formerly reported *in vitro* methods are limited in physiological relevance and predictive quality. We developed; calibrated and validated a novel *in vitro* technology (TIM-Carbo) that measures digestibility of carbohydrates (as single compound or in a meal matrix), the absorption of glucose and fructose, and predicts the human glycemic response. Development: a dynamic computer-controlled in vitro gastrointestinal system (TIM) simulates accurately the luminal digestion of carbohydrates and the removal of maltose, maltotriose and oligosaccharides. A brush border enzyme mix was developed to further digest these oligosaccarides into monosaccharides. The analyzed amounts of glucose and fructose are used in an *in silico* model to translate these data (based on insulin response etc.) into predicted glycemic response curves. Calibration: by testing 4 different food products in TIM-Carbo and comparing the predicted glycemic curves with their *in vivo* glycemic response curves, the technology was fine-tuned. Validation: 18 different food products were tested in TIM-Carbo and the predicted glycemic response was compared with their *in vivo* glycemic response data. Results showed an accurate prediction glycemic curves (within 10% range) and of T_{max} (range of <10 min) and a very good correlation of C_{max} ($r = 0.91$, $n = 22$ tested products). The TIM-Carbo technology is accurate for determining carbohydrate digestibility, glycemic load, reliable for predicting glycemic response curves and max plasma concentrations. It is a rapid and cost-efficient alternative to human studies.

Lentil-based extruded snacks fortified with nutritional yeast: Physico-chemical and nutritional evaluation

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Lentil (lents culinaris L.) and other pulses are rich source of nutritious and healthy food components. They are high in good quality protein, dietary fiber, B-vitamins and minerals. Nutritional yeast is grown from pure strains of Saccharomyces cerevisiae, on a purified nutrient source, specifically for its

nutritional value. This study aimed to develop unique, healthy, crunchy extruded snack-type foods from lentil-based formulations fortified with nutritional yeast. Lentil flours and lentil-based formulations with and without nutritional yeast were extruded using a Clextral EVOLUM HT-32-H twin screw extruder, run at die temperatures of 160°C and constant screw speed of 500 rpm, to produce the snacks-type product. The SME (KWh/Kg) of lentil extrudates was significantly lower ($p \leq 0.05$) than those from lentil-based formulations with and without nutritional yeast. In general, the expansion ratio was proportional to values of SME. Shelf stability of the developed products was similar to those of dehydrated food products with water activity in the range of 0.44–0.50. Extrusion processing significantly increased ($p \leq 0.05$) the in vitro protein digestibility in the final extrudates. The incorporation of nutritional yeast into lentil-based formulations produced extruded snack-type products with enhanced textural characteristics and acceptability than control extrudate. The development of value-added expanded extrudates, formulated with lentil and nutritional yeast, have a great potential to provide the population with highly nutritional, healthy and convenient food.

Composition of building blocks in clusters of amylopectins

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Cereal Foods World 55:A20

The cluster hypothesis of the structure of the amylopectin macromolecule was introduced 4 decades ago. Despite its wide acceptance, however, remarkably few investigations concerning the actual fine structure of the clusters are found in the literature. Recently, clusters were isolated from a few samples (including starches from cassava, amaranth, potato and waxy rice) that suggested that the clusters are build up by small, tightly branched units of dextrins that were named building blocks. In this work the investigation of the building block structure was extended to include amylopectins from 10 widely different plants that represented A-, B-, and C-type starch granules. The clusters were isolated from the amylopectin by a mild treatment with alpha-amylase. The external chains were then removed by exo-acting enzymes and the resulting so called fi,beta-limit dextrins contained the intact inner structure of the clusters. The limit dextrins, having average DP values from 50-80, were then extensively treated with the alpha-amylase a second time to produce very small “near alpha-limit dextrins” that represented the building blocks of the clusters. The blocks were divided into 4 principle types representing blocks with 2, 3, 4, and more chains, respectively. The most common blocks in all samples had DP 5-9 and contained only 2 chains. In multiply branched blocks the average internal chain length was approx. 2-3 glucosyl residues. Large blocks, found in only small quantities in all samples, possessed DP in the order of 20-40. Inter-block chain lengths of 6-8 residues separated the branched blocks from each other.

Starch granules under attack: Multidisciplinary investigation of structural mechanisms governing starch digestion

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Starch is not only the most important carbohydrate in the human diet but is also a key ingredient in animal feed and has many industrial applications outside the food industry such as in paper manufacture, packaging and the production of biofuels. Therefore, understanding the factors that control the kinetics and extent of enzymic digestion of native starches is essential to ensure fitness-for-purpose for such a diverse range of end uses. Most in-vitro studies of granular starch digestion have been limited to samples for which aliquots have been removed from the reaction mixture at various time intervals and freeze-dried to be subsequently characterized using a range of techniques. In this study, we report the first neutron scattering study of enzymic digestion of granular starch in which data have been collected in real-time and in-situ. We have utilised a range of complementary powerful analysis techniques such as X-ray diffraction, small-angle X-ray scattering, differential scanning calorimetry and microscopy to determine the structural changes of six commercial starches of varying crystal structure and amylose content over six orders of magnitude in spatial resolution. We find that in the course of digestion, the lamellar peak intensity gradually decreased and low-q scattering increased and these trends were more substantial for A-type than for B-type starches. These observations may be explained by preferential digestion of amorphous growth rings. Consideration of the changes in the molecular densities of the three granular regions in the course of digestion, alongside a range of other characteristics among starches from different botanical origin indicates that the enzymic susceptibility is not determined by the lamellar nanostructure of the semi-crystalline growth ring but, to a great extent, by the opportunity of access through granular pores and channels.

Influence of food matrix on the stability of polyphenols through processing

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Polyphenolic compounds are secondary plant metabolites commonly found in most cereal grains. While associated with several positive health effects due to their reported biological activities, polyphenols are also known to bind non-covalently to proteins, negatively impacting nutritional quality of cereals, such as sorghum, containing appreciable amounts of these compounds. Moreover, while polyphenolic compounds are relatively stable in cereal grains, these phytochemicals appear to be more easily degraded when removed from their natural matrix. Thus, we hypothesize that isolated phenols and polyphenols, increasingly common as food ingredients, could be protected from degradation by interacting non-covalently with proteins. To assess the stabilizing effect of proteins, polyphenols of various chain lengths and degree of galloylation (gallic acid, catechin, epigallocatechin gallate) were selected and formulated into model systems with water, starch, or starch and proteins (zein, gelatin or whey). These model systems were then subjected to specific processing conditions, including cooking under normal or nitrogen atmosphere, and UV treatments. Phenolic compounds were then extracted, recovered and quantified by HPLC. Phenolics were found to more stable when co-formulated with hydrophobic proteins (zein) compared to other proteins, possibly due to hydrophobic interactions with phenolics. Surprisingly, phenolics appeared also to interact directly with starch itself. These results are a first step towards a better understanding of polyphenol/protein interactions in cereals and may lead to development of targeted delivery systems for polyphenol antioxidants through normal cereal consumption.

Digestion mechanism and *in vitro* test method of maize starch granule digestion

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Starch is a major component in cereal foods. Since the rate and the extent of starch digestion depend on its source and food-processing conditions, the fundamental knowledge with respect to the relationship of starch structure and digestion is of particular interest to the food industry. To determine the rapidly digestible starch, slowly digestible starch (SDS), and resistant starch (RS) content found in a starch sample, the addition of amyloglucosidase is often used to convert hydrolyzates from α amylase digestion to glucose. The objectives of this study were to investigate the exact role of amyloglucosidase in determining starch digestibility and understand the mechanism of enzymatic actions on starch granules. Four maize starches differing in amylose content: waxy (0% amylose), normal (≈26% amylose), and two high amylose starches (≈50% and ≈ 70% amylose) were examined. Without amyloglucosidase addition, the expected SDS fraction was 20% lower, while RS increased with increasing amylose content. In a method without α amylase addition, less RS was produced than without amyloglucosidase added, except in 70% amylose maize starch. Multiple analytical techniques were employed to understand roles of amyloglucoisdase and α amylase in the *in vitro* test. The molecular weight distributions of the digestive residues were compared with gel permeation chromatography (GPC). Scanning electron microscopy (SEM) revealed the digestive patterns of pinholes with α amylase and burrowing with amyloglucosidase as well as the degree of digestion between samples. Also, synchrotron small-angle and wide-angle X-ray detection was used to determine the molecular and crystalline structure before and after digestion. Amyloglucosidase has a significant impact on SDS and RS content of granular maize starches.

The impact of redox agents and N-ethyl maleimide on the extractability of gluten proteins during fresh pasta making and cooking

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The network forming ability of gluten proteins is of great importance for pasta cooking quality. We used redox agents as a tool to impact the protein reactions necessary for forming a protein network during fresh durum wheat pasta making (mixing and sheet rolling) and/or cooking on a laboratory scale. SE- and RP-HPLC data showed that, in control fresh pasta (dough water content of 34.8%), gluten proteins form a disulfide linked network during cooking due to fast glutenin polymerization and slower gliadin incorporation in the network. The thiol blocking agent N-ethyl maleimide and, to a lesser extent, the oxidizing agent potassium iodate hindered gliadin-glutenin copolymerization and glutenin cross-linking during cooking. However, the introduction of reactive thiol groups by adding the reducing agent glutathione resulted in a faster gliadin-glutenin copolymerization during cooking.

Cellulolytic enzyme production in solid state fermentation: Role of physico-chemical characteristics of a substrate

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Cereal Foods World 55:A21

Solid state fermentation is an effective means of producing cellulolytic enzyme system for biomass hydrolysis for biofuels and chemicals. The current work investigates the effect of physicochemical characteristics of soybean hulls on production of cellulolytic enzyme system in T. reesei and A. oryzae in solid state fermentation. Mild acid and alkali treatments, and steam treatment were performed to minimize compositional changes so that detailed study of three physicochemical characteristics: crystallinity, bed porosity and volumetric surface of substrate particles can be performed. Both crystallinity and porosity increased significantly after treatments while total cellulosic composition remained almost unaltered in treated and untreated substrate. Steam treated and untreated soybean hulls inoculated with T. reesei had 4 FPU/g-ds, and 45 IU/g-ds (endocellulase) compared to 0.75 FPU/g-ds and 7.29 IU/g-ds (endocellulase), respectively. Crystallinity and porosity were significantly implicated in all the activities except xylanase in T. reesei culture. In A. oryzae culture, endocellulase was found to be significantly related to increase in crystallinity and porosity. Porosity was important from growth point of view, whereas crystallinity had decisive role in production profile of two cultures. The effect of crystallinity was further explained by adapting cultures on standard crystalline substrates before using as inoculum in solid state fermentation. Results indicated that crystallinity significantly enhanced production of both filter paper units (5.23 FPU/g-ds) and endocellulase (65.13 IU/g-ds) in T. reesei while there was significant reduction in production of xylanase (47.86 IU/g-ds) in A. oryzae.

Metabolomics - a new platform in establishing metabolome profiles of basmati and jasmine rices

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Basmati and jasmine are the two leading fragrant rices in world trade, and consumers tend to have a strong preference for either basmati or jasmine, but few Asian consumers like both types. Fragrance in both types is reported to be due to the same compound - 2-acetyl-1-pyrroline (2AP) - making it difficult for breeding programs to select for each market type. In order to find differences between the types, members of the International Network for Quality Rice from 10 countries supplied the fragrant rices prized in their countries. We conducted non-targeted metabolomics to determine the volatile compounds present in a set of 45 varieties of fragrant rices from South-East, South and Central Asia, and in controls. At least 500 volatile compounds were identified that were consistently present in basmati or jasmine and are associated with taste descriptors. Principal component analysis separated all the jasmine varieties from basmati varieties on the basis of 134 discriminating compounds. Basmati rices are consumed after storage for 12 months. 2AP did not contribute to aroma in the basmati rices ready for consumption, and it was not the most important compound in jasmine types either. Once the important, discriminating compounds are identified, such information represents a new set of phenotyping information that could be used to see the genetic basis of fragrance in jasmine types and in basmati types.

Continuous ozonation treatment systems as a more efficient non-chemical grain protection technologies

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Previous static bed ozonation scale-up and demonstration trials have proven the use of ozone as an effective technology for grain protection without affecting its end-use quality. Due to the lack of current availability of high capacity ozone producing generators, grain treatment through static bed ozonation systems are limited to be used in metal silos of capacities smaller than 644-tonnes. Also, the trials have shown that treatment time has to be of no less than 4 days during application in order to be effective for pest control. Therefore, more efficient ozonation treatment systems are needed for proper ozone usage for stored product protection. The primary objective of these research studies was to design and test a semi-continuous counter-flow ozonation and a continuous ozonation flow treatment systems in order to ozonate grain at faster rates based on the concentration-time product (CTP) of ozone required to achieve 100% insect mortality and effective mold and reduction in grain. The procedure of the counter-flow semi-continuous ozonation system consisted of removing each grain layer inside a metal silo with a tapered unloading auger after each layer reached the desired ozone CTP. The treated grain is subsequently transported to a storage or shipping silo. The continuous ozonation flow system involves applying high ozone concentrations through a modified grain loading screw conveyor where ozone and grain are moving continuously in the same flow direction. The counter-flow semi-continuous ozonation system was successfully tested and proved to be a technically feasible tool for pest control and mold reduction. The continuous ozonation flow system was proved as an effective tool for treating grain during handling while achieving 100% insect mortality, and effective mold reduction.

Carbon dioxide sensing: A new food safety tool for early detection of spoilage due to fungi, mycotoxins and stored-product insects in stored grain

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Field experiments were conducted in 20 storage silos to evaluate carbon dioxide (CO2) sensing for early detection of spoilage due to fungi, mycotoxins and stored-product insects. The CO2 concentrations in these storage silos were observed for up to eight months and correlated to grain spoilage. The data showed that safe grain storage was observed at CO2 concentrations of 400 to 500 ppm. Carbon dioxide concentrations of 500 to 1200 ppm indicated onset of grain spoilage, whereas CO2 concentrations of 1500 to 4000 ppm and beyond clearly indicated severe fungal infection or stored-product insects infestation. The percent kernel infection by molds was in the range of 30% for CO2 concentrations of 500 to 1000 ppm to 90% for CO2 concentrations of 9000 ppm. Fungal concentrations were in the range of 2.0×102 cfu/g at 500 ppm CO2 concentration to 6.5×107 cfu/g at 9000 ppm CO2 concentration. Fungi of genera Aspergillus spp., Penicillium spp., and Fusarium spp. were isolated from spoiled grain. High concentration of fungi, mycotoxins (aflatoxin, fumonisin, and deoxynivalenol) and stored-product insects were correlated with high CO2 concentration in the silos. Our data clearly showed that CO2 sensing can be effectively used to monitor spoilage due to fungi, mycotoxins and stored-product insects prior to spoilage detection by traditional methods such as visual inspections and temperature cables. The CO2 sensing technology is expected to save U.S. grain producers, handlers and processors millions of dollars annually by minimizing the storage, handling and pest management costs. Further, this technology will reduce the residue levels of mycotoxins, pesticides and other foreign material assuring food safety throughout the grain based food supply chain.

Nutritional enhancement of soybean carbohydrates and hulls for animal feed using microbial cultures

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In commercial broiler diets, large quantities of soybean meal (SBM) are used due to their high protein content (usually between 47% and 48%) and a favorable amino acid composition. However, the dietary energy value of SBM is relatively low mainly due to the oligosaccharides in the carbohydrate fraction which constitutes approximately 32% of this ingredient. Furthermore, raffinose and stachyose oligosaccharides could lead to flatulence and abdominal discomfort for mono-gastric animals. The objective of this research is to use *Bacillus* spp. and *Aspergillus oryzae* for effective utilization of the soluble carbohydrates present in SBM to single cell protein as well as reducing the concentration of oligosaccharides. Raffinose and stachyose contents were analyzed using HPLC with a monosaccharide (Ca^{+}) column. Protein and fiber were analyzed based on AOAC methods. The results showed that after fermentation with *Bacillus* spp., the protein content for soybean meal increased about 10.6% and for soybean hull, it was about 36.17%, and fiber content for soybean hull decreased about 18.34%. Also, similar results were obtained after fermentation with *Aspergilllus oryzae*. The increment of protein for soybean meal was 9.93% and for soybean hull was 5.25% and the fiber content for soybean hull decreased 29.12%. Further, the stachyose and raffinose reduced to undetectable levels after fermentation with *Aspergillus oryzae* and the specific results will be discussed in the presentation. The increased protein and nutritional content, and decreased oligosaccharides concentration, demonstrated added value of soybean meal and hull for the wider usage in animal feed industry.

Effect of steam-cooking and parboiling on phenolics and antioxidant capacities of red and purple rice cultivars

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Red and purple rice cultivars contain high concentrations of phenolics, such as proanthocyanidins and anthocyanins respectively. We investigated the effect of cooking processes on these antioxidants and antioxidant capacities of pigmented and common light-brown bran rice. The cooking processes included whole-grain steam-cooked (S), paddy (with hull) parboiled (PP), parboiled paddy steam-cooked (PP-S), whole-grain parboiled (PW), and parboiled whole-grain steam-cooked (PW-S). Uncooked whole-grain (Raw) served as a control. Raw red and purple rice cultivars had 3- to 20-fold higher total phenolic (TP) and total flavonoid (TF) concentrations, DPPH radical scavenging capacity and ORAC oxygen radical absorbance capacity than did the raw light-brown bran rice. The cooking processes, in general, decreased TP, TF, DPPH and ORAC among all rice cultivars in the following pattern, from least to greatest decrease compared to Raw: S < PP < PP-S < PW < PW-S. The concentration of proanthocyanidins relative to that in Raw decreased as the intensity of the cooking processes increased, and were highly correlated with those of TP, TF, DPPH and ORAC. Concentrations of proanthocyanidins were 42% and 12% of Raw in S and PP-S samples, respectively. Anthocyanins were quite heat sensitive. Concentrations of anthocyanins in purple rice cultivars averaged 29% and 1.6% of Raw in S and PP-S samples, respectively. However, heat-resistant phenolic compounds were present since the % TP, TF, DPPH and ORAC of purple rice ranged from 83 to 95% and from 46 to 75% of Raw in S and PP-S samples, respectively. Phenolics in light brown bran rice were relatively more resistant to cooking processes than those in pigmented rice. Nevertheless, one of the steam-cooked purple rice cultivars, for example, still had 6.8- and 18-fold higher ORAC and TF, respectively, than did the common light-brown rice.

Oat avenanthramides: Potential mode of action as natural anti-inflammatory agents and production of an oat product with physiologically-significant level

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Avenanthramides represent the major readily-bioavailable, soluble phenolics present in the oat kernel and these hydroxycinnamoyl alkaloids are found only in oats. Our recent *in vitro* work shows that they inhibit pro-inflammatory cytokines IL-6, IL-8 and MCP-1 signaling associated with atherosclerotic disease progression. To put this in context, a purified avenanthramide mixture at 20 and 40 ppm reduced the secretion of cytokine IL-6 in an IL-1β-stimulated human aortic endothelial cell cultures by 55 and 60%, respectively. However, our preliminary *in vivo* pharmacokinetic studies shows pure avenanthramide bioavailability in humans is only about 1% following acute oral administration. Therefore the anti-inflammatory effects observed *in vitro* would necessitate an oral dose of about 30 to 60 mg total avenanthramides to be physiologically relevant. Analyses of avenanthramide levels in North American covered oat varieties ranged from about 50 to 100 ppm and are far too low to be effectively incorporated into an acceptable oat product (e.g. a baked muffin). Producing a 60 g oat bran muffin, containing about 30% oat bran as a test vehicle for *in vivo* human clinical trials, would require bran containing from 1,500 to 3,000 ppm total avenanthramides. To accomplish this, we have developed a proprietary oat malting and abrasion milling process to produce an oat bran ingredient with 3,000 to 3,500 ppm total avenanthramides. This bran was then incorporated (30% by weight) into a 60 g bran muffin which contained about 48 mg total avenanthramides after baking. This oat bran muffin is highly suitable for both short and long term in vivo studies of the potential vascular health benefits of avenanthramides. This represents the first oat product with physiologically relevant avenanthramide levels in a native food matrix. Details of the malting and milling process will be discussed.

Modification of gluten by methionine binding to prepare wheat bread with reduced reactivity for serum IgA of celiac disease patients

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Celiac disease (CD) is an enteropathy caused by ingestion of wheat gluten proteins, due to immune response to proline- and glutamine-rich sequences. In this study a steric bulk was induced by enzymatically bound methionine to gluten proteins to reduce the immune recognition. Additionally, a bread-making process with modified gluten was assayed. The reaction system included wheat gluten, alpha chymotrypsin and methionine plus glycerol as depressor of the water activity. The methionine binding was monitored by measuring the alpha-amino groups disappearance and reduction of celiac IgA immunoreactivity. The best methionine binding was done after 60 min reaction to pH 10, inducing a reduced to null IgA immunoreactivity to prolamins extracted from modified gluten. The bread-making process included a mixing time periods longer than the used for bread-making with wheat flour. The bread elaborated with modified gluten had lower specific volume (3.86 cc/g) than the control wheat bread (4.52 cc/g) but higher than those reported for gluten-free loaves. The major functional properties of gluten proteins were preserved after modification, making feasible the application for different wheat-based foodstuffs, as the assayed bread in this study.

Hyperspectral imaging of wheat kernels for fusarium damage

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Fusarium head blight (scab) affects the world's small grains, such as wheat and barley. Attacking the heads during anthesis and onward, the fungus causes a reduction of yield and grain of poorer processing quality. It also is a health concern because of the secondary metabolite, deoxynivalenol, which often accompanies scab. While chemical methods exist to measure the concentration of the mycotoxin and manual visual inspection is used to ascertain the level of Fusarium damage. Government and private inspection procedures include a component that requires visual inspection for Fusarium damage. As an alternative, fast optically based techniques that can assess this form of damage are the subject of current research. This research differs from our previous work in that the wavelength region of interest has changed from the visible and short near-IR region (400-1000 nm) to the conventional near-IR region, a region that contains the overtone vibration bands of CH, NH, and OH intramolecular groups. The newly developed hardware was tested for recognition of Fusarium-damaged individual wheat kernels. With anticipation of an eventual multispectral imaging system design, 5 wavelengths were manually selected from a pool of 146 images as the most promising, such that when combined in pairs or triplets, Fusarium damage could be identified. Results are presented of two pairs of wavelengths [(1199, 1474 nm) and (1315, 1474 nm)] whose reflectance values produced adequate separation of kernels of healthy appearance (i.e., asymptomatic condition) from kernels possessing Fusarium damage. Refinements on the image extraction at the sub kernel level will also be discussed.

Potential of xylanases with different temperature optima and substrate hydrolysis patterns in bread making

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Xylanases are enzymes which hydrolyze the backbone of cereal cell wall arabinoxylans (AX) and which, in doing so, can have a significant impact on cereal based processes and end products. In this study, a set of xylanases from diverse glycoside hydrolase families, with different temperature optima and substrate hydrolysis patterns, was used to investigate the dependency of xylanase functionality on the enzyme characteristics in bread making. Comparison of the impact in bread making of three psychrophilic, three mesophilic and four (hyper-)thermophilic xylanases revealed that xylanases should be optimally active during mixing or fermentation to beneficially affect bread volume, rather than during baking. Indeed, statistical analysis of the data indicated that bread loaf volume and bread height are strongly positively correlated with the portion of AX solubilized during mixing whereas they are negatively correlated with the enzyme's optimal temperature. In agreement with the above, much less enzyme has to be added to a bread formula when it is of psychrophilic nature, than when it is mesophilic or thermophilic. This is particularly relevant for industrial bread making.

Wheat quality and its relation to kernel elastic properties of high and low molecular weight glutenin subunits

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Twenty six wheat lines with differences in high and low molecular weight (HMW and LMW) glutenin subunits (GS) were included in this study. The samples were evaluated by SDS sedimentation, HMW- and LMW-GS allelic composition and kernel elastic (WE) and plastic (WP) work calculated from force-deformation curves. The locus Glu-A1 with null subunit showed one allelic variant with poor sedimentation volume and low modulus of elasticity. The Glu-A1 1 genotypic group presented 9 allelic variants with relatively

good quality, and poor quality in one allele. The presence of LMW Glu-A3 e silent allelic form was determinant in the poor quality by increasing the plastic work (WP) value. Most of the samples containing HMW-GS Glu-A1 2* presented good quality. Those that presented poor quality also showed low elastic work (WE) and high WP explained by the influence of LMW-GS Glu-A3 e, and Glu-B3 i and j. Other allelic variants of good HMW-GS representing Glu-B1 7+9 and Glu-B117+18 also showed similar tendencies. At the locus Glu-D1, most of the samples with 5+10 presented higher SDS sedimentation values than those of 2+12. In general, good quality performance was represented by a relatively high WE and medium-low WP, in samples containing a range of protein content of 12.3–13.4% in this set of samples. The presence of HMW-GS Glu-1 null, 7+8 and 2+12 had lower WE and relatively high WP values. The intact kernel elastic properties showed a clear influence of HMW and LMW alleles associated with the overall quality of the wheat related to the WE and WP values.

Effects of tyrosinase and laccase on the oat proteins and the quality parameters of gluten-free oat breads

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Cereal Foods World 55:A23

Crosslinking enzymes generate covalent bonds in and between food biopolymers, and thus have potential in improving the structure of gluten-free breads. The effects of oxidative cross-linking enzymes, tyrosinase (TYR) from *Trichoderma reesei* and laccase (LAC) from *Trametes hirsuta*, on oat proteins, doughs, and breads were investigated. Albumin, globulin and prolamin were extracted from endosperm oat flour, and the solutions were incubated with LAC or TYR (0, 100 or 500 nkat/g protein). The effects of enzymes on proteins was investigated by SDS-PAGE analysis. The impact of TYR (0, 10, or 30 nkat/g flour) on the structure of dough was studied by microscopy and rheology (Kieffer test). Additionally, gluten-free oat breads were baked with LAC (14 nkat/g flour), TYR (20 nkat/g flour) or xylanase (XYL, Pentopan mono BG) alone, and in combination with LAC and XYL or TYR and XYL. Specific volume (BreadVolScan) and firmness after 0 and 2 days storage (Texture Analyzer using TPA test) of these breads were analysed. TYR crosslinked oat globulins, as visualized from the formation of higher molecular weight products in the SDS-PAGE gel, while LAC treated protein fractions showed no polymerization. More intensive formation of the protein rich areas in the TYR treated dough than in the control dough without enzymes was observed by microscopy. TYR hardened the oat dough; the resistance to extension increased from 17.7 of the control dough to 21.3 g of the dough with TYR. LAC increased the specific volume of gluten-free oat bread only in combination with XYL, when compared to the control oat bread (from 2.6 cm3/g to 2.7 cm3/g bread). LAC did not affect the firmness of oat bread. TYR alone, or together with XYL, increased significantly the specific volume and decreased the firmness of oat bread when compared to the control oat bread (from 2.6 to 2.8 cm3/g, and from 0.8 kg to 0.6 kg, respectively).

Rebiana, a natural high-potency sweetener, is stable in baking consumer-acceptable, reduced-sugar cookies and muffins

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Rebiana is the common name for purified rebaudioside A, a new, zero-calorie, natural, high-potency sweetener derived from *Stevia rebaudiana*. Reduced-sugar cookies and muffins were made using rebiana to eliminate 40% and 50% of the added sugar respectively, while maintaining a natural sweetening system. Inulin and erythritol were used as bulking agents. Control full-sugar products were baked at the same time. Finished reduced-sugar cookie mean diameter was 467 mm (control 453) and height was 54 mm (control 69). Average volume of reduced-sugar muffins was 125 ml (control 128) with a height of 55 mm (control 53). Analytical recovery of rebiana after baking was 98% for cookies and 100% for muffins, corrected for baking losses of 11.7% and 9.0% respectively. Consumer sensory assessment rated both reduced-sugar cookies and muffins as not significantly different ($p \leq 0.05$) from their full-sugar counterparts for flavor, texture and overall liking.

Rheological and structural properties of hard and soft wheat flour systems with bran inclusions

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Cereal Foods World 55:A23

Phytochemicals and nutrients associated with the non-endosperm portion of the cereal grains have been proven to have significant health benefits like type 2 diabetes risk. However, the inclusion of the non-endosperm components to dough systems presents challenges. Among cereal brans, wheat bran is one of most important dietary fiber sources in the bread making industry. The aim 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, starch pasting behavior of the dough systems were studied using Farinograph, Mixograph and Mixolab. HRW and SW bran inclusions (0–10%) in HRW flour have higher absorption rates from 65–69% as compared to 59–61% for SW flour due to bran addition. The peak time and peak value was higher in HRW flour as compared to SW flour with and without of all bran inclusions. There is no significant difference in the effect of coarse and fine HRW and SW bran addition for all levels on mixing properties of HRW flour dough. The crumb structure and texture of the bread loaves were characterized using C-cell imaging techniques and TA-XT2 texture analyzer. The loaf volume of HRW flour bread decreased as percent bran addition increased and no significant difference was observed in source of bran. Microstructural analysis of bran added bread samples indicated shift in air cell size distributions towards higher values due to coalescence of air cells during proofing or baking. From above results, HRW flour performed better compared to SW flour both during dough mixing and baking. Bran affected the performance of HRW flour negatively.

Inverse identification of viscoelastic material properties using the biaxial bubble inflation test

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Cereal Foods World 55:A23

The bubble inflation test, such as the Alveograph, has been routinely used to assess the breadmaking quality of flour. However, the assessment is normally considered to be “empirical” since the results are expressed in terms of bubble pressure versus time and not in terms of particular rheological parameters such as the stress-strain relationship which may be used to predict dough behaviour during baking or processing. Efforts to convert the bubble test measurements into rheological properties has been carried out previously but the analytical solution requires tedious measurements of the geometrical characteristics of the bubble. In addition, the time dependent behaviour of the dough is not built into the analytical solution. In the current work, an inverse method has been applied to convert the bubble pressure–time measurements into strain hardening and time dependent properties of the dough. The method consisted of an inverse algorithm and a finite element simulation of the bubble inflation process. A non-linear viscoelastic material model was assumed for the dough and data from a single set of bubble pressure-time relationship was used to identify the rheological parameters. The predictions of the stress-strain properties from the inverse method showed good agreement with the actual solution and is expected to improve if more than one set of data were used to identify the rheological parameters. Thus, the bubble inflation test is more than just an “empirical” test and the bubble pressure-time data may be further analysed using an inverse method to provide both the strain hardening and time dependent rheological properties of test samples.

Effect of sugar and salt on gluten development when studied by using fluorescence spectroscopy and Gluten Peak Tester

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Cereal Foods World 55:A23

This study investigates the effect of salt and sugar on gluten development. The effect of Sucrose (0–25%) and NaCl (0–5%) addition on gluten development in soft wheat flour (SWF) dough (40% moisture) and slurries (55% moisture) were investigated with the use of fluorescence spectroscopy and Gluten Peak Tester (GPT), respectively. In this study, 1,8-anilino-naphthalene-sulfonate, a non-covalent external probe was used to monitor changes in the surface hydrophobicity of gluten proteins. GPT provides information on the kinetics of gluten aggregation by measuring the torque generated when a slurry is stirred at 2750 rpm. NaCl decreased the fluorescence intensity of samples at addition levels less than or equal to 1%, but increased the fluorescence intensity at greater addition levels. The fluorescence intensity of dough increased with sucrose addition ($R^2 = 0.93$). Peak maximum time (PMT) of SWF slurries decreased with NaCl addition levels less than or equal to 1%, but increased with greater addition levels. The torque of SWF slurries increased with NaCl addition ($R^2 = 0.87$). SWF displayed opposing gluten aggregation trends in the GPT dependent on the nature of sucrose addition. Dry sucrose addition resulted in increasing ($R^2 = 0.94$) PMT and decreasing ($R^2 = 0.93$) torque values. The addition of pre-dissolved sucrose increased torque ($R^2 = 0.97$), and decreased PMT values. The data shows that salt and sugar, and the manner in which they are added, play a large role in gluten development.

Components and benefits of cereal brans

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Cereal Foods World 55:A24

Cereal bran is one of least expensive functional ingredients in grain based foods. Bran is an integral part of the grain contributing from approximately 7% of the kernel in corn to nearly 33% of the kernel in oats. Bran forms the outer layer of the grain and protects the grain from insects, pests and adverse climatic conditions. Bran layers are a store house of nutrients, from fiber to phytochemicals. Bran layers are very complex and contain both soluble and insoluble fiber. The ratio of soluble to insoluble fiber varies from grain to grain. The water soluble feruloylated oligosaccharides and ferulic acid esters of arabinoxylans in bran have been shown to have antioxidant properties. The type and amount of nutrients and the physiological effects of bran vary with species as well as agronomic conditions. Several studies have shown that bran has beneficial effects on laxation, cholesterol lowering, weight management and blood glucose attenuation. The small chain and soluble polymers in bran fibers act as a prebiotic and are good substrates for the growth of beneficial intestinal microflora. Fortification of food products with cereal brans can affect sensory quality, but new processing technologies facilitate the addition of bran to more foods. A review of the composition and benefits of bran and its components will be presented.

Contributions of grain-products to total phenolic antioxidant intake in the DASH eating plan: Impact of whole-grain selection

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Cereal Foods World 55:A24

The DASH (Dietary Approaches for Stopping Hypertension) plan encourages consumption of high phenolic foods including whole grains, and fresh fruit and vegetables. Polyphenols exhibit anti-inflammatory and antioxidant effects that may reduce symptoms of obesity, hypertension, cardiovascular disease, and diabetes. A total phenolics (TP) database specific to the suggested menus in the DASH Eating Plan was established. TP in 58 grain-based products were determined in triplicate with the Folin-Ciocalteu assay after hexane extraction; data are reported in mg Gallic Acid Equivalents (GAE)/g. Specific brand names for the products analyzed were based on supermarket shelfspace when not included in the June 2009 Mintel US Bread Report as most purchased in the US. Foods within 5 grain-foods categories (bread, breakfast cereals, pasta, grain-based snacks, cereal grains) and flours were analyzed. Literature data for non-grain foods only were included when the same phenolics assay was employed; non-grain foods in the menus not found in the literature were analyzed. TP in suggested menus were 2070 ± 263.1 mg GAE per day; grains contributed from 6.8% to 21.3% of the daily total with a mean % contribution of 12.5 ± 5.2. 75% of the grain-based items in the suggested menus were whole-grain products. Incorporation of all whole grains resulted in a mean % contribution of 15.3 ± 6.0; all non-whole-grain products resulted in a mean % contribution of 10.6 ± 5.2. Independent samples t-test (alpha = 0.05) revealed a significant difference in TP present in 9 of 11 paired whole-grain vs non-whole grain products when brand names were held constant. Exclusive incorporation of whole-grain products has the potential to increase the contribution of grains to total phenolics intake by approximately 30%; deliberate selection based on high TP grain-based foods would have an even greater impact.

Extraction and characterization of starch from pig digesta to understand the *in vivo* digestion of starch

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Cereal Foods World 55:A24

Small intestine digesta from seven pigs fed on a diet containing 47% (dry weight basis) raw maize starch were collected to understand the mechanism of *in vivo* starch digestion. Most *in vivo* studies have been carried out using feces and digesta from terminal ileum and colon, which provide limited information about the mechanism. The small intestine was divided into four sections labeled as SI-1, -2, -3, and -4 from the stomach end to the cecum end. The starch contents of the digesta from SI-1, -2, and -3 were 28-50%, 4-53%, and 1-8% (dry weight basis), respectively. An extraction technique has been modified from previous method [Syahariza et al., *Carbohydr. Polymers*, in press doi:10.1016/j.carbpol.2010.04.014] to extract residual starch from the digesta. This involves ethanol precipitation to separate starch from soluble non-starch components in the digesta and dissolution in DMSO/LiBr at 80°C to separate starch from insoluble non-starch components. The extracted starch (fully branched and debranched using isoamylase) was analyzed by size exclusion chromatography (SEC). The fully branched and debranched distributions of the starch in SI-1 and -2 digesta were similar. The fully branched distributions of the starch in SI-3 digesta, however, show smaller molecules than those of the starch in SI-1 and -2 digesta. On the other hand, the debranched distributions of starch in SI-3 digesta show larger amounts of long amylopectin branches and amylose branches than those of starch in SI-1 and -2 digesta. The results suggest that the digestion of starch is mostly taking place in SI-3, although it may be started in SI-1 or -2. The debranched distributions of the *in vivo* digesta also suggest that amylose and long branches of amylopectin are less susceptible to *in vivo* enzyme hydrolysis than the short branches of amylopectin. The *in vivo* results show similarities and differences from those obtained through *in vitro* studies.

Permeability of crust is key to crispness retention

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Cereal Foods World 55:A24

Bread loses crispness rapidly after baking because water originating from the wet crumb accumulates in the dry crust. Water accumulation may vary depending on crust properties (e.g. permeability, thickness and microstructure). Our objective was to investigate the influence of water vapor permeability of the crust on water uptake in the crust in relation to crispness retention. To achieve this objective, we increased the permeability of the bread crust by varying ingredients or by applying small channels through the crust. The water vapor permeability of crust was measured using a newly developed method for brittle materials. Three other properties were measured over time: sensory crispness, instrumental crispness and water content of the crust. Control bread crust had a low water vapor permeability and clearly functioned as a barrier, leading to increased uptake of water in the crust. Water uptake was 50% less, however, if the water vapor permeability of the crust was doubled. As a consequence crispness retention increased eight-fold: breads with an increased crust permeability stored for four hours were as crispy as control breads stored for 30 min as determined instrumentally. It could be shown that there was a direct relation between the increased water vapor permeability and the water absorption in crust, and that by varying the first the latter property can be regulated. Physical modeling was performed to investigate the mechanism behind the observed changes in water migration. Based on the results we can conclude that permeability of crust is key to crispness retention.

Morphology and physicochemical properties of ball-milled corn starches with different amylose contents

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Cereal Foods World 55:A24

The purpose of this study was to investigate the effect of ball-milling on the granular morphology, molecular structure, pasting and thermal properties of corn starches with different amylose contents. Normal, waxy and Hylon VII corn starches were ball milled with a planetary ball mill for 0.5–2.0 hr. The morphology and physicochemical properties of ball-milled starches were investigated by scanning electron microscopy (SEM), wide angle X-ray diffractometer (WAXD), small angle X-ray scattering (SAXS), modulated differential scanning calorimetry (MDSC), rapid visco analyzer (RVA), and high-performance size-exclusion chromatography (HPSEC). The SEM investigations revealed that the damages of Hylon VII corn starch were limited, while those of normal and waxy corn starch were significant after 2 hr ball milling. As ball milling time prolonged the molecular weight of normal and waxy corn starch decreased gradually, while Hylon VII corn starch remained the same. It suggests that ball milling was more effective in reducing the amylopectin molecules in waxy and normal corns than in Hylon VII. For normal and waxy corn starch, the peak viscosity, final viscosity, breakdown viscosity, and set back decreased with increasing in milling time, and the gelatinization endotherms disappeared after ball milling for 2 hr. In addition, the WAXD and SAXS peaks of all these starches (conditioned at 54% RH) decreased while the ball milling time increased. These revealed that ball milling was effective in reducing the crystallinty and the double helical order arrangements of all the starches, among which the waxy corn starch had the highest degree of disintegration.

Genetic improvement of barley lines for altered granule size distribution

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Cereal Foods World 55:A24

Cereals like wheat, barley, rye and triticale are unique in having bimodal size distribution for starch granules. In these cereals, granules can be divided into large A (>15 µm), medium B (5-15 µm) and small C (1-5 µm). Granule size

distribution affects the functional properties of starch and hence its end use. Small starch granules cause problems during malting as they adhere easily to proteins resulting in clogging of filters. The main objective of this study is to increase the concentration of large granules in Canadian barley and study their starch characteristics. Screening of barley (*Hordeum vulgare L.*) for starch granule size distribution identified a Japanese semi-dwarf genotype with reduced small granule content. This Japanese line was crossed with a Canadian genotype CDC-Kendall. F5 population obtained from this cross was screened for granule size trait and 8 lines with reduced small granules content were selected. The selected lines were analyzed for total starch, amylose content and amylopectin chain length distribution. Altered granules distribution resulted in slight decrease in total starch content and reduced difference in amylose content of large and small granules. Amylopectin chain length distribution between DP 6 and 55 was analysed using fluorophore assisted capillary electrophoresis (FACE). On the basis of degree of polymerization amylopectin chains can be divided into A (6-12), B1 (13-25), B2 (26-34) and C (35-55). Reduced concentration of smaller granules was found to be associated with decrease in the content of A and some B1 chains (dp 7-16) and increase in frequency of B chains (dp18-27).

Novel hydrocolloid matrices for protecting bioactive components in food formulations

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Cereal Foods World 55:A25

The poor water solubility and thermal degradation of many dietary ingredients such as nutraceuticals and vitamins greatly hinders their effective utilization in food applications. Their bioavailability in food formulations has greater demand due the inherent relationships between the total caloric consumption and nutrients intake, especially in reduced caloric diets. In this regard, a new food formulation that has the ability to thermally protect as well as deliver the active substance is very much in need. Food hydrocolloids that are Generally Recognized As Safe (GRAS) substances standout as attractive choices especially in their crystalline state. Our research demonstrates that polysaccharide (e.g. sodium iota-carrageenan) fibers have the potential to entrap nutraceuticals and vitamins through the formation of polymeric co crystals. X-ray fiber diffraction analyses have shown altered unit cell parameters for the iota-carrageenan:curcumin and iota-carrageenan:vitamin C complexes suggesting the co-crystallization of the ingredient in the crystalline lattice of iota-carrageenan. Further, viscoelastic properties of the co-crystals are significantly different from those of the starting material, and the differential scanning calorimetry data reveal the thermal protection bestowed by the polysaccharide matrix to the entrapped molecule. These results provide an elegant and cost effective methodology towards developing novel delivery vehicles aimed at protecting nutraceuticals, vitamins and other active ingredients in food formulations using non-starch polysaccharides.

The Bioeconomy – 2010 and Beyond

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Cereal Foods World 55:A25

Applied Research Award

A vision of a bioeconomy, wherein agriculture replaces petroleum as a source of carbon and energy, is profoundly affecting global agriculture. We have over 13 billion gallons (gal) (49 billion liters [L]) of annual ethanol capacity and are producing 11.9 billion gal (45 billion L). We are moving from a farmer-driven industry to one focused on science and engineering. Ethanol yields are increasing, the energy balance is improving, and water consumption is declining. An estimated 4.3 billion bushels (bu) (109 million metric tons [t]) of corn was converted to ethanol in the United States from a harvest of nearly 12 billion bu (305 million t) in 2009. Federal mandates for corn-derived ethanol are being easily met but producing biofuels from cellulosic crops in 2011 is behind. Producing a profit has been challenging, and last year 23 ethanol plants were idled, representing nearly 1.2 billion gal (4.5 billion L) of capacity. We reached a blend wall in which higher blend levels will be needed to make the industry profitable again. An estimated 850 million gal (3.2 billion L) of biodiesel were produced in the United States during 2008, nearly one-half of that capacity has been idled due to loss of tax subsidy and high virgin oil prices. Those operating do so on low-value animal fats and waste oils. Today's biofuel industries based on grain will need to transition into tomorrow's biorefineries, which use crop by-products and cellulosic crops to supplement grain as feedstock and produce industrial chemicals, biobased products, and bioenergy, as well as biofuels. Biological, thermochemical, and hybrid conversions will be used to produce intermediates or platform chemicals that then can be chemically converted into fuels and industrial chemicals. Advanced biorefineries may shift from ethanol to better performing and more energy-dense fuels. Some believe microalgae offers great opportunities, but significant engineering challenges need to be solved. This presentation will focus on where we are and where we are going in the bioeconomy.

Is there a role for gluten-free diets beyond celiac disease? A review of the literature

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Cereal Foods World 55:A25

Recent reports in the medical literature have documented that celiac disease is markedly under-diagnosed. Coupled with that are numerous reports, blogs and testimonials that recommend the use of gluten-free diets for conditions other than celiac and allergies. These include disorders such as obesity, attention deficit hyperactivity disorder or (ADHD,) autism spectrum disorder (ASD), rheumatoid arthritis, and multiple sclerosis. This paper will evaluate the claims from the testimonial world, evaluate the plausibility of purported mechanisms and compare these data with peer reviewed medical literature. In addition the diet quality, cost and other aspects will be addressed.

Study of the role of nicotinamide coenzymes in breadmaking

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Cereal Foods World 55:A25

Nicotinamide adenine dinucleotide coenzymes [NAD(P)(H)] are naturally present in wheat flour. These coenzymes are strong redox agents and are indispensable cofactors in many redox reactions. Therefore, it is not unconceivable that they affect gluten crosslinking during breadmaking. Provided an improving effect by the coenzymes is observed, the promotion of the NAD(P)(H) effect could present a valuable alternative to addition of the classical redox improvers in bread dough recipes. We studied the effect of addition of increasing concentrations of NAD(P)(H) on dough properties, gluten crosslinking, and bread volume using two flours of different breadmaking quality. Separate addition of all four nicotinamide coenzymes did not significantly impact dough mixograph properties. While addition of NAD+ hardly affected bread volume, supplementation with NADP(H) and NADH significantly decreased loaf volumes of breads made using a flour of high breadmaking quality. In order to investigate the actual effect of the coenzymes on gluten crosslinking, free thiol groups were quantified and protein crosslinking was studied by size exclusion HPLC. Based on these results, we hypothesize that at least three reactions which compete for NAD(P)(H) occur during breadmaking and determine the final effect on protein, dough and loaf properties.

Impact of cellular architecture and solid matrix properties on the texture of high fiber expanded foods

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Cereal Foods World 55:A25

Expanded cereal products can be delivery mechanisms for significant amounts of fiber, however a major hurdle is the accompanying decrease in quality, mainly in terms of texture. Information on cellular architecture of expanded high-fiber extruded products and mechanical properties of the solid matrix can potentially be used to predict and control the product texture. The objective of this work was to understand the relationship between macro and micro structural parameters and the texture of high-fiber expanded products. A lab-scale twin screw extruder was used for processing directly expanded products based on corn flour and apple pomace (0–28%), resulting in a total dietary fiber (TDF) content of 1.1–22.5%. Processing moisture content (MC) was 17.5, 20 and 25% for each pomace level. Macro-structural properties such as radial expansion, piece density and specific length were measured using standard methodology. Micro-structural analysis was conducted using X-ray microtomography to obtain cellular architecture parameters (void fraction, average cell wall thickness - CWT, and average cell size - CS). Average crushing force (F), number of spatial ruptures (Nsr) and crispness work (Wc) were characterized using a texture analyzer. Addition of apple pomace decreased radial expansion, but increased specific length, thus specific volume of the samples was not affected. CS (range 0.30–1.25 mm) and CWT (range 0.11–0.40 mm) were lower for treatments with apple pomace, while moisture affected only the CWT. CS was significantly correlated to F ($r = –0.69$), Wc ($r = –0.69$), and Nsr ($r = 0.74$), while CWT had no significant correlation with texture parameters. Interestingly, F decreased with TDF within the same CS range, thus indicating that the effect of apple pomace on texture is twofold: it causes decrease in CS but also negatively impacts the mechanical strength of the solid matrix.

Phytase treatment to improve the E-Mill process

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Cereal Foods World 55:A26

Phytase addition was evaluated on germ and pericarp fiber recovery in the E-Mill process. The E-Mill process involves soaking corn, grinding and incubation with starch hydrolyzing enzymes. Germ and pericarp fiber are separated and the remaining endosperm fraction is fermented. Endosperm fiber is recovered after completion of fermentation. Phytases are enzymes that hydrolyze phytic acid into inorganic phosphate and inositol. In the dry grind process, phytases can be used to reduce slurry viscosity, increase alpha-amylase activity and reduce phytic acid content of distillers dried grains with solubles. Since corn germ is the major repository of phytic acid, addition of phytases to the E-Mill process could affect coproduct (germ and pericarp fiber) yields and quality (residual starch contents). The E-Mill process was modified with phytase incubation step prior to incubation with starch hydrolyzing enzymes. Slurry specific gravities prior to fermentation were measured with and without phytase incubation. Germ and pericarp fiber yields were compared for processes with and without phytase treatment. Germ oil, protein and residual starch contents were determined. Pericarp fiber was analyzed for residual starch content. Slurry specific gravities with and without phytase addition were 1.076 sp. gr. (10.2 ± 0.53 °Baume) and 1.067 sp. gr. (9.13 ± 0.64 °Baume), respectively. Phytase treatments had no effect on coproduct yields. Germ oil contents were higher (40.9%) than without (39.1%) phytase incubation. Phytase treatment resulted in germ with higher protein content (20.0%) compared to germ with no phytase addition (19.2%). Phytase treatment resulted in lower residual starch contents in germ and pericarp fiber (12.2 and 19.9%, respectively) compared to germ and pericarp fiber without phytase addition (18.1 and 27.4%, respectively).

Effects of ice structuring proteins on the freeze-thaw stability of corn and wheat starch gels

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The texture of SG are physically damaged, form a sponge-like structure, by repeated freezing and frozen storage due to a formation of ice crystals and growth of ice crystals. ISP, protect living organisms from damage by ice crystal formation and growth in an extremely low temperature environment, bind to the ice surface and reduce the ice crystal growth (ICG). The aim of this study was to determine the effect of ISP (ISP, 0.5%, starch weight basis) on freeze-thaw stability of corn and wheat starch gels. The syneresis of both SG, hardness, thermal properties using differential scanning calorimetry (DSC), and their microstructures (MS) by a scanning electron microscopy (SEM) were determined with both SG subjected up to 9 freeze-thaw cycles (FTC). The gelatinized SG were stored at –20°C for 22 hr and thawed at 30°C for 2 hr. As the number of FTC increased, the syneresis increased; however, ISP significantly ($P < 0.05$) reduced the syneresis for all FTC except at the 1st FTC. The hardness of both SG increased up to the 4th FTC and then decreased; ISP significantly lowered their hardness. The ice melting enthalpy (ΔHice sample) of SG increased with an increase in FTC; ISP significantly lowered their enthalpy values. The retrogradation ratio (RR) from a DSC significantly increased with an increasing FTC; ISP reduced RR but most of RR was not significantly different at the same FTC. The MS from SEM showed that the addition of ISP reduced the size of ice cell cavities.

The effect of mixing conditions on the behaviour of refrigerated wheat dough

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Cereal Foods World 55:A26

In spite of the growing importance of refrigerated dough (dough that is stored at 4–8°C for up to 8 weeks before baking), the published literature on its properties and behaviour during refrigerated storage, such as release of liquid (usually called "syruping") is still relatively scarce. In the present work, we wanted to address how some of the mixing conditions (specifically, energy input during mixing and hydration level) affect two aspects of dough performance: specific volume after baking and degree of syruping during chilled storage. In addition, during storage we analyzed: a) the evolution of protein fractions and its eventual link to specific volume after baking, and b) the evolution of arabinoxylans and damaged starch and their link to syruping. Two different flours were used for the tests: soft wheat bread flour and heat-treated wheat flour. The results show that mixing conditions considered "ideal" for standard dough may need to be modified when producing refrigerated dough, since they may lead to increased syruping and reduced specific volume. The link between protein fraction evolution and baking performance seems to be more complex: no direct link was seen between the unextractable protein fraction and specific volume, which was however positively correlated with the soluble protein fraction. On the other hand, it was confirmed that arabinoxylan degradation and to a certain extent, hydrolysis of damaged starch during storage are linked to the degree of syruping, while this undesirable behaviour is less apparent in a heat-treated flour.

Protein composition of rye dough as affected by the addition of transglutaminase

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Cereal Foods World 55:A26

Since protein aggregation and the formation of a continuous protein matrix in rye dough is very limited, increasing the number of crosslinks within rye proteins might have an impact on the breadmaking performance of rye flour. The number of crosslinks could be increased by using transglutaminase (TG), an enzyme catalyzing the formation of isopeptide bonds between glutamine and lysine side chains of proteins. The aim of the present study was, therefore, to improve the breadmaking performance of rye dough by adding TG and to analyze the protein modifications associated with the enzyme treatment. Rye dough with added TG (0 – 2500 U/kg of flour) was analyzed for its quantitative protein composition by means of a combined extraction/HPLC procedure. The content of glutelin macropolymer (GMP) was quantified by dissolving the SDS-insoluble protein residue under reducing conditions and HPLC analysis of dissolved proteins. The addition of TG during rye dough preparation led to a strong decrease of extractable protein from 70 mg/kg in the control dough to 23 mg/kg in the dough with the highest TG level. Furthermore, the distribution of the protein fractions changed from 35/51/14% (albumins-globulins/prolamins/glutelins) to 43/27/30%, indicating that mainly prolamins were subject to crosslinking by TG. This shift in protein composition was also reflected by the prolamin/glutelin ratio, which decreased from 3.7/1 (control) to 1/1 (2500 U/kg) and corresponded to improved technological properties. TG also strongly affected the GMP content, which increased by a factor of 4 after addition of 2000 U TG/kg flour, indicating strong crosslinking of proteins. The degree of crosslinking was so high that a considerable part of the protein (ca. 67%) was completely insoluble even after reduction of disulfide bonds. In conclusion, TG is suited to crosslink rye proteins and to improve the technological properties of rye dough.

Development of a standardized, batter-based, pancake-making method

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Cake and pancake are major batter-based products made with soft wheat flour. A standardized baking method for high-ratio cake has been widely used for evaluating the cake-baking performance of soft wheat flour. While chlorinated flour is used to make high-ratio cake, and the cake formula contains relatively high levels of sugar and fat, a pancake-baking method has not yet been explored much or implemented as an AACCI Official Method, due to several issues, such as the absence of standard analytical criteria for pancake-making evaluation, a wide range of potential formulas and mixing procedures, and a wide range of consumer preferences in eating quality. In a preliminary investigation, the effects of leavening acids and type of fat have been explored, in an effort to identify preferred ingredients and a formula. Flow distance for batter viscosity, pancake diameter and height, and pancake texture were measured. Validation of these preliminary results was performed using various sample flours, leading to the following conclusions. As a diagnostic formula to distinguish differences in flour performance for pancake baking, soda (2.25 g), MCP (0.38 g), and SAPP 28 (2.7 g) were selected as the leavening system. Pancake-making performance using liquid canola oil was very similar to that using solid shortening, with a minor adjustment in water level. Pancake-making performance for two samples (A and B) of unchlorinated flour or their blends could be predicted from flour SRC values. When the SRC values in all four solvents were lower for flour A than for flour B, the flow distance of the batter and the diameter of the pancake were both greater for flour A, but the pancake height was smaller. Chlorinated flours showed a different trend in pancake geometry. With increasing extent of flour chlorination, both pancake diameter and height decreased. Excessively chlorinated flour (pH 4) produced an even greater decrease in pancake height.

The relationship between RP and SE-HPLC peaks and some quality characteristics in a double haploid wheat population varying in LMW glutenin subunits

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Twenty five doubled haploid lines from a good quality hard red wheat cultivar Kariega and a standard white Australian spring wheat Avocet were selected based on their variability for low molecular weight glutenin subunits. A randomized complete block design trial with two replications was planted in the field and the greenhouse in 2006 and both trials were repeated in 2007. Reversed phase high performance liquid chromatography (RP-HPLC) and size exclusion (SE)-HPLC was done on all samples. Mixograph development time, SDS sedimentation, grain protein content, single kernel characteristics, and starch and amylose content were measured. Single gliadin peaks correlated highly significantly with especially kernel characteristics. Some gliadin peaks also significantly correlated with grain protein content. Gliadin peaks correlated significantly with either small monomeric or small polymeric protein fractions of the SE-HPLC, indicating that some of the gliadins are probably low molecular weight glutenin proteins. Some RP-HPLC glutenin peaks were highly significantly correlated with especially kernel characteristics, but also with grain protein content. Most RP-HPLC glutenin peaks were highly significantly related to the large polymeric proteins of the SE-HPLC, as well as the large unextractable polymeric proteins. Some of the gliadin and especially the glutenin peaks were more than 90% correlated, indicating that they are probably linked pairs. The environment influenced the expression in RP-HPLC peaks, as the profiles for the greenhouse and the field differed to some extent.

Heat-induced gluten polymerization and its application in biotechnological processes

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The unique properties of the wheat grain primarily reside in the gluten-forming storage proteins of its endosperm. Their low-water solubility, cross-linking capacities and viscoelastic properties have led to an expanding diversity of food product applications. However, its structural and functional properties are also very interesting features for non-food applications. In the processing and setting of gluten containing products, temperature plays a very important role. This presentation discusses the reactivity of gluten proteins and highlights the importance of sulfhydryl (SH) and disulfide (SS) groups. Upon thermosetting, wheat gluten aggregation proceeds through direct covalent cross-linking within and between its glutenin and gliadin protein subgroups. A model explaining further gluten polymerization through SH oxidation and SH-SS interchange, and demonstrating the effects of redox agents is put forward. This model is instrumental for understanding gluten behavior in food systems, such as bread. Furthermore, thermal treatment of gluten can result in the formation of other than SS covalent bonds. As such, alkaline conditions, and/or high temperatures lead to protein cross-linking not involving SS bonds. The types, formation and relevance of these non-SS cross-links, which are only briefly mentioned in literature, will be discussed here in more detail.

Effects of corn preparation method on ethanol yield and solids partitioning in dry-grind corn ethanol production using raw starch hydrolysis

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The effects of corn preparation- hammermill grinding of corn with different size screens, and rollermill flaking at different roller gaps- on dry-grind ethanol production using raw starch conversion was evaluated. The partitioning into thin stillage of residual solids in beer after fermentation and particle size distribution of partitioned solids were compared for both of the preparations. The average d(0.5) values for ground corn decreased as hammermill screen opening size decreased from 2.36 mm to 0.68 mm, the largest being 340 µm for 2.36 mm screen. The particle size distribution for ground corn was bimodal. More starch damage occurred with smaller screen sizes (1.6% for 2.36 mm screen compared to 2.9% for 0.68 mm screen). Visual evaluation of damaged starch with light microscopy also indicated that ground corn with larger screen openings exhibited more Maltese crosses (indicating more intact granules, thus less starch damage) than ground corn with smaller screen openings. Screen opening size did not appreciably affect starch digestibility at any time of incubation, but starch digestibility was less than 85% even after 72 h of incubation. The final ethanol concentration in fermentation broth for ground corn at 15% moisture was lower (19% v/v) than for ground corn at 22% moisture (20% v/v). The partitioning of solids in fermentation broth after distillation showed variation for ground and flaked corn preparations. About half the dry matter in the broth of ground corn partitioned into thin stillage, compared to 36% for flaked preparations. The particle size distribution of the partitioned solids in thin stillage was affected by rollermill faking, in that, dispersed particles were smaller compared to particles in thin stillage of ground corn. Rollermill faking is a promising treatment to increase the efficiency of dry-grind corn ethanol production.

Whole grain or high fiber: Which message is most effective with young adults?

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Cereal Foods World 55:A27

U.S. nutrition surveys have found that young adult do not consume recommended amounts of whole grains and dietary fiber. This pilot study examined the relative importance of whole grain and high fiber messages for 18 to 24 year olds in the Bangor, ME area. Participants (N = 116) were presented with 5 commercial bread samples – white; whole grain white (WGW) labeled "whole grain;" 100% whole wheat (WW) labeled "whole grain;" and double fiber 100% whole wheat presented labeled "whole grain" (DFWG) and again as "high fiber" (DFHF). Samples were rated on a 9-point hedonic scale for appearance, flavor, texture, and overall appeal and on a 7-point scale for perceived healthiness and purchase intent. Participants then completed a demographic and health questionnaire and the sampling and rating procedure was repeated for five pasta salad samples. Pasta samples included regular, fiber-enriched labeled "high fiber" (FE) multigrain labeled "whole grain" (MG) and whole wheat presented once labeled "whole grain" (WWWG) and once as "high fiber" (WWHF). All samples were served in a randomized order and coded with 3 digits. DFWG, DFHF and WW were all liked more ($P < 0.05$) than white bread for appearance, texture, flavor, and overall appeal. DFWG, DFHF and WW were all liked more than white or WW for appearance, texture, and overall appeal. Darker WG breads were rated as more healthy and more likely to be purchased than either light-colored bread. White pasta, WWWG, and FE were liked more than was WWHF for texture and flavor. White pasta and MG were preferred over WWHF overall. Darker WG pastas were rated as more healthy but the sample labeled as high-fiber had a lower purchase intent score. Whole grain messages may be more appealing to young adults than are high fiber messages, but more research is needed to evaluate these labeling messages in young adults in other geographic areas.

Recovery of zein from distillers dried grains obtained from a raw starch fermentation bio-ethanol process

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Cereal Foods World 55:A27

We have investigated the extraction of zein from distillers dried grain (DDG). The yield of recovered zein was improved when sodium hydroxide was added to 70% aqueous ethanol during the extraction. Zein yields improved from 40% of the total zein in DDG to 80% by adding sodium hydroxide during extraction. It is hypothesized that the protein bodies in corn survive the bio-ethanol manufacturing process and remain intact in the DDG. The sodium hydroxide is needed to break down the highly cross-linked β and γ-zein on the periphery of the protein body. Zein extracted from DDG using only 70% aqueous ethanol and then analyzed by RP-HPLC was shown to contain only α-zein. Zein extracted from DDG with 70% aqueous ethanol containing sodium hydroxide and analyzed by RP-HPLC was shown to contain β and γ-zein along with α-zein. Zein extracted using 70% aqueous ethanol containing sodium hydroxide contained on average about 20% β and γ-zein. The added sodium hydroxide also increased α-zein yield by 30%. To further test the hypothesis that the zein remains intact during fermentation, DDG was steeped in 1% aqueous sodium metabisulfite for four days prior to extraction. The steeped DDG was extracted with 70% aqueous ethanol that contains no sodium hydroxide. RP-HPLC analysis of zein recovered from the steeped DDG showed it to be similar to the results of the RP-HPLC chromatograph obtained from zein extracted from corn gluten meal using only 70% aqueous ethanol. SDS-PAGE analysis of the zein obtained from sodium metabisulfite steeped DDG showed it to contain α-zein and β-zein, but only minor amounts of γ-zein. Analysis of the aqueous sodium metabisulfite steep liquor revealed it to contain γ-zein. Corn protein bodies survive the ethanol bio-refining process; because of this it is necessary to include a reducing agent in aqueous ethanol to maximize zein recovery.

Characterization of food-grade tracers for the global grain tracing and recall system

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Cereal Foods World 55:A28

Tracing grain from the farm to its final processing destination as it moves through multiple grain handling systems, storage bins and bulk carriers presents numerous challenges to existing recordkeeping systems. This study examines the suitability of coded tracers to trace grain; in particular, to evaluate methodology to test tracers' ability to withstand the rigors of a commercial grain handling and storage systems as defined by physical properties using measurement technology commonly applied to assess grain hardness and end-use properties. Three types of tracers were developed using three food-grade substances (processed sugar, pregelatinized starch, and silicified microcrystalline cellulose (SMCC)) as a major component in formulations. Due to a different functionality of formulations, the manufacturing process conditions varied with each type of tracers, resulting in the unique surface roughness and variations in weight, dimension, and physical and spectroscopic property of tracers before and after coating. The applied two types of coating (pregelatinized-starch and hydroxypropylmethylcellulose (HPMC) coating) using an aqueous coating system containing appropriate plasticizers showed uniform coverage and clear coating. Coating appeared to act as a barrier against moisture penetration, protect mechanical damage of the tracer surface, and improve the mechanical strength of tracers. The results of analysis of variance (ANOVA) tests showed the type of tracer, coating material, conditioning time, and a theoretical weight gain significantly influenced the morphological and physical properties of tracers. Optimized combination of these factors for a specific purpose needs to be pursued to produce desirable tracers with consistent superior quality and performance when they flow with bulk grains throughout the grain marketing channels.

Measurement of fat soluble vitamins in foods, feeds, and ingredients: Progress and problems

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Cereal Foods World 55:A28

Edith Christensen Award

Measurement of fat soluble vitamins in foods and feeds represents a continuing challenge to testing laboratories. Test methods have improved steadily since AACC Method 86-05.01 for vitamin A and carotenes received final approval in 1968. During the next 40 years, advances were made that improved the scope, sensitivity, specificity, and reliability of fat soluble vitamin methods. Challenges remain however, and even the best methods conducted by experienced analysts can, inexplicably at times, result in erroneous test results. Problems encountered during testing of common samples include higher than expected variability, low recovery, and disagreement between independent laboratories. Approved methods and currently accepted approaches to measurement of fat soluble vitamins will be reviewed, including vitamins A, D, E, K, and carotenes. The status of current methods, limitations of accepted procedures, and likely sources of error will be reviewed. Selected trends in HPLC and LCMSMS methods for measurement of fat soluble vitamins will also be briefly examined.

Literature review project on pulse processing, ingredients, functionality: Finding the pulse in your food product formulation

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Cereal Foods World 55:A28

Pulses have often been used in research as a novel ingredient to improve the nutritional quality of food products. Functional properties are often documented during these developmental studies. However to date there has not been a stand-alone document to compare the results of these studies. In order to bring existing information into one place and to understand the gaps in knowledge, Agriculture and Agri-Food Canada (AAFC) has sponsored a comprehensive literature review of recent research on the uses of pulse crops in food research applications. Functional properties of the ingredients will be discussed with respect to pulse type, pre-treatment of the seed, processing and analysis method. Six functional properties of pulse flours were researched including water absorption capacity (WAC), oil absorption capacity (OAC), bulk density (BD), least gelation concentration (LGC), foaming capacity (FC) and emulsification capacity (EC). WAC, OAC and LGC each exhibited a wide range in values for different pulse types when subjected to different pre-milling treatments, milling methods and analysis methods. For WAC green gram flours ranged from 1.23–1.86 g water/g flour while the respective ranges for cowpea, chickpea, lentil and pea WAC were 0.73–7.74, 0.70–3.75, 0.97–3.36 and 0.78–4.04 g water/g flour. OAC demonstrated similar variations. The respective variations of green gram, cowpea, lentil, chickpea and pea flours for OAC were 0.90–2.93, 0.41–4.10, 0.86–4.82, 0.78–2.61 and 0.41–2.49 g oil/g flour. The LGC of black gram, cowpea and bean ranged anywhere from 8–12% while pigeon pea demonstrated the greatest range in LGC of 4–14%. LGC of pea ranged from 8–14% and chickpea from 10–14%. The effect of the variation of functional properties with respect to product development will also be discussed. For more information on the full document please visit pulsecanada.com.

Breakfast cereal nutrition renovation

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During the past 10 years there has been an increased focus on the nutritional composition of food products. This has led to product renovation across a number of key food categories, including breakfast cereals. The nutritional profiles of breakfast cereals have been modified by decreasing public health sensitive nutrients (such as sodium and sugar) and increasing positive nutrients and food components such as whole grain, while managing consumer expectations for great tasting products. Whilst a number of dietary surveys have found that breakfast cereals are not a major contributor of sodium or sugar in the diet, these renovations have been undertaken to help consumers reduce the total sodium and sugar intakes in their diets. More recently, global regulatory proposals to control nutrition and health claims have become additional drivers to further renovate products. Breakfast cereals are nutrient dense foods, providing a significant contribution of important vitamins, minerals, whole grains and fibre relative to the amount of energy that they provide. They remain a key part of a healthy, balanced diet.

Glycemic impact as a cereal food property

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Cereal Foods World 55:A28

A major challenge has been communicating blood glucose-raising potential of cereal foods as grams per serving, or as reference amounts customarily consumed per eating occasion (RACC). Analysis of the glycemic impact of RACC's in vitro requires that allowance is made for the homeostatic response to differing amounts of glycemic carbohydrate consumed in RACCs of different foods. Blood glucose responses to six foods, each fed three times at three intakes to twenty volunteers, were analysed to obtain equations for the dependence of rate of blood glucose clearance on the glycemic glucose equivalent dose consumed. The equations were used to obtain an accurate prediction of the relative glycemic response to foods from in vitro measurements of carbohydrate digestion using an available carbohydrate method that mimicked the glycemic response. Using the glucose disposal equation: blood glucose clearance rate (GGE/min) = 0.0135 GGE + 0.023, (R^2 = 0.93), the following in vitro predictions of clinical (in vivo) response, expressed as glycemic glucose equivalents, was obtained: In vivoGGE (y) = In vitroGGE (x)-0.5; R^2 = 0.90. A Bland-Altman methods comparison showed an almost perfect correspondence between the two methods (In vivo GGE = -0.055 in vitro GGE + 1.16, R^2 = .027). Glycemic impact was thus measured as a food property independent of the physiological fluctuations that lead to high variability in blood glucose responses. Treating glycemic impact as a food property, and measuring it in vitro by a modified available carbohydrate determination would provide the cereal food industry with a precise, valid and economical alternative to the costly and imprecise clinical measurements presently used to guide consumers and product developers. The advantages of using glycemic impact as a property of cereal foods will be discussed.

Environmental effects during crop growth on properties of wheat grain starch

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The structure and functional properties of native starch vary between and within plant species. This variability results from diversity in the genes that encode starch biosynthetic enzymes and environmental factors that act on the genes and enzymes concerned during plant growth. To increase our understanding of environmental factors that influence starch variability, grain

was obtained from five commercial wheat varieties that were grown under a controlled national variety trial in four different climatic regions of Australia. Data from analyses of the grain and starch, and crop growth data (soil nitrogen and organic carbon, rainfall, temperature, number of clear days), were subjected to statistical analyses to seek correlations between quality parameters and environmental factors, and to determine the extent to which grain and starch properties were influenced by genotype and environment. Total starch content of the grains was positively correlated with rainfall, maximum temperature and soil organic carbon, and negatively correlated with length of growing period and soil nitrogen. Significant differences were observed in flour swelling power, total starch content, amylose content and DSC thermal properties when the same wheat variety was grown in different locations. The proportion of B type starch granules, amylose content, DSC peak temperature, and starch swelling power were influenced mainly by genotype, whereas starch content and starch gelatinization enthalpy were influenced strongly by environmental factors. Flour swelling power was affected by both genotype and environment.

Modeling of Mixolab profiles by nonlinear curve fitting and prediction of breadmaking parameters

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Cereal Foods World 55:A29

Prediction of breadmaking parameters is a crucial step in wheat quality evaluation for breeders and end-users. This research was performed to investigate the association of flour breadmaking parameters with mixing characteristics and the rheological property of dough subjected to thermal constraint. Individual flour from 30 hard spring wheat was analyzed by a Mixolab standard procedure. The Mixolab profile was divided into six different stages, and torque measurements of individual stages were modeled by nonlinear curve fitting using multidimensional unconstrained nonlinear minimization. Specifically, mixing patterns were fitted to exponential equations and dough rheological patterns were described by Sigmoid logistic equations as functions of time. The new parameters calculated from fitted equations presented significant associations with breadmaking parameters. In particular, bread loaf volume (LV) had a significant correlation ($r = -0.77$, $P < 0.001$) with a model parameter which was related to rate of torque decrease during heating due to protein weakening. This parameter also had a significant partial correlation with LV when effect of flour protein content was removed, indicating that it can supplement protein content to predict LV. Torque measurements between 6.5 to 16.0 min also had significant and positive correlations with LV. Multivariate continuum regression was employed to develop prediction models of breadmaking characteristics using Mixolab parameters. The calculated prediction models explained over 95% variations in bake water absorption, mix time and LV. Taken together, these results indicate that Mixolab is effective for evaluation of flour breadmaking parameters. The new parameters generated from equations fitted to Mixolab torque profiles appear to have great potential to aid in the evaluation of flour breadmaking quality.

Impact of processing aids on the Net Cost of Goods Sold for various extruded products with consideration towards regulatory and sustainability issues

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Cereal Foods World 55:A29

The study contains two parts. Firstly, the Net impact on ingredient and processing costs when using a processing aid; and secondly, identifying profit opportunities from addressing health / nutrition and sustainability issues. Several commercial, university and industry studies were analyzed to answer the question, how and when can increased ingredient costs actually lower the finished cost of extruded products? Data was analyzed across various extruded cereals, snacks, pastas and bakery inclusions. Economic data analyzed included ingredient costs (grain, starches and processing aids) and processing costs (facilities, labor, utilities, off specification product and output per hour). It was determined that certain processing aids can reduce the Net Cost of Goods Sold by 5–10% in certain extrusion systems. Processing aids compared in this study included a control (no processing aid), mono & diglycerides and rice extract. Additional analysis and assumptions were made on the added value of "clean labels" and market expansion opportunities (domestic and exports). In conclusion, data showed that profits can be increased by the use of processing aids, even though they raise ingredient costs. Additional profit opportunities exist by embracing current health / nutrition and sustainability issues.

The basis for compressibility of bread

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A primary indicator of bread quality is firmness which is determined by the consumer through squeezing the loaf between their fingers and their thumb. Despite the fact that the consumer perceives this bulk firmness to be important, standard objective tests of bread firmness rely on the compression of small regions of a slice. It has been recognised that the spatial distribution of firmness varies across the bread slice. This study aims to understand how structure, density and moisture relate to local firmness of the bread slice and furthermore how this relates to the bulk compression of bread. Transmitted light images of bread have been captured. The relationship between optical density and bread density has been established and follows the Beer-Lambert law for a particular bread type. This calibration has been used to map density across the image of the bread slice. Subsequently images were recorded during the deformation of the whole bread slice in a customised rig built for a texture profile analyser. The slice has been compressed in the same orientation as that carried out by the consumer "squeeze" test. The comparison of the cell structure between successive slices has revealed the vector of compression throughout the slice. The compression of structure has been calibrated against firmness tests based on spatially distinct regions. A near infrared calibration for bread moisture content has been determined and used to map the moisture content in the bread slice by hyperspectral imaging. Finally, C-Cell has been used to measure cell structure. The results will be presented showing how the relationships between structure, density and moisture contribute to local firmness and ultimately bulk firmness.

Improved shelf life and bread quality by use of new anti-staling enzymes

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Cereal Foods World 55:A29

Anti-staling enzymes are widely used in bread baking in order to prolong the shelf-life and improve the bread properties. The changes that occur during aging of bread are often attributed to two processes: starch retrogradation and loss of moisture. The important parameters that change during storage of bread are loss of crumb softness, elasticity and moistness, which are all parameters linked to the consumer's perception of the bread quality. Often initial evaluations of anti-staling enzymes are focusing on the effect on crumb softness and elasticity measured by textural methods, and the attention on sensory evaluation and consumer perception is lacking. This presentation demonstrates the effect of a new maltotetraose releasing exo amylase (G4-amylase) in different types of bakery applications. Baking trials followed by texture profile analysis are evaluated with regards to bread softness and resiliency of the crumb structure. In addition sensory evaluations (including key descriptors of bread) and NMR measurements are conducted. Correlation between the data are evaluated within this study and presented. The NMR method monitors the changes in water properties occurring during storage, which can be linked to moistness perception. Improved moistness perception and softness is demonstrated in both white and whole wheat bread.

Response of wheat plant to stress as expressed by antioxidant levels of whole grains

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Cereal Foods World 55:A29

Producers of whole wheat are interested in using high antioxidant wheat in their products and marketing the recognized nutritional benefits, but need assurance that they can access wheat with consistent, significant antioxidant levels. In order to produce wheat with known amounts of antioxidants, the factors and mechanisms involved in their expression by plants must be understood. The purpose of this comprehensive study is to determine the effect of specific stress factors on plant expression of phenolics as a defensive response to stress. The biotic and abiotic factors studied in this research are insect damage, fungi infestation, heat, soil acidity, and drought. Plants of wheat (var. Karl 92) will be exposed to the following treatments: long term post-anthesis high temperature stress, plant damage by aphids, and leaf rust infestation. Another set of Karl 92 plants will be exposed to acid soil growing conditions, and drought stress. Samples of grain will be collected for analysis. The following tests will be performed for determination of phenolic content and antioxidant potential: total phenolic content on grain, DPPH Radical Scavenging Capacity Assay, and polyphenolic-oxidase activity. Preliminary results on the effect of fungi infestation of wheat on antioxidant activity provided evidence to support the aforementioned hypothesis. That study was designed to determine the effect of fungicide application time on fungal

infestation. Several samples were analyzed to determine whether the level of fungal activity corresponded with antioxidant activity. The antioxidant content of 5 out of 7 wheat variety pairs showed strong positive relationship with the degree of fungal damage. The results of the current study will allow comparing the defense response of wheat plants to the individual stress treatments. The antioxidant levels will be reported and its significance discussed in the future.

Effect of alkali dipping prior to baking on the levels of dehydroalanine, lanthionine and lysinoalanine in hard pretzels

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Cereal Foods World 55:A30

Pretzel production includes alkali dipping prior to baking to gelatinize the starch at the surface and to result in the desired smooth surface of the final product. Hard pretzels are typically dipped in 1.0% NaOH at a temperature of about 90°C for 10 to 60 s. Chemical changes during this treatment also result in the unique taste, and color of the end product. However, alkali treatment may also result in protein degradation and affect nutritional quality. Model system studies recently showed that beta-elimination reaction of cystine occurs when gluten proteins are heated at alkaline pH. As a follow up to that study, the objective of the present work was to investigate whether an alkaline treatment typical for that during pretzel production, would also affect the gluten at the surface of the product. Gluten/water dough and pretzel dough were dipped in NaOH solution [0.5, 1.0, or 1.5% (w/v)] for different times (30, 45, and 60 s) and at different temperatures (50, 65, 80, and 95°C), and subsequently baked. Protein extractability and levels of intermediate and end products of beta-elimination reactions of cystine were determined in the dough before and after the alkali dip, and after baking. Protein extractabilities decreased during pretzel production, even after reduction of disulfide bonds, which indicated that some non-disulfide cross-links were formed. Further investigation showed that beta-elimination from cystine resulted in the formation of dehydroalanine, which reacted with cysteine and lysine to lanthionine and lysinoalanine, respectively. It was concluded that the concentration and temperature of the lye solution and the dipping time impact protein cross-linking and beta-elimination reactions during laboratory scale pretzel production.

Development of a gluten-free sorghum based master baking mix

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Cereal Foods World 55:A30

The objectives of this study were to develop a sorghum-based gluten-free master mix for the gluten intolerant population (Celiac sufferers) and their families, and to promote sorghum's application not only for the booming gluten-free food market but also for overall human food consumption in the western world. The baked product model initially chosen was a baking-powder biscuit. Xanthan gum and guar gum were added at a 1:1 ratio at a total 2% (baker's %) to increase the batter viscosity in order to hold air bubbles and increase the specific volume. Dextrose and fructose were added at a 3:1 ratio at a total 20% to enhance the crust color and the overall flavor and crumb firmness. Monoglycerides were added at 1% to give the biscuit batter a uniform mixing behavior and a biscuit with a finer crumb texture. Tapioca, potato, and corn starches were tested at 10%, 20%, 30%, and 40% levels in this master mix. Tapioca starch at the 20% level gave the best crumb texture. Whey protein and egg white powder were tested at the 5% and 10% levels, not only for texture improvement but also for their nutritional value. The best formula contained 10% egg white, 20% tapioca starch, and 70% sorghum flour. Nine products were developed, based on this sorghum master mix: pumpkin bread, banana bread, layer cake, cup cakes, cookies, waffles, pancakes, pie crust, and muffins. Sensory tests indicated that pumpkin bread, cup cakes, and pancakes received the highest acceptance level. The overall acceptance scores for foods made from the sorghum master mix ranged between 5.7 and 7.4 on a 1–9 scale. The various ages, and gender, educational level, and purchase preference groups did not show significant differences.

A novel lecithin organogel technology suitable for use in food products

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Cereal Foods World 55:A30

Liquid crystalline structures are generally well ordered structures that can hold a large number of active ingredients, yet restrict the diffusion of the active ingredients to facilitate a controlled release of the active ingredients. Organogels OGs can be used to carry/deliver both water- and oil-soluble actives or essential oils. The lecithin OGs (LOGs) discussed are composed of 3 main phases - an organogelator, an organic phase and a polar phase. Traditional technology required the use of extremely pure phosphatidylcholine as the organogelator and block co-polymer in the polar phase. The technology to be discussed in the presentation is novel (patent-pending) in that the organogelator is refined, but crude commercial lecithin, the organic phase is TAG or DAG oils with a suitable food-grade emulsifier and the polar-phase contains xanthan gum. By changing the polarity of the organic or aqueous phases the gel can be made to be cubic, lamellar or a mix. Rheology measurements were performed and the G", loss modulus, was always higher than G', storage modulus, indicating more viscous behavior of the gel over the entire frequency range studied. Polarized light microscopy (PLM) was used to determine structure and confirmed by Small Angle X-ray Scattering (SAXS). The LOG was used to structure liquid soy oil (5–10% of oil) for use in a number of baking applications reducing saturated fat by 30% or more. Results against popular emulsifier blends and monoglyceride hydrate demonstrated 1–2% increased cake volumes at a 6x reduced usage. The LOG was also used to structure high oleic-sun oil (5% rate) for use as a topical application for chips and crackers. The structured oil carried both polar and non-polar antioxidants resulting in longer shelf life and producing a less greasy product. Additional application work will be discussed.

Cadmium in wheat - A new challenge?

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Cereal Foods World 55:A30

Cadmium (Cd) is a heavy metal found as an environmental contaminant both, through natural occurrence and from industrial and agricultural sources. Regulation (EC) 1881/2006 sets maximum levels for Cd in foodstuffs. Last year the European Food Safety Authority (EFSA) published an updated scientific basis on the health based guidance for the tolerable weekly intake of Cd and a new risk assessment on Cd in food. The EFSA study came to the conclusion that the current exposure to Cd at the population level should be reduced. It is not yet known which way Europe will turn to reduce the exposure to Cd at the population level. Considering this background the interest in Cd in cereals awoke again, because cereals and cereal products make a large contribution to the dietary intake of Cd. In the presentation the following aspects will be highlighted: (i) information, which help to follow the discussion in Europe; (ii) overview on the long-time monitoring of the Cd content in the German wheat harvest; (iii) the importance of farming region and wheat variety; (iv) the Cd distribution in the wheat kernel and (v) the Cd content of different kind of milling products. Against the background of the currently valid legal situation, the Cd load of German wheat can be regarded as unproblematic. Because of the high consumption of wheat, even the relatively low Cd content in wheat contributes to a high degree to the dietary uptake of Cd. Therefore the low Cd content found in wheat is presenting a challenge when looking for ways to reduce the Cd uptake.

Outer layers of rye, oat and wheat grains show differences in their *in vitro* fermentation quality in colon

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Cereal Foods World 55:A30

Conventional rye, wheat and oat bran samples as well as mechanically refined aleurone or cell wall concentrates of the bran samples were compared in their chemical composition, structure and *in vitro* fermentation quality. Detailed chemical and structural characterization and analysis of water absorption capability were performed before and after enzymatic in vitro digestion mimicking the upper intestine. Fermentation rate and colon metabolites (SCFA, phenolic acids) from an in vitro colon model were analysed by GC-MS or GCxGC-ToF-MS. On-line measurement for gas pressure was also performed. Besides the dietary fibre composition, microstructure, particle size distribution and water absorption capability of the samples were clearly different. Wheat bran contained most insoluble fibres; rye bran had highest content of water extractable arabinoxylan and fructan, and oat bran was highest in β-glucan. Refined bran fractions contained more water extractable fibre than the corresponding conventional bran samples. As expected based on the chemical and structural differences, also the *in vitro* fermentation rates of the samples were different. Highest fermentation rates and extents, measured as SCFA production and gas pressure, were achieved for refined rye bran, followed by conventional rye bran, whereas conventional wheat bran was the least fermentable among the bran samples. Acetate dominated the SCFA profiles. Highest production of propionate was in the presence of the oat samples, and again conventional wheat bran was the lowest in production. Then again, interestingly, refined wheat bran generated as high amounts of butyrate as conventional rye fractions in the *in vitro* model. The results show that the refined cereal fractions rich in outer layers of different grains have

very different fermentation patterns *in vitro*. This may open up possibilities to tailor the fermentation properties of cereal ingredients.

Effect of extrusion and *in vitro* digestion on microstructure and amylopectin chain length distribution of high amylose starch

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Cereal Foods World 55:A31

High amylose starches are of commercial and nutritional interest due to their relative resistance to amylase digestion. Processing is known to alter the granular, supramolecular and molecular structures of native high amylose maize starch as well as lower *in vitro* digestibility. The aims of the current study are to identify the structural changes in high amylose starch during processing and digestion in order to further understand the mechanism(s) leading to enzyme resistance. High amylose maize starch (Gelose 80) was extruded at three different moisture contents and digested with alpha-amylase/amyloglucosidase for various times. Raw, extruded starches and enzyme-digest residues were analysed for enzyme resistant starch yield; crystallinity and molecular order; thermal properties and amylopectin chain length distribution. All the extruded starches had >15% RS which is nutritionally useful but much lower than granular Gelose 80 (52%). Extrusion resulted in a significant reduction in crystallinity (WAXS), lamellar layering (SAXS) and molecular order (^{13}C NMR and FTIR), whereas the analysis of starch digesta showed the re-establishment of crystallinity and molecular order. SAXS data suggested new structures resistant to digestion were formed during the digestion process rather than being present in the original undigested material. Extrusion led to a significant reduction of long amylopectin branches (DP 36-70). With the progression of digestion, more medium length branches were hydrolysed leading to a significant increase in shorter branches (<DP 13) in enzyme-resistant material. The progress of enzyme digestion for extruded Gelose 80 is qualitatively different to that of the granular form, which shows no systematic change in branch length profiles or levels of molecular order in residual undigested material following amylolytic treatment.

Effect of extruder screw speed on physical and chemical characteristics and in vitro starch hydrolysis of pinto, navy, red and black bean extrudates

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Commercial precooked pinto, navy, red and black bean flours were extruded at different screw speeds (320, 380 and 440 rpm) using a twin screw extruder. Effect of speed on physical and chemical characteristics and in vitro starch hydrolysis was investigated. Data was analyzed using one way ANOVA ($P < 0.05$) in a completely randomized design on each type of bean with extrusion speed being the independent variable. Moisture retention decreased significantly in black beans at 440 rpm but was not significant in extrudates of navy, pinto and red beans. Water activity decreased significantly in extrudates made at 440 rpm for all beans, except navy. Expansion index decreased at higher speeds, with significant difference at 440 rpm for all beans. Color changes on hunter color scale were not significantly different for extrudates made from black, pinto and red beans, but navy bean extrudates had increased b value with increasing rpm. Texture hardness values decreased at higher speeds, except for navy bean which was not significantly affected. Significant reduction in hardness was observed for black and pinto bean extrudates extruded at 380 and 440 rpm. Hardness in red bean extrudates processed at 440 rpm was significantly lower than at other speeds. Water absorbance index and water solubility index were not significantly affected by screw speed. In addition, extrusion speed had no significant effect on resistant starch in extruded beans. Resistant starch in pre-cooked flour however, was significantly higher than extrudates of the four beans. Resistant starch ranged from 3.65–4.83% d.b. in extrudates, and 5.02–5.78% d.b. in pre-cooked bean flours. Details of these results will be presented, in addition to effect on glycemic index. Data obtained will provide useful information in selecting an appropriate extrusion speed to produce low glycemic index bean snacks.

Crystal structure, carbohydrate- and protein-protein interactions of barley limit dextrinase, limit dextrinase inhibitor and thioredoxin

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Barley limit dextrinase (HvLD) of glycoside hydrolase family 13 acts on α-1,6-linkages in limit dextrins and has a role in starch degradation and biosynthesis. HvLD crystal structures show interactions with the competitive inhibitors α- and β-cyclodextrin at subsites +1 and +2. HvLD has an N-terminal immunoglobulin-fold like domain, a carbohydrate binding module of family 48, a catalytic $(\beta/\alpha)_8$-like barrel lacking α-helix 5, and a C-terminal β-sandwich fold of unknown function. Glycerol and three water molecules mimic glucose at subsite –1 identifying residues involved in catalysis. A bulky Met^{440} is unique to HvLD among α-1,6 acting enzymes and obstructs subsite –4. This steric hindrance implies low HvLD activity toward amylopectin. Part of a loop (Asp^{513}–Asn^{520}) between β5 and β6 appears also affect substrate specificity and the higher affinity for α-cyclodextrin of HvLD compared to pullulanases. This first limit dextrinase structure provides new information about the substrate binding site, cation sites and the concerted action of starch degrading enzymes. The corresponding limit dextrinase inhibitor (HvLDI) was produced in *Pichia pastoris* and binds HvLD with subnanomolar affinity in a 1:1 complex as analysed using surface plasmon resonance. pH optimum, ionic strength dependence and van't Hoff thermodynamics of binding were examined. HvLDI is a CM-protein with four disulfide bonds and one cysteine forming a mixed disulfide with cysteine or glutathione. HvLDI is a target protein for thioredoxin and the possible regulatory role of the disulfide reduction on LD activity is discussed based on analysis of identified reduced HvLDI disulfide bonds and inhibitory activity. Supported by the Danish Natural Science Research Council, Danish Research Council for Technology and Production Sciences, Center for Advanced Food Studies, the Carlsberg Foundation, DTU PhD (MBVC) and Oticon Foundation MSc (JMJ) scholarships.

Improvement in the protein quality of sorghum-based foods through compositing with legumes and biofortification

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Cereal Foods World 55:A31

Sorghum is a major staple food in many developing countries, particularly in Africa. It is, however, very deficient in the indispensable amino acid lysine and on cooking has poor protein digestibility. Hence, sorghum is a poor protein source for human nutrition, especially child nutrition. This work investigated improving the protein quality of sorghum-based foods through compositing with legumes and the use of protein biofortified sorghum. For use as a complementary food, sorghum cookies were made with various levels of defatted soya flour. A 50:50 sorghum:soya ratio produced cookies with good textural properties, which had an eight-fold increase in Protein Digestibility Correct Amino Acid Score (PDCAAS). A range of traditional African porridge and flatbread foods were made with sorghums composited with cowpea at a 70:30 ratio. All the foods had good textural characteristics and their PDCAAS was improved 2-3 fold. Both cookies and traditional African sorghum-based foods were produced from 100% protein biofortified sorghum, developed using genetic engineering. The sorghum foods had similar textural quality to those from normal sorghum but had substantially increased lysine content and improved in vitro protein digestibility. Hence, protein biofortification of sorghum appears to be suitable way to improve the protein quality of sorghum-based foods.

Physical properties and microstructure of oat bran cereals processed to achieve a range of beta-glucan molecular weights

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The mixed linked (1-3)(1-4)-β-D-glucan (β-glucan) found in oats forms viscous solutions because it is at least partially water soluble and has high molecular weight. This viscosity is thought to be related to its ability to lower serum cholesterol levels in humans. A series of 4 extruded oat bran cereals were manufactured with a range of β-glucan molecular weights by modifying the extrusion conditions. The temperature and standard mechanical energy in the extruder were increased and the water injected into the extruder was decreased to induce depolymerization. The resulting increase in shear produced cereals with molecular weights ranging from 1,930,000 to 251,000. Increasing shear also intensified Maillard browning, producing a darker colour and lower sugar content. Increasing the pressure drop at the exit increased the expansion of the cereals, decreasing the hardness and density. An extraction protocol using physiological enzymes at 37°C was used to estimate the effect that the cereals would have on gut viscosity. The apparent viscosity in the physiological extract ranged from 2900 to 131 mPa.s (at $30s^{-1}$) for the different cereals. The solubility of the β-glucan increased with increasing extrusion temperature from 38.7% at 181°C to 100% at 237°C. The microstructure of the 4 cereals was examined. In the commercial type cereal,

large pieces of intact subaleurone were visible with swollen cell walls and intact cell contents. As the extrusion conditions became more harsh, the cell walls became disrupted and protein bodies were fragmented. Phenolic compounds and β-glucan appeared to leach out of the cell walls. The objective of creating 4 cereals with a range of molecular weights, while maintaining an acceptable product was accomplished.

Technical challenges with reducing the sodium content of bread

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Cereal Foods World 55:A32

According to the UK Food Standards Agency (FSA), eating too much salt is a significant risk factor in developing high blood pressure, triples the risk of heart disease and stroke, and contributes to > 170,000 deaths a year in England alone. Typical salt consumption for adults in 2009 in the UK is 8–9 g per day with a targeted average intake of 6 g. Salt reduction targets apply to 85 food categories that contribute most of the salt in our diet including everyday foods such as bread, pizza, cereal products, cakes and pastries. Although bread does not contain a particularly high level of salt compared to processed meats or cheeses, the role bread plays as an every day staple food means that it can contribute significant levels of salt to the diet. The FSA has an objective to reduce added salt in food to the lowest practicable levels and specifically an average salt level in bread of 1 g/100 g by 2012. Reducing salt levels in bread is challenging because of the many roles salt plays in bread making. Salt helps to control the rate of fermentation in dough and also affects the handling properties of the dough during mixing, moulding and proving. Salt level can also affect the eating quality of the bread through an impact on loaf volume and crust and crumb structure. Finally, salt content can have an impact on flavour. Work at Campden BRI, supported by the FSA and the UK Federation of Bakers, has shown that low salt level can have a big impact on the handling of dough pieces, especially under hot conditions where the dough can stick in the moulders. The reasons for this are complex. This paper will present ongoing empirical work carried out to optimise dough handling.

New mechanistic insights in the shear-induced separation of wheat flour

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Cereal Foods World 55:A32

Wheat flour separation into its constituents is an important industrial process. Recently, we have introduced a newly developed separation principle for wheat flour into the main constituents starch and gluten. The separation process is driven by the differences in rheological properties between these constituents: gluten has viscoelastic properties, while starch shows a dilatant behaviour at the moisture levels used in this process. Separation follows a two-step mechanism: first gluten forms local aggregates, second, those aggregates will migrate and cluster to a cohesive mass in the apex of the cone. In the separation process, wheat flour is exposed to well-defined shear in an in-house developed lab scale shearing device, which is based on cone-cone geometry. Main features of the new process compared to the traditional dough separation processes (e.g. Martin processes) are the relatively dry processing conditions and the simple shear deformation. The latter allows potential advantages being reduction of water and energy consumption, and improved product characteristics. The aggregation and migration steps have opposite optimal process conditions. Gluten aggregation (step 1) benefits from an increased temperature, low rotation rate and high water content, while the migration (step 2) is positively influenced by an increased rotation rate and higher dough viscosity. Special focus was on the role of NaCl during separation. Increased NaCl amount enhanced separation. Fortunately, separation of dough with decreased NaCl concentration is possible, but makes the dough less process tolerant, which narrows the process window that can be used. The molecular compositions of the gluten-enriched and gluten-depleted fractions are compared with commercial available gluten protein using SE-HPLC and SDS PAGE.

A novel method for the production of gluten-free products using whey proteins

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After a few decades of intensive research on gluten free bread, people obtained gluten free bread with acceptable properties. The formulation of current gluten free breads was obtained by trial and error, using a mixture of various ingredients. In this presentation we show that it is possible to obtain a gas holding bread by adding only two ingredients, namely whey proteins and locust bean gum. Key characteristic of the whey protein – locust bean gum mixture is the fact that the whey proteins are structured into a colloidal scale particle suspension. This particle suspension is obtained through phase separation and cold gelation. Phase separation is induced by addition of locust bean gum. Gelation is induced by the addition of glucono-delta-lacton, which gradually decreases the pH. In this way, a protein particle system was obtained, in which a large particle interaction was present. It led to elastic properties, which were comparable to gluten properties. The whey protein suspension was added to a mixture of starch, salt and water. The resulting dough was compared to a regular wheat flour dough and to gluten-starch doughs, with respect to strain hardening properties. The whey protein dough, however, contained only 2.5% protein, Due to the preparation method of the whey protein particles, we needed locust bean gum and a pH of 5.2. We checked the effect of locust bean gum and pH. The pH had a minor effect compared to meso-scopic structuring. The addition of locust bean gum increased dough consistency of the whey protein dough. The influence of the locust bean gum can be explained by a depletion effect. We were also able to bake a bread with the gluten-free dough described above, having a specific volume of 3.7 ml/g. We therefore concluded that by building a network with comparable interactions as the gluten network, we approached the unique properties that gluten gives to bread.

Physico-chemical properties of β-glucan in cereal bars containing creatine are key for increased creatine retention in the body

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Cereal bars containing the bio-active creatine were developed for stop/go sports to provide explosive energy. Oat/barley β-glucan concentrates were added to the bars to extend the aborption phase of creatine and thus to slow down the loss of creatine in the urine. This physiological effect is linked to the viscosity of the β-glucan in the intestines. The physico-chemical properties (solubility, molecular weight, concentration) of the β-glucan in seven commercial oat/barley β-glucan concentrates were studied. The viscosity after in-vitro digestion of β-glucan concentrates as such and their bars were assessed. The in-vitro screening was used as predictive tool for clinical trials. 2-hour urinary creatine recovery (% of the dose/serving) was assessed in the clinical trials. Not all oat/barley β-glucan concentrates were adequate for addition to bars. Good extractibility of the β-glucan (>50%), a high molecular weight of the soluble β-glucan and 1.3 g of soluble β-glucan/serving was key to have a high viscosity (3400 mPas) after in vitro-digestion. Bars containing such β-glucan (concentrates) had a reduced 2-hour urinary creatin recovery. In conclusion, the physiological effect was only observed for cereal bars containing β-glucan with specific physico-chemical properties.

Protease treatment to enhance a dry fractionated corn ethanol process

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Fractionating the corn kernel to separate endosperm from germ and pericarp improves corn ethanol processing by increasing fermentation throughput and generating salable coproducts. One such fractionation technology, dry fractionation, suffers from loss of germ derived nutrients and amino acids, resulting in poor fermentation kinetics. In the fuel ethanol industry, such deficiencies may be addressed by increasing inorganic nitrogen and other nutritional supplements. We investigated the addition of a commercial protease as an alternative to exogenous nitrogen supplementation. Although proteases have the ability to break down the endosperm protein matrix, we observed that protease pretreatment did not alter the effectiveness of amylases during liquefaction and saccharification. Protease generated free amino nitrogen (FAN) resulted in fermentation being 99% complete in 48 hr, compared to 93% with urea supplementation. Total nitrogen as FAN required to complete fermentation was one third that for total nitrogen as urea. Viable cell biomass yields were similar in both FAN and urea supplemented fermentations. Adding urea in addition to protease generated FAN resulted in similar fermentation characteristics as with FAN alone, which indicated FAN was assimilated preferentially. A small reduction in final ethanol yield (2 g/L) at high protease loading (generating 480 mg FAN/L) was attributed partly to lower utilization of maltose and, to a lesser degree, maltotriose. Using model fermentations, we confirmed reduction in maltose uptake with high FAN. In contrast to conventional dry grind process employing separate high temperature liquefaction, a granular starch hydrolyzing enzyme process (simultaneous liquefaction) did not result in reduced ethanol yields, including at high FAN concentrations.

Two-dimensional structural distributions for starch based on size and branching: Method development and implications for biosynthesis

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Cereal Foods World 55:A33

Starch is a complex branched macromolecule, whose branching structure can only be completely described by multidimensional distributions based on the number and length of the branches and their position within the macromolecule. Current characterization techniques only produce one-dimensional projections of these multidimensional distributions. The first 2-dimensional structural distributions for starch based on size and branching will be here presented, obtained by using multidimensional off-line size exclusion chromatography (SEC) and enzymatic debranching. These new distributions reveal additional features about the branching structure and the biosynthetic pathway of native rice and high-amylose maize starches. The branching structure of amylopectin is independent of macromolecular size, consistent with the hyopthesis that its chain-length distribution is crucial for its biological function as a energy-storage polymer. Amylose, on the contrary, exhibits a wide range of branched architectures within macromolecular sizes, indicating that its biosynthetic kinetic mechanism involves an unsuspected size dependence, which is unconstrained by the biological imperative constraining amylopectin.

Creation and properties of sweet wheat

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Cereal Foods World 55:A33

DNA markers were used to identify a double mutant of hexaploid wheat produced from a cross between a GBSSI null mutant and an SSIIa null mutant. The developing endosperm of the double mutant had sugar levels that were high enough to make it worthy of being called “sweet wheat” (SW). Maltose was present at high levels in the developing endosperm of SW but was barely detectable in wild-type or SW parental lines. While a sucrose peak was observed in all lines, this peak was considerably higher in SW samples, and only SW possessed a peak attributable to the presence of maltotriose. SW seed appears shrunken and shriveled, and starch granules from SW had a lower density than wild-type granules. Upon centrifugation, granules from wild-type and SW parental lines formed a firm pellet, but most of the SW precipitate consisted of a gelatinous mass, which was shown by electron microscopy to consist of very small granules. After drying, this mass lost most of its volume, mirroring the drastic decrease in volume of SW seed at the seed drying stage. The structure of SW starch also differed, with the average molecular weight of amylopectin from SW starch being substantially lower than that of amylopectin from wild-type wheat. To further investigate changes in starch structure, debranched chains of polyglucans were separated according to their degree of polymerization (DP). Although the chain length distribution patterns of SW and the SSIIa null line were similar, the relative amount of very short chains (DP2-5) increased to a much higher level in SW than in other lines. The markers used to produce SW were also used to produce 64 homozygous lines with various combinations of GBSSI and SSIIa alleles from the A, B and D genomes. Many of these wheat lines differ notably in their starch and seed characteristics, and will potentially have novel applications in the food industry.

Changes of pasta structure and rheological properties during cooking

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Cereal Foods World 55:A33

The cooking stage of pasta induces large textural changes that are governed by important structural and molecular changes in proteins and starch. The objective of this study was to describe these changes and to understand how they influence their rheological properties. Various cooking times (1 to 12 min) were applied to fresh and dried pasta. Rheological properties were determined by compression and elongation tests under large strain. Starch gelatinization and crystallinity were determined respectively by DSC and X-ray diffraction. Pasta protein features were determined by measurement of thiol, disulfide bond, soluble proteins and partial protein reduction kinetics (in DTE 6 mM) using SE-HPLC to characterize protein aggregation rate and polymerization level of gluten network. Elongation test until break was found to be more discriminative for pasta rheological properties than the compressive one. The increase of cooking time induces a decrease in stress (sigma b) from 0.43 to 0.04 MPa associated with an increased strain at break (epsilon b) from 0.9 to 27%. All products can be located on a single master curve sigma b = f(epsilon b), whatever their composition and cooking time. During cooking, starch gelatinization occurs progressively while the protein aggregation reinforces the gluten network, which protects starch granules against a premature rupture. Indeed, starch gelatinization involves a decrease of sigma b and a concomitant increase of epsilon b. Conversely, the protein network aggregation involves the opposite effect. These structural changes have opposite effect on product texture and the master curve is not only explained by a mere plasticization effect due to the increase of water content during cooking (from 11 to 444%, db).

Direct chemical imaging of single modified starch granules with 320 × 25 milliradian synchrotron beams and a focal plane array FT-IR microspectrometer

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Cereal Foods World 55:A33

This is the first starch granule study with the newly commissioned, custom-built synchrotron illumination infrared environmental imaging (IRENI) system designed for environmental investigation by physicists of the University of Wisconsin-Milwaukee. In the carbohydrate chemistry community, the utility and importance of octenyl succinic anhydride (OSA) modified starch is well known. Esterification with OSA produces emulsifying properties, improves emulsion stabilizing properties, gives water resistance to films and improves the flow properties of dry starch. From bulk consideration, the intergranular modification level differences are expected to affect functionality of the product. The intergranular uniformity of modification has been a goal on the industrial scale and FT-IR microspectroscopy has recently been employed to obtain a carbonyl group census, one granule at a time. On a microscopic scale, because all dipole-dipole interactions are highly localized, the intragranular homogeneity or lack thereof is also of concern. Imaging single 15 μm diameter modified waxy maize granules has presented an analytical challenge requiring a multihour mapping procedure. The object of this study is to meet the challenge with the sophisticated optical system which allows rapid, direct chemical imaging. With the IRENI system, a 320 × 25 mrad synchrotron beam illuminates the target on the microscope stage. The result is a diffraction limited spatially resolved image that is wavelength dependant. With a 64 × 64 element focal plane array and an appropriate condenser, a 32 μm × 32 μm image is displayed in 0.5 μm divisions. Images of several individual granules are presented. Experimental breakthrough is shown to be a viable way to deal with the question of intragranular uniformity wherever the question should arise in the future.

Using residual lipid to assess rice degree of milling

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Cereal Foods World 55:A33

Color is often used to measure the degree of milling of rice. Milled rice color is determined by the adhering, pigmented bran. Bran and germ are successively removed during milling and those tissues contain large quantities of lipid, therefore, surface lipid content may be used to assess milling quality. Once the bran is removed, small amounts of germ may remain because the germ, a convex structure extending into the starchy endosperm, is not easily removed. Thus, an understanding of grain anatomy is essential to assess milling quality. Fluorescence microscopy combined with a lipid-specific probe provided a procedure to highlight milling characteristics and varietal differences. Standard embedding and sectioning techniques are limited for localization of lipids, because lipids are extracted during the process. Therefore, a protocol for sectioning whole milled rice while preserving lipid was used for this study. Additionally, due to the relatively large surface area of sections, the lipid oxidizes over time, so the sections must be made, stained and documented in a short period of time. Intact rice kernels were encased in paraffin and sectioned with the assistance of clear packing tape. The sections were stained with aqueous Nile Blue A and the resulting characteristic fluorescence of polar lipids was observed in a stereo microscope. Bulk samples of rice pureline varieties and hybrids were milled for 0, 10, 20, 30 and 40 sec. Individual kernels were examined to reveal lipid distribution in the whole-kernel sections. The fluorescence in sections as milling duration increased show how the bran and embryo components were removed during milling. Differences in lipid distribution and remaining lipid in rice varieties and purelines were noted and correlated with data obtained by petroleum ether extraction using the Foss Soxtec extraction procedure.

Developing cereals with higher resistant starch: Goals and constraints

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Cereal Foods World 55:A33

In vitro digestion studies on processed starches with various amylose contents were performed and the time evolution of the size distribution of both the whole and debranched starch were examined with multiple-detector SEC (also known as GPC). As seen elsewhere, this showed the appearance of a small, slowly digested entity, probably formed by retrogradation of longer branches of amylose and amylopectin as they are liberated from the parent starch molecule during digestion. This is consistent with the nutritional desirability of so-called high-amylose starches, which have such a branching pattern. Developing cereals with such a branching pattern is a challenge for plant engineers. A mathematical model for the chain-length distribution (CLD) of starch is developed, using a reductionist approach that assumes that an individual branch grows under the control of a single set of isoforms of starch synthase, starch branching and debranching enzymes. This also includes the requirement that branching enzyme only operates on branches longer than a minimum degree of polymerization (DP). The resulting expression for the CLD shows that only a restricted range of enzymatic activities will lead to a viable plant that will be well adapted in evolutionary terms. Fitting to data from a wide range of starch-accumulating plants reveals the presence of a hitherto unsuspected feature in CLDs which verifies the 'minimal-DP' restriction on branching enzyme. This also shows that the CLDs of branches confined to a single crystalline starch lamella are very restricted, and also indicates targets for plant engineers for developing crops whose CLDs will lead to improved resistant starch.

Systematic investigation of thermo-mechanical extrusion processing as a pretreatment method for ethanol production from soybean hull and sorghum stover

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Cereal Foods World 55:A34

Annual production of ethanol in the U.S. is expected to reach 36 billion gallons by 2022, most of which is likely to be based on cellulosic biomass. In this study, thermo-mechanical extrusion processing was evaluated as a pretreatment method for cellulosic ethanol production. Two biomass substrates, soybean hull and sorghum stover, were processed on a lab-scale twin screw extruder to breakdown their lignocellulosic structure. Soybean hull and sorghum stover contained 35.4 and 31.4% of cellulose, 17.21 and 19.2% of hemicellulose, and 2.3 and 6.3% of lignin, respectively. Utilizing a factorial experimental design, glucose yield after enzymatic hydrolysis and ethanol yield after subsequent fermentation were evaluated as impacted by extrusion processing conditions, viz. in-barrel moisture (40–50%) and screw speed (280–420 rpm). Decreasing in-barrel moisture and increasing screw speed resulted in higher specific mechanical energy (SME) input, which ranged from 323 to 1569 kJ/kg. Glucose and ethanol yields were impacted by SME and residence time inside the extruder. Washing of extruded samples resulted in an increase in glucose and ethanol yields, indicating the presence of inhibitors that were most likely produced during pretreatment. This was confirmed by high performance liquid chromatography assays. Compared with soybean hulls, sorghum stover required higher moisture for processing and resulted in lower sugar and ethanol yields because of its high lignin content. The relative economics of extrusion processing and traditional dilute acid hydrolysis pretreatment was also investigated using a system dynamics model, which proved extrusion to be a competitive alternative. To summarize, thermo-mechanical extrusion processing is a technically and economically feasible pretreatment process for cellulosic ethanol production and has great potential as high throughput alternative to traditional pretreatment methods.

2010 Annual Meeting
Abstracts of Poster Presentations

Abstracts submitted for poster presentations at the 2010 annual meeting in Savannah, Georgia, October 24–27. 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.

Differences in free and bound phenolic acids of black, blue and yellow barleys and their contribution to antioxidant capacity

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Cereal Foods World 55:A35

Barley contains a number of components that have demonstrated physiological health benefits such as the effect of beta glucan lowering blood cholesterol and the antioxidant properties of phenolic compounds. Phenolic acids are the main phenolics and key antioxidants in barley. This study was carried out to investigate 28 barley varieties including yellow or regular (13), black (10), blue (4) and one color mix in terms of free and bound phenolics and their contribution to the antioxidant capacity. Free phenolic acids were extracted by using aqueous methanol and bound phenolics were obtained by alkaline hydrolysis and solvent extraction. Phenolic acids were then separated and quantified by RP-HPLC. Total phenol content in free and bound phenol extracts was also measured based on Folin reaction. DPPH scavenging capacity test was used to determine antioxidant capacity of barleys. Significant differences in total and individual phenolic acids were observed between the barley groups (black, blue and yellow) as well as within each group exhibiting a wide range of phenols concentration. These results show a potential for the development of barley varieties exhibiting high content of phenols. Ferulic was the predominant phenolic acid in free and bound phenol extracts. The contribution of total and individual phenolic acids to antioxidant capacity varied significantly and changed with the concentration of phenolic acids within each group in particular for yellow barley group. Some varieties of black and blue barley were extremely high in pheolic acids and showed antioxidant potential.

Durum quality assessment: A comparison of different physical and rheological methods

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Cereal Foods World 55:A35

The best rheological test that can be used to differentiate gluten strength of different durum wheat cultivars is not recognized yet. Sixteen durum wheat cultivars were grown at three locations in North Dakota using a randomized complete block design to compare different rheological methods for pasta quality assessment. Different quality tests were performed to distinguish the weak, medium and strong gluten cultivars. Among those tests, the alveograph, farinograph, gluten index (GI), glutograph and mixograph have been used to provide the best estimate of end-product quality. Alveograph was able to differentiate between medium and strong gluten samples that were not detected with the mixograph and farinograph. Mixograph might be used to evaluate breeder samples due to its simplicity and the small sample size (10 g) required to run the test; however, it did not clearly differentiate between medium and very strong gluten cultivars. The simplicity of GI makes it another useful tool for predicting end-product quality of various levels of gluten strength cultivars. In comparison with alveograph test (250 g), the GI was faster and required less semolina (10 g) and differentiated samples similarly as the alveograph. The use of farinograph to measure gluten quality was not a good option for breeders because the amount of semolina needed to run the test (50 g) is larger in contrast with GI (10 g) and due to the long running time of farinograph. In conclusion GI and alveograph were the best two tests that can be used to predict high quality end-products. Both tests clearly differentiated among the weak, medium and strong gluten strength cultivars.

Effect of whole waxy wheat flour on muffin quality

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Cereal Foods World 55:A35

In recent years, there has been interest in uses for waxy wheat flours in baked goods, but little has been done with whole waxy wheat flours. Quality parameters of muffins made with different amounts of whole waxy wheat flour blends (0, 15, 30, 45, and 60% by flour weight) were characterized. High amounts of whole waxy wheat produced darker crust color ($p < 0.05$). Muffins with higher levels of whole waxy wheat were found to have softer crumb on the day of baking but significantly higher increase in firmness during storage. All muffin formulations became less springy while in storage. Water activity and moisture content were higher on bake day than all other sampling days for all formulations. Proton NMR showed two distinct transverse relaxation time constants as well as a possible movement of water from one area (crumb) of the muffin to another (crust). Sensory evaluation showed lower overall likability scores for muffins made with 60% whole waxy wheat flour blend, while there was no difference for all other formulations. The 15% whole waxy wheat muffin formulation most resembled the control (0%) for all sensory attributes, and the 15% scored highest for moistness. Levels of whole waxy wheat flour above 45% also decreased cake volume. When compared to the control, up to 15% of whole waxy wheat flour may be added to improve softness and moistness without reducing other quality parameters of whole wheat muffins.

Molecular characteristics of maize starch and tortilla digestibility as affected by pigmentation of the grains

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Pigmented maize varieties are being considered for tortilla production at industrial levels due to their nutraceutical characteristics. To determine the operation conditions for tortilla production of these varieties, analyses of the starch are need because this molecule is the main one responsible for texture and digestibility. The aim was to evaluate the effect of the starch molecular structure on the digestibility of tortillas. Two varieties of pigmented maize (blue and black) and white maize (as control) were used. The starch was characterized by X-ray diffraction and infrared spectrometry (IR). Tortillas were prepared and stored at 4°C for 0, 48 and 96 h. Total (TS), available (AS), resistant (RS) and retrograded resistant (RRS) starch were tested using Goñi's, Holm's and Saura-Calixto's methods, respectively. Starches showed X-ray diffraction pattern type A, but differences in the crystallinity level were found due to that starch of pigmented maize showed higher crystallinity. The IR spectrum indicates that starches of pigmented varieties had higher amounts of crystalline regions than white maize. The TS content of tortillas stored did not differ significantly with respect to storage time, but difference was found depending on the variety (white tortilla 69.5% and blue tortilla 73.5%). In blue (73.5% to 70.3%) and black (71.2% to 65.3%) maize tortillas the AS decreased more slowly, but in greater proportion than in white maize (68.8% to 66.3%), this agrees with the RS content, which increased to a lesser extent in white maize tortilla (1.1% to 3.2%). This increase is due to the formation of RRS, which showed a similar trend to that found in the RS content (blue tortilla 1.4% to 1.9%). In conclusion, pigmented maize tortillas retrograde more slowly than white maize but in greater proportion after 48 h of storage. These differences are related with the molecular structure of starch present in those varieties.

Influence of wheat starch structure on starch hydrolysis

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Cereal Foods World 55:A36

Wheat (Triticum aestivum) is one of the major cereals grown worldwide. A wheat grain stores carbohydrates in the form of starch, which is present as discrete water insoluble granules. One quarter of starch is occupied by amylose and three quarters by amylopectin. Starch biosynthesis is a complex process and involves a cascade of enzymes, which include, starch synthases (SSI, SSII, SSIII, SSIV and GBSSI), starch branching enzyme and starch debranching enzymes. Absence of Granule bound starch synthase-I (GBSSI) results in amylose-free (waxy) starch. Since wheat is an allohexaploid, thus GBSSI from different genomes would affect the amylose content as well as the amylopectin structure of starch. The objective of the work was to study the influence of GBSSI on starch structure. Twelve near isogenic lines with a combination of functional waxy locus i.e. $A^+B^-D^-$, $A^-B^+D^-$, $A^-B^-D^+$ along with control $A^+B^+D^+$, and completely waxy $A^-B^-D^-$ lines were studied. Starch extracted from these lines was used to determine the starch properties. Total starch was determined in all these lines using AA/AMG procedure. Debranched starch was analyzed using high performance size exclusion chromatography (HP-SEC) to determine amylose concentration. The absence of B and D genomes reduced amylose concentration to 18–19% as compared to the wild types. Amylopectin structure was determined using Fluorophore assisted capillary electrophoresis (FACE), which revealed higher number of longer chains (DP 50-60) in completely waxy lines over control lines. *In vitro* starch hydrolysis assay showed that fully waxy lines showed a higher hydrolytic index as compared to partially waxy or normal wheat lines. This indicates that waxy lines with longer chains are more susceptible to hydrolysis as compared to the control lines. The influence of amylopectin structure on starch hydrolysis will be discussed.

Starch/poly vinyl alcohol/ Na^+ MMT based biodegradable nanocomposites produced through melt extrusion

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Cereal Foods World 55:A36

Starch is a cheap and abundant renewable source which has a great potential to be used as a base material for producing biodegradable packaging. This study is a step towards replacing petroleum-based packaging with biodegradable nanocomposite material made from starch (67%) and poly (vinyl alcohol) (PVOH) (33%) as base polymers. Glycerol (10–30%) and sodium montmorillonite (0–20%) were used as a plasticizer and nano-filler, respectively. A lab scale melt extrusion process was used to create these nanocomposites and films were produced by casting. Process parameters, including in-barrel moisture (10–20%), screw speed (200–400 rpm) and barrel temperature (145–165°C), were also varied systematically. Film nanostructure was characterized by X-ray diffraction (XRD) and transmission electron microscopy (TEM). Differential scanning calorimetry (DSC) was carried out to understand the thermal properties of nanocomposites. Tensile strength and elongation at break ranged from 14.93 to 33.03 MPa and 17.02 to 111.28%, respectively, while water vapor permeability ranged from 0.48 to 2.24 g.mm/kPa.h.m^2. Nanostructure and thermal data indicated important role of glycerol and Na^+MMT along with process parameters in controlling exfoliation and glass transition temperature of nanocomposites. Raw material cost of the nanocomposite films ($0.85/lb) was comparable to that of commercial polyethylene-based films ($0.70/lb). This is very encouraging as a move towards replacing petroleum based plastics. Further work remains to be done on this technology to bring the biopolymers films to parity with commercial plastic films that currently have superior elongation at break (500–900%) and water vapor permeability (.001 g.mm/kPa.h.m^2).

Characteristics of nixtamalized maize tortilla, added with banana native starch

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Cereal Foods World 55:A36

The maize tortilla is consumed by 94% of Mexican people. It is elaborated from nixtamalized maize grains. To improve the amount of fiber and the nutritional properties in this food, fiber of other food has been added. By the other hand, when the native starches, as banana starch, are consumed without processing have lower digestibility than that processed starches, and they act as natural fiber. To obtain advantages of the characteristics of these two foods, in this work, tortillas from mixtures of dehydrated masa of nixtamalized maize and banana native starch, were elaborated and characterized. The starch was extracted from unripe banana. The nixtamalized maize flour was made by the traditional nixtamalization method. The moisture content, water absorption and solubility index, color, proteins, lipids, ash, ΔH gel, and amylographic profile of starch and the nixtamalized maize masa, were determined. Mixtures of flour/starch with different proportions: 70/30, 60/40 y 50/50% w/w, were made. Tortillas were elaborated by the traditional method, and their properties physicochemical, rheological, thermal and texture (adhesiveness, cohesiveness, rollability, elasticity and cutting force) were determined. The tortillas were evaluated at two store times: 0 and 24 h. The masa with the best adhesiveness and cohesiveness was that elaborated with the mixture 60/40 flour/starch. All prepared tortillas showed a good puffing and rollability degree. The tortillas made with mixture of 70/30 flour/starch, showed the best tensile strength and cutting force. In general, we concluded that the best tortilla with similar characteristics to the traditional tortillas, were made with the mixture of 60/40 flour/starch.

Evaluation of nine maize genotypes, to elaborate tortillas

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In the world there are 300 genotypes of maize, but only few can be used as raw material to produce tortillas with good quality. In this work the potential of nine genotypes of maize (P22, P23, P25, P32, P43, P49, HS-3G, VS-536 and CM) to produce tortillas, were evaluated. The grains of each genotype were nixtamalized, milled, dried and used to make tortillas by the traditional method. Size, weight, hardness and moisture of the grains were measured. The water absorption index, water solubility index, and amylographic profile for the flours were obtained. The adhesiveness and cohesiveness of the masa, puffing degree, rollability, tensile strength, elasticity and the cutting force of tortillas were also determined. The physical dimensions of the grains showed significant differences. The grain hardness of P23 maize and CM, was out of the range considered as adequate to elaborate tortillas (11.77 and 12.05 kg). The P43 maize flour and P49, showed the highest water absorption index (3 g gel/g dry matter). The highest viscosity was developed by the P32 maize flours and HS-3G, and the lowest was from the P22 maize flour and P23. The maize masa of P22, P25, P49 and VS536 showed the highest values of adhesiveness. All tortillas elaborated showed good characteristics of puffing and rollability. The tortillas from P32 maize were the most resistant, and those from P22 maize and CM, showed the lowest elasticity. The tortillas elaborated with P32 maize showed the highest values of cutting force, followed by that made with maize of HS-3G, S53G, P49, P25, P23, P22 and CM. In general, the tortillas with the best characteristics were elaborated with maize of P49, P43 and VS-3G. The rest of the evaluated maize genotypes produced tortillas with low quality. Base on results, the maize of P49, P43 and VS-3G, can be used as raw material to produce tortillas with good quality characteristics.

Composition and functionality of wheat flour mill fractions obtained through different test mills

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Cereal Foods World 55:A37

Flour milling is continuous grinding and sifting operation composed of several breaking and reduction steps to extract endosperm from bran and germ with highest purity and yield. There are several systems available for experimental milling which vary in number of breaking and reduction steps and the resulting flour and by-product streams. The greater the number of separations and the more specific the grinding operations in a milling system the higher the flour yield and the purity. This study aims at comparing the composition and functionally of break, reduction and straight grade flours, and whole wheat flours of hard red winter and soft white wheats milled on Brabender Quadrumat Jr and Sr, Buhler and Chopin CD1 test mill. Mixolab (Chopin Technologies) was used to study mixing and pasting behavior of each flour sample. Tests were carried out at the constant water absorption (80% db) and mixing speed (80 rpm). The thermomechanical parameters (water absorption-C1, mixing stability, protein weakening-C2, starch gelatinization and gelling) were recorded. Proximate analysis of the streams indicated a wide range of protein and ash contents for breaking and reduction flours, and for flours obtained from different mills. Starch pasting and gelatinization parameters were found to be reflective of the composition of flour streams resulting from nature of the test milling applied. Whole wheat flours, independent from the milling method, had higher C1 and C2 due to inclusion of bran which leads to increased water absorption capacity and decreased weakening at elevated temperatures. Solvent retention capacity test was used to predict baking performance by measuring the capacity of flour to retain four solvents (water, Na2CO3, sucrose, and lactic acid) to assess overall absorption capacity, starch damage, pentosan and gliadin content, and glutenin quality, respectively.

Determination of the mixing and pasting properties of health grains using Mixolab

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Functional foods are an emerging field in food science due to their increasing popularity among health-conscious consumers. Development of new technologies of cereal processing that enhance the acceptability of healthy food product are of primary importance. The aim of this study was to develop mixing and pasting profiles of healthy natural and/or organic cereal flours like whole dark rye, whole teff, whole brown rice, whole amaranth, whole quinoa, sorghum, masa harina, potato, tapioca using Mixolab (Chopin Technologies, France). Tests were carried out at the constant water absorption (112% db) and mixing speed (80 rpm). Mixing and pasting behavior was studied following modified (90 g of dough) 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. A set of parameters (water absorption, mixing stability, protein weakening, starch gelatinization and gelling) were determined. First part of the curve corresponding to mixing and initial heating has been associated to proteins that undergone hydration, changes induced by mechanical input, thermally induced aggregation and unfolding. Further heating and cooling resulted in starch gelatinization and gelling, respectively; with the consequent increase in dough consistency. Cereals and pseudocereals displayed thermomechanical behaviors that are distinctly different than characteristic behavior of wheat flours. They typically led to low consistency dough due to the lack of gluten. Minimum torque was observed at 58–74°C indicating that such cereals require higher temperatures for pasting. Maximum peak torque during heating was reached at 72–86°C after which a pronounced torque decrease was observed, which reflects the fragility of the swollen granules as they break down under continuous stirring.

Mixing and pasting characteristics of organic and conventional whole wheat flours milled on roller and stone mills

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Organic food industry has been showing the highest levels of growth of all food sectors. Knowledge about the effect of milling technique on pasting properties of organic and conventional whole wheat flour could lead to effective use of flour to make high quality products without encountering processing or end product quality problems. There is, however, limited research on organic whole wheat flours. The aim of this study was to compare effect of milling technique (roller mill vs. stone mill) on mixing and pasting characteristics of organic and conventional hard red wheat harvested in Turkey in 2008. Mixolab analysis was carried out at the constant water absorption using standard Chopin+ protocol. Water absorption (C1), mixing stability, protein weakening (C2 and alpha), starch gelatinisation (C3 and beta), amylasic activity (C4 and gama) and starch gelling (C5) were determined. Pasting curves were obtained using STD1 (AACC 76-21.01) temperature profile provided with the instrument (RVA-4, Newport Scientific). The resulting curves were analyzed for peak, trough, breakdown, setback, final viscosities, peak time and pasting temperature. Mixolab data of flours were found to be in the range of 1.1-1.4 Nm for C1, 0.5-0.6 Nm for C2, 1.9-2.1 Nm for C3, 1.7-1.9 Nm for C4, 2.6-2.9 Nm for C5, and 8.6-9.9 min for stability. RVA viscosities showed a wide variation: 2540-3590 cp for peak, 3140-3910 cp for final viscosity. Peak time and pasting temperature ranged between 5.8–5.9 min and 65.9–85°C, respectively. Milling technique affected the mixing and pasting behavior significantly ($p < 0.05$). Peak, trough, breakdown viscosities of stone milled flour were lower than the roller milled ones. However, pasting temperatures of stone milled flours were higher than the roller milled samples.

Healthy cookies for woman

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Women's health is very much influenced by the female hormone estrogen, which chemical structure is very similar to that of isoflavones. Because of this similarity in structure, the isoflavones can interfere with the action of the body estrogen increasing its activity. During menopause the body's natural level of estrogen drops, isoflavones can compensate this by binding to the same receptor, thereby easing menopause symptoms as a result. The isoflavones can reduce menopause symptoms such as hot flushes and increase bone density in women. The purpose of the present work is to develop a new cookie with reduced calories, increased fiber and isoflavones levels compared to a standard cookie, in order to satisfy woman needs. To obtain the new product, 100% of sugar, 15% of wheat flour and 30% of fat were replaced in the original cookie. In order to achieve this objective we include: wheat fiber, powdered cellulose, sucralose, polidextrose, inulin, powdered soy lecithin, gums, modified starches, soy extract (40% isoflavones) The cookies were made in our laboratory with an internal procedure; physical, sensory and nutritional characteristics of the end product were analyzed. We conclude that it is possible to obtain a product with a 25% of caloric reduction and a 15% of fiber. We could verify the presence of 0.015% of isoflavones on the end cookies.

Sorghum based gluten free whole grain snacks

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Sorghum based gluten free snacks were produced by using different types of whole ground sorghum. White, black and high tannin sorghum, were used in the proportion of 50–80% of total formulation weight with a margin of 10%. Other ingredients were corn flour, soy isolates and corn starch, and a twin screw extruder was used for snacks manufacturing. After extrusion, extrudates were dried in an oven at 105°C for 6 minutes. For seasoning, extrudates were coated with 45% flavor slurry containing 25% of cheese seasonings and 75% of vegetable oil. Keeping all the processing parameters like feeding rate, extruder screw speed, water to extruder, knife speed same, the effects of different types of sorghum and their percentages on the functional and physical properties of snacks were evaluated. Properties studied were included water absorption index (WAI), water solubility index (WSI), bulk density, expansion ratio and texture hardness. Bulk density of extrudates with 80% of white, black and high tannin sorghum was 0.055 kg/L, 0.060 kg/L and 0.055 kg/L respectively, while bulk density of extrudates based on corn was 0.065 kg/L. However, the expansion ratio of extrudates with black sorghum was less (3.42) as compared to extrudates of white (3.86) and high tannin (3.78) sorghum. Therefore sorghum based, gluten free whole grain snacks were comparable to commercially available corn-based snacks in taste, functional and physical properties.

Relationship between waxy alleles and the amylose content in wheat isogenic lines

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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 amylose content. Isogenic lines (ILs) of three soft wheat cultivars with either one, two or three waxy null alleles were used to study the genome response to these null alleles. The main differences were observed for the Granule Bound Starch Synthase (GBSS), product of the *waxy* genes. As the results show the percentage of amylose in starch grain was highly and positively correlated to the GBSS spot volume which was revealed through precise quantification of the GBSS in each IL. Therefore, in this study we demonstrated that Wx-D1a proteins were more abundant than the waxy proteins encoded at the two other *Wx-A1a* and *Wx-B1a* alleles. These Wx-D1a proteins had the highest impact on amylose synthesis in the wheat endosperm. Based on our results it seems that the double null isogenic lines, only two genes, Wx-A1 and Wx-B1, were additive and not in presence of Wx-D1.

Reaction of octenyl succinic anhydride with insoluble granular starch and soluble maltodextrin

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Octenyl succinic anhydride (OSA) modified starches are widely used in emulsion and encapsulation applications. There modified starches are typically prepared by suspending starch granules in water and mixing OSA reagent under alkaline conditions. The modified starches are then degraded and converted to soluble starches for industrial applications. The objectives of this work were to compare the OSA reaction with granular waxy maize starch and soluble maltodextrin and determine if there was any advantage to react OSA with soluble maltodextrin. Granular starch, soluble maltodextrin as well as their mixture (1:1, w/w) were used as starting materials. Five levels of OSA (3, 9, 15, 25 and 50%, based on the weight of starch) were reacted with granular starch and soluble maltodextrin, respectively. For the reaction with the mixture of the granular starch and maltodextrin, 3 and 9% (wt%) OSA was added. All the reactions were carried out at pH 7.5 and 40% solids, which is the optimum for high reaction efficiency. The maltodextrin had a higher reaction efficiency than the granular waxy maize starch at all OSA levels. The highest DS of OS soluble maltodextrin was 0.27 comparing with 0.088 for granular waxy maize starch. In the reaction of 3% OSA with the mixture of starch and maltodextrin, 13% (wt%) of the total OSA was reacted on the granular starch and 70% reacted with the maltodextrin. In the 9% OSA modification, 16% (wt%) of OSA was reacted on the granular starch whereas 67% reacted with the maltodextrin. In conclusion, higher reaction efficiency was achieved when OSA was reacted on soluble maltodextrin compared to the reaction of OSA with granular waxy maize starch. When both maltodextrin and granular waxy maize starch were presented in the slurry, significant amount of OSA was absorbed and reacted with granular waxy maize starch.

Development of new markers to genotype the functional SNPs of SSIIa, a gene responsible for gelatinization temperature of rice starch

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Cereal Foods World 55:A38

Gelatinization temperature (GT) is an important quality predictor that determines the cooking quality of rice. GT is controlled by the starch synthase IIa (SSIIa) genes. Two functional single nucleotide polymorphisms (SNPs) inside the SSIIa have already been found to be responsible for the variation of GT. One of which, GC/TT SNP at 4329/4330bp could be genotyped by four primers in a single PCR (Bao et al. 2006), but another one, G/A SNP at 4198bp has not been genotyped as a PCR based marker. Here, we developed cleaved amplified polymorphic sequences (CAPS) and derived cleaved amplified polymorphic sequences (dCAPS) markers to genotype the SNPs. A dCAPS marker that the PCR products was cleaved by the BseR I restriction enzyme was designed to genotype GC/TT. Both CAPS and dCAPS markers were designed to genotype G/A SNP using the restriction enzyme Nla III and Tsp45 I, respectively. The new method for GC/TT genotyping produced the same result as the four primers method. Both of CAPS and dCAPS markers gave the same G/A SNP genotype for the same rice accession. With rare exceptions, the rice possessing GC SNPs had high or intermediate GT, while the rice possessing TT SNPs had low GT. However, when the 4198bp position was A, the GT was low. The F2 individuals from two crosses were used to detect the co-segregation of the SNPs and the GT, The segregation ratio of two SNPs did not accord to the Mendelian ratio of 1:2:1, but the SNPs were co-segregated with GT.

Protein quality evaluation of new Mexican bean varieties by rat bioassays

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Dry beans, represent an important source of vegetable protein in the Mexican diet. In this study four new Phaseolus bean varieties from the north central part of Mexico were analyzed in their protein quality using rat bioassays. These four new Phaseolus varieties were obtained from the state of Durango Experimental station and they belong to the 2009 spring harvesting season. A commercial variety Pinto Bill-Z was used as a control. Bean varieties were first analyzed in their optimum cooking times. Cooked beans were tunnel dried (65°C) and milled to 80 mesh particle size. Experimental diets, prepared from cooked bean flours, adjusted to 10% protein, were used for rat bioassays. A casein-based diet (control) and a protein-free diet were also included. 14-day feeding trials were conducted using Sprangue dowley rats within 45–65 grams in weight. A group of four rats were used for each experimental diet. % Digestibility (dry matter, apparent and true N) and NPR were measured for each experimental diet. Results showed that the four new bean varieties were significantly different in their cooking times. All bean varieties showed % true N digestibility between 75–80. New Pinto varieties showed slightly lower % digestibility than the commercial variety (control). However, NPR results showed that the new varieties: Flor de Mayo, Pinto and Pinto Durango have a protein quality significantly higher than the control. Results from this investigation probe that the new Phaseolus bean varieties developed for the north central part of Mexico were also significantly improved in their protein quality. Therefore, they are highly recommended for commercial production, since they represent high protein quality varieties that will undoubtedly contribute to the improvement in the nutritional value of the diet of the population of that region.

Effect of pearling on the morphological and physicochemical characteristics of barley starch

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In diverse industries, the starch of different botanical sources is widely used due to its functionality. Pearled or whole barley is utilized both in the brewing industry and as animal feed. However, there is an emphasis on diversifying the end-use of both types of barley such as starch isolation. The hypothesis is that pearling step can produce changes in the starch structure and affect its physicochemical and functional properties. On the other hand, whole barley can be used for starch isolation without the pearling step. The objective was to evaluate particle size distribution. thermal and pasting properties of starch isolated from pearled and whole barley. Commercial corn starch was used for comparison. Amylose content of whole barley starch (WBS) and pearled barley starch (PBS) was similar. The granule size distribution of PBS and WBS showed a bimodal pattern, with a small peak between 2–4 μm, and the principal component 17.8 and 18 μm for PBS and WLS, respectively. Differences in the shape, size and surface of both barley starch granules were not evident; the pearling of the seed did not affect the morphology of the starch granule. WBS and PBS had average gelatinization temperature of 61.3 and 61.6°C, and enthalpy value of 9.19 and 8.54 J/g, respectively. Stored samples for 7 days had phase transition temperature of 49.9 and 51.8°C, and enthalpy value of 1.9 and 1.7 J/g for WBS and PBS, respectively. At the longest storage time (14 days) the temperature of the phase transition was similar and an increase was showed in the enthalpy value for WBS (2.3 J/g) and PBS (2.4 J/g). The pasting temperature of both barley starches was similar; the PBS presented a higher value of peak viscosity than WBS. The pearling of barley did not significantly affect some of the characteristics of its starch.

Estimating the theoretical energy required to dry rice

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The energy required to dry rice primarily comprises that necessary to evaporate water from rice. This evaporation energy, also referred to as heat of desorption, was determined for long-grain rough rice (Cybonnett and Wells cultivars) as a function of moisture content (MC) using a semi-theoretical approach. The method involves the use of rice desorption isotherms, in conjunction with the Clausius-Clapeyron equation. Desorption isotherm data were obtained from two studies, one conducted at high temperatures (Ts) ranging from 60–90°C and relative humidities (RHs) from 7–75%, and the

other at low Ts ranging from 10–60°C and RHs from 10–70%. The high-T equilibrium moisture content (EMC) data were obtained using a fluidized bed drying system. Drying data from this system were described using the Page equation; EMC values were obtained as asymptotic values of this equation. The low-T EMC data were determined using a chamber with controlled T and RH. EMCs for this study were determined by measuring the final sample MC via an oven drying method. Heat of desorption was assessed for MCs ranging from 8–28% dry basis (d.b). Using the Clausius-Clapeyron equation, linear regressions of Ln RH vs 1/T data were performed for selected MC levels to compute the net heat of desorption from the slopes. The total heat of desorption, obtained by adding the net heat to the latent heat of evaporation of free water, ranged from 3,480-2,430 kJ/kg water over the 8–28% d.b. MC range when using the 10–60°C EMC data and from 3,690-2,340 kJ/kg water when using the 60–90°C EMC data. As expected, the total heat of desorption increased as moisture content decreased. The total heat of desorption was close to the latent heat of evaporation of free water for rice MCs above approximately 25% d.b., indicating that the water in rice behaves as unbound water above this MC level.

Evaluation of hydration and wheat gluten secondary structure in dough in the presence of bran by ATR-FTIR spectroscopy

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The aim of this work was to determine the impact of bran addition on hydration and wheat gluten secondary structure to help decipher the underlying physical mechanisms by which bran impacts dough properties. The effect of 0 – 10% bran addition on hydration and structural changes in gluten at 25 – 50% moisture content was studied in model flour- and gluten-bran dough systems using ATR-FTIR and differential scanning calorimetry (DSC) techniques. ATR-FTIR spectroscopic analyses of the OH stretch absorbance of water in the 3000 – 3500 cm^{-1} region indicated that bran took up free water in both model dough systems, with decreasing absorbance observed as bran content increased. The OH stretch absorbance patterns changed progressively as the moisture content was increased up to a threshold moisture content and remained constant thereafter, indicating that complete hydration was achieved at all bran addition levels. Addition of bran caused slight changes in the ATR-FTIR spectrum in the 1600 – 1700 cm^{-1} region, suggesting alterations in gluten secondary structure with increasing amounts of bran: Secondary structure estimates indicated that inter-molecular β-sheet and β-turn structures decreased while aperiodic and intra-molecular β-sheet structures increased with increasing bran content. However, DSC experiments did not show an endothermic heat flow indicative of the presence of true hydrogen bonded inter-/intra-molecular β-sheet pleated structures, which suggested that the absorption bands in the 1600 – 1700 cm^{-1} region may be due to pseudo structures of extended chains with similar infrared absorption characteristics. These results suggest that bran competes for water in model flour- and gluten-bran dough systems, and this competition may affect the extent of hydration of gluten and hence its structural state in dough at a given moisture content.

Quality control of industrial millstreams

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Cereal Foods World 55:A39

Making flour from wheat requires understanding of different techniques associating mechanics, chemistry and biochemistry. In the aim to better understand the impact of the milling process on flour quality, we studied the rheological behavior of different industrial millstreams with the Mixolab, a new quality control tool allowing a complete checking of the flour in one test (protein, starch, enzyme activity, interaction between flour components). Break flours: Head break flours, coming from the same break, (0.75% ash content, 27UCD starch damage) present the same behavior on Mixolab (Mixing index = 6, Gluten+ index = 7, Viscosity index = 5, Retrogradation index = 4). Flours from the 5th break (break tail) were analyzed too (1.35% ash content, 29UCD starch damage). Comparing head and tail flours gives very different results. While if we compare results on the same type of flours (head or tail), behaviors are comparable. Logically, hydration is higher in the case of the tail flour (+7%), protein behavior is different (Mixing index = 4, Gluten+ index = 5) but the highest variation is seen on the starch phase as far as viscosity (Index = 2), amylasic activity (Index = 2) and retrogradation (Index = 2). Reduction flours: The same observations where made comparing the head and the tail of reduction. The 1st reduction flour shows a very good quality with very high stability. As much as the process advances, the protein behavior changes. But the most variation is observed on starch behavior. This study shows that the milling impact on the flour quality is better seen on starch behavior (damaged starch, viscosity and amylasic activity). Selecting and blending the different millstreams not only focusing on their protein quality but considering the starch and all interactions between flour components is possible using the Mixolab.

Sorghum flour: Characteristics and aptitude for gluten-free pasta making

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Molecular and rheological properties of unfermented (UF) and fermented (F) sorghum flours and doughs where investigated, and the possibility of producing gluten-free pasta enriched with F or UF was explored. MVA tests indicated peak viscosity values and a retrogradation tendency lower in F than in UF flour. The lowest soluble proteins content was obtained for F, that also showed a marked decrease in the total thiol content, suggesting that cysteine is actively taken up by the fermenting bacteria. Gluten-free pasta samples were prepared by using 100% whole rice flour (reference) or 85% whole rice flour and 15% of each sorghum flour (LT drying diagram). No difference were found in the viscoamylograms of flour mixtures and corresponding pasta samples, suggesting that the pasta-making process did not modify the structural organization of starch. Protein solubility tests indicated that some inter-protein network was present in the raw sorghum pastas, and that both disulfide bonds and hydrophobic interactions were involved in its stabilization, in particular when F flours were used. All pasta samples gave a 70% weight increase upon cooking. Cooking losses were lower in both sorghum-enriched samples, suggesting an increased compactness of the protein network upon cooking, as assessed also by fluorescence titration with hydrophobic probes. However, both enriched samples had a lower resistance to compression than rice-only pasta. No difference in pancreatin susceptibility were found among the three samples, but the fraction of resistant starch in the F-containing cooked pasta was twice that in the other two samples. The relevance of these findings as for their impact on the glycemic response of healthy individuals was also assessed by means of glycemic index evaluation.

The use of gum arabic as a functional ingredient to modulate the glycaemic effect of extruded snack products

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Cereal Foods World 55:A39

Extruded breakfast cereals are regarded as high glycaemic index food items. Previous research from our lab has shown that specific hydrocolloids can reduce the rate of the glycaemic response of an individual. Gum arabic is a food ingredient which may be regarded as a novel hydrocolloid representing a source of dietary fibre. A series of physico-chemical and in vitro digestibility experiments were conducted on extruded snack products ranging form a 5%–15% inclusion of gum arabic. Whilst high levels of gum arabic inclusion had a slight negative effect on some of the phyisco-chemical properties of extruded snack products (for instance reduction in product expansion ratio and increased product density) these products were not significantly different from the control samples. In addition, the use of gum arabic in the extruded snack products significantly reduced the amount of readily digestible carbohydrate within the samples and increasing the proportion of slowly digestible carbohydrates compared to a control maize based product. This had the effect of attenuating the in vitro glycaemic response of the products. Such preliminary work indicates a potential use for this low-calorie food additive in reducing the energy density of ready to eat snack products.

The effect of fibre inclusion in extruded snack products on physical and textural properties of extrudates

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Extruded breakfast cereals are regarded as high glycemic index food items. Previous research has shown that dietary fibre can reduce the rate of the glycemic response of an individual. The extrusion process has the effect of significantly altering the physical and chemical attributes of ingredients. Research was conducted to quantify effects of differing dietary fibre inclusions (soluble and insoluble) into an extruded breakfast cereal product and determine the physico-chemical and nutritional properties of the extruded food products. Dietary fibres guar (G), inulin (I) and wheat bran (WB) at 5 and 10% w/w) were included into a wheat flour base preparation as replacement to flour. Extruded breakfast cereals were made from the base preparations. Expansion ratio, cereal texture and chemical composition were determined. Expansion ratio of the breakfast cereals were significantly affected by the inclusion of dietary fibre (control 285%; WB 5%-240%, 10%-250; I 5%- 310%, I-10% 325%; G- 5% 302%, 10% 305%). Hardness of WB products were significantly higher than the control ($P > 0.05$) and increased

with increasing inclusion rate, however crispiness of product decreased with addition of WB. There was no significant difference in hardness or crispiness from the control samples with addition of guar gum. Inulin products showed a significant reduction in hardness compared to the control and an increase in product crispiness ($P > 0.05$). Results indicate that with careful manipulation of product formulation fibre can be added to extruded snack products up to 10% inclusion rate.

Rheological properties of aqueous dispersions of amylose-sodium palmitate complexes

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Cereal Foods World 55:A40

A wide range of materials with applications as thickeners and as dispersants for lipids can be formed from aqueous dispersions of amylose helical inclusion complexes with sodium palmitate. This work examines the range of rheological properties that can be obtained by preparing materials under a variety of conditions. High-amylose corn starch was jet cooked at concentrations between 1 wt% and 5 wt% and blended with aqueous solutions of sodium palmitate to form amylose helical inclusion complexes. The rheological properties of the materials ranged from low-viscosity liquids for low starch concentrations to gels at higher concentrations. A sufficiently high level of sodium palmitate was used to ensure that all of the amylose was complexed, and that the gels were not the result of starch retrogradation. The properties could also be controlled by adjusting the pH, either to increase the viscosity by association of complexed free palmitic acid, or to decrease the viscosity at low pH due to the precipitation of palmitic acid. For a 5 wt% dispersion, the complex modulus at a frequency of 1 rad/s increased from 0.4 Pa at pH 7.4 to 3500 Pa as the pH was decreased to 6.4, and then decreased to 5.2 Pa at pH 5.3.

Melting and crystallization of short linear α-glucans studied by in-situ synchrotron wide-angle X-ray diffraction

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Cereal Foods World 55:A40

In-situ melting and crystallization of short-chain amylose (SCA) from debranched waxy starches were investigated by synchrotron wide angle X-ray diffraction (WAXD). Amorphous SCA was prepared by dissolving completely debranched waxy wheat, waxy maize and waxy potato starches into alkaline solution and neutralized by hydrochloride acid. When hydrated with about 50% water at 25°C, all amorphous SCA immediately crystallized and gave a B-type X-ray diffraction pattern. The hydrated SCA paste was heated from 25 to 100°C at 10°C/min, held for 5 min, and cooled to 25°C at 10°C/min. The whole heating and cooling process was monitored by WAXD. The SCA from debranched waxy potato starch had higher average chain length, relatively low crystallinity upon hydration, but higher melting temperature. It was not completely melted at 100°C and remained its original B-type polymorph during rapid cooling. In contrast, the SCA from debranched waxy wheat and waxy maize starch had a large portion of low molecular weight fraction, higher crystallinity upon hydration but lower melting temperature (100°C). These differences suggested that short chains were more readily crystallized but had weaker crystals than long chains. After the SCA from waxy wheat and waxy maize starches was melted, it reformed into an A-type polymorph under cooling.

Utilization of sorghum in Central American foods

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Significant progress has been made in the utilization of white sorghums for use in a wide variety of foods as a partial or complete substitute for more expensive wheat, rice and maize. Sorghum is processed into flour using small plate mills that produce finely ground whole sorghum flour. The mills have been modified by inclusion of a small sifter which efficiently produces flours with various particle sizes for use in bread, cakes, cookies, atoles, horchata, tiste and other products. The effect of refined and whole sorghum on the quality of these products will be discussed. Comparisons of the plate mill with hammer mills clearly indicated that the plate mill flour had the best texture. The more refined products are used in bread while whole grains are used in cookies especially in feeding programs for children. The sorghum bran can be used effectively in production of semitas which are moist sweet breads. Small farmers produce and store their own grain which is sold as food products in local markets and is a major source of income. New white tan plant color sorghums are significantly better for processing into light-colored products with bland flavor than the native varieties. Numerous workshops and educational programs have disseminated the technology to small entrepreneurs and food companies. The types of products and factors affecting their quality are discussed.

Structural characterization of Peruvian carrot starch by acid hydrolysis

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Cereal Foods World 55:A40

Objective of this study was to determine the structural characteristics of Peruvian carrot starch, compared with that of cassava and potato starches. The starches were submitted to 15.3% H_2SO_4 at 38°C for 1, 3, 6, 12, and 30 days and their Näegeli dextrins were analyzed. Peruvian carrot starch presented, at 30th day of treatment, 97% of hydrolysis followed by cassava (89%) and potato (82%) starches. Like potato starch, the Peruvian carrot starch displayed B-type X-ray pattern and had larger proportions of amylopectin long branch-chains (DP ≥ 37) than cassava starch (C_A-type). A-type starches generally show larger proportions of short branch-chains (DP 6-12) than B-type starches. However, Peruvian carrot starch showed larger proportion of DP 6-12 branch-chains (32.0%) than potato (22.6%) and cassava (30.5%) starches. The X-ray pattern of potato starch did not change after acid hydrolysis, whereas it progressively changed for cassava (from C_A to A-type) and Peruvian carrot (from B to C_B-type) starches. HPAEC-PAD analysis of their Näegeli dextrins and debranched Näegeli dextrins suggested that the cassava starch had more branch points, α-(1,6)-D-glycosidic linkages, located within the double-helical crystalline lamella than the B-type starches. However, the Peruvian carrot starch also showed significantly more branch points into crystalline lamella than the potato starch probably due to larger proportion of short branch-chains of its amylopectin. These results demonstrated that Peruvian carrot starch presented singular characteristics in its structure.
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Inulin-type fructans as gluten-free bread improver: Sensory and nutritional quality

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Cereal Foods World 55:A40

Celiac disease does not have a cure and the only scientifically proven treatment is strict lifelong adherence to a gluten-free diet. Celiac disease is associated with an increased incidence of type 1 diabetes and osteoporosis. So, gluten-free products should be made with ingredients that contribute to the calcium absorption increase and glycemic response attenuation, such as the fructans inulin and oligofructose. The effect of adding increased levels of fructans (inulin and oligofructose mixture) on sensory and nutritional quality of gluten-free bread were assessed. A gluten-free bread, based on rice flour and potato starch, was developed with 4%, 8%, 10% and 12% of fructans added to this formulation. A 32% loss of the fructan added during the process was observed, which required 12% more fructan to the formulation in order to obtain breads with 4 g of fructan/portion (50 g), consistent with their functional properties. The addition of 12% fructans is technologically feasible, resulting in improved quality of the final product. This better quality was observed as an increased fiber content (from 7 to 20% db) and specific volume (from 1.8 to 2.4 cm^3 / g), an improved crumb texture (firmness reduction from 12 to 7.2 N), a browning of the crust ($\Delta L = -12$) and crumb ($\Delta L = -2.4$) of the bread, and a consequent increase in overall sensory acceptability of bread (from 5.4 to 7.0 on a nine-point hedonic scale). Conventional gluten-free bread presented a high glycemic index (GI = 71) and moderate glycemic load (GL = 12 for a portion of 50 g). The addition of 12% fructans resulted in a low GI (48) and low CG (8) product. The developed gluten-free breads presented superior nutritional composition than conventional products, reduced glycemic response, high consumer sensory acceptability, great potential to contribute to variation of celiac diet and also contribute to increase calcium absorption.

Optimization of nutritional and sensory quality of amaranth based gluten-free bread using response surface methodology

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Cereal Foods World 55:A40

Gluten-free breads frequently present lower levels of fiber and micronutrients as in comparison to the regular wheat-containing products they are intended to replace, because they usually consist of refined flour and/or starches, and they are not typically fortified. Thus, development of novel approaches for enhancement of the nutritional value of gluten-free bread remains an important task for research. As amaranth is a highly nutritious gluten-free grain it is a sound raw material for preparing gluten-free foods. Therefore, the objective of the present study was to use mixtures containing rice flour, potato starch and whole amaranth flour and, through response surface methodology,

to identify the proportion of these components that would maximize the nutritional value and sensory acceptability of a gluten-free bread. The regression models fitted to the experimental data [$R^2_{(adj)}$>94%, p = 0.00] demonstrated that the amaranth flour enhances the nutritional value, and decreases expansion and darks bread crumb. Rice flour and potato starch contributed to the product expansion and texture, generating lighter breads. This suggests that a mixture including all three components is essential for optimizing bread physical properties. A validation assay for the models was performed. The optimized gluten free breads (formulation 1: 33.3% rice flour, 33.3% potato starch and 33.3% amaranth flour; formulation 2: 40% rice flour, 15% potato starch and 45% amaranth flour) presented high fiber content (23.4 and 25% db respectively), adequate expansion (2.3 and 2.3 cm^3 / g, respectively), proper crumb firmness (5.8 and 5.7 N, respectively), and also were sensory well accepted (overall acceptance 7.4 and 6.6, respectively). Results also show that whole amaranth flour can be successfully used to elaborate both nutritive and tasty gluten-free breads.

Different technological approaches to reduce the glycemic index of bread
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Cereal Foods World 55:A41

Bread is a rich source of available starch and complex carbohydrates and hence an important part of a balanced diet. Although carbohydrates are a major component of the diet, the fundamental concept underlying the utility of glycemic index and load is that by minimizing the postprandial disturbances in blood glucose and insulin there could be a beneficial effect on preventing and managing different metabolic disorders. In this frame, it is expected that the structural characteristics and the baking conditions may influence the metabolic responses to carbohydrate-containing foods. To assess the effect of bread making on postprandial glucose metabolism, three white flour-based breads, differently prepared (sourdough fermentation, dried sourdough and preparatory sponge), were tested in vivo by assessing glucose and insulin post-prandial responses in comparison with a yeast leavened white bread (WB) and with bread enriched with a soluble dietary fiber (10%). Products were also characterized by physico-chemical, and nutritional indices (proximate composition, specific volume, image analysis, starch and protein in vitro digestibility). Sourdough bread had the highest efficacy in attenuating blood glucose and insulin responses, probably because the resulting protein-starch network decreased starch availability to digestive enzymes. Sourdough bread showed technological quality traits very similar to those of WB, and had very appreciated acidulous smell, taste and aroma.

Sponge & dough baking quality of wheat grown in Western Australian trials
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S&D bread is produced in most Asian countries to service the requirements for white sandwich bread. Cereal chemists refer to S&D baking as a process rather than being a baking method which has developed around American and Canadian strong wheats. The reasons for the lack of consistency in S&D performance of Australian wheat are not well understood. Although relatively little research has been done on S&D baking surveys do indicate that dough strength is important quality attribute for this product. Loaf volume appears to be the primary S&D quality consideration, even if this is not strictly true, loaf volume is the means by which bread makers compare alternative wheats. The opportunity exists for developing Australian wheats with S&D baking capability to meet the demands of the growing Asian bread market. Therefore, the aim of this project was to evaluate the quality of wheat lines grown in trials across Western Australia (WA) for S&D baking performance and to understand wheat quality attributes responsible for good S&D baking performance. The trials ranged from being low, medium and high in grain protein content. All samples were analysed for protein and starch characteristics using the MixoLab®, Flour Swelling Volume test (FSV) and the Rapid Visco Analyser (RVA). The outputs from these three dough rheology tests were correlated to the quality attributes of baked loaves. This preliminary study indicates that the C3 and C5 outputs from the MixoLab® (measuring starch gelatinisation and starch retrogradation during cooling respectively) showed the best correlation between both loaf volume and crumb softness for S&D baking.

Sensory attributes of whole and refined wheat products using descriptive analyses
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Cereal Foods World 55:A41

Continued consumer interest in healthier foods is reflected in the increasing number of products containing whole grains on store shelves. However, increased use of whole grains has raised concerns around product acceptability due to the presence of characteristic flavours that some consumers consider to be unacceptable. The objective of this study was to quantify the sensory attributes of products made from commercial whole wheat flours produced from red or white wheats and with fine or coarse particle sizes. Commercial patent flour was utilized as a control. A descriptive analysis approach, by using a trained panel, was used to characterize both low (cracker) and intermediate (bread) moisture products made with the flours. In the crumb of the intermediate moisture products, the colour of the wheat was observed to affect only the bitterness and sweetness, with a sweeter, less bitter crumb perceived in the product made with the red flour than with the white flour. Particle size had a greater effect on the sensory properties of the whole grain products, particularly within the low moisture products. Eleven of the fourteen attributes evaluated by the panel were affected by the particle size in the low moisture products. The following interactions between size and colour were observed in each product category; grain-like in the intermediate moisture crumb, salty, yeasty and grain-like for the intermediate moisture crust and earthy for the low moisture product. With few exceptions, whole wheat products were perceived as having a more intense flavour when compared to the control product. Sensory differences in whole wheat products made from red or white wheat, of varying particles sizes and moisture were observed. Sensory perception was most affected by the particle size of the flour particularly within the low moisture products.

Formation and stability of rice bran oil-in-water (o/w) emulsions stabilized by food grade biopolymers
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Rice bran oil (RBO) contains varying amounts of bioactive compounds depending on its origin and processing. Cold press oils have been developed in response to consumer desire for natural, flavorful and healthy food products. The low temperatures involved in the cold press procedure cause less damage to the beneficial bioactive components within crude oils than conventional isolation methods. The purpose of this research was to determine the fatty acids and bioactive components present within cold press RBO, as well as the possibility of incorporating RBO into emulsion-based delivery systems. The saturated fatty acid (SFA) content of crude oil was 24.1%, with the majority being palmitic acid (20.1%). The unsaturated fatty acid (UFA) content was 75.9% with 41.8% oleic acid (18:1), 32.3% linoleic acid (18:2) and 1.0% linolenic acid (18:3). The crude oil also contained various bioactive components: total phytosterol (4662 ppm); tocopherol (187 ppm), tocotrienol (485 ppm); gamma-oryzano (10,000 ppm). RBO emulsions were prepared by homogenizing rice bran oil with aqueous solutions containing biopolymer emulsifiers: whey protein isolate (WPI); Gum Arabic (GA) and modified starch (MS). The effects of pH (3, 5 and 7) and thermal processing (50, 70 and 90°C) on emulsion stability were examined. WPI produced smaller droplets than MS or GA during homogenization. However, WPI-emulsions were unstable to droplet aggregation around their isoelectric point (4<pH<6) and at high temperatures (>70°C). There was no effect of pH and heat processing on RBO emulsions stabilized by MS or GA, which was attributed to strong steric stabilization. We also studied the stability of emulsified RBO to oxidation during storage (pH 7, 37°C). RBO emulsions stabilized by WPI had better oxidative stable than those stabilized by MS or GA. These results have important implications for the application of RBO in commercial food products.

Evidence of polymer mobility in a starch lintner
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Starch lintners are mostly crystalline material due to the hydrolysis of the amorphous zones by acid. It is hypothesized that crystalline structures within starch granules will not bind iodine. Polymer segments within the crystalline structure would have physical constraints that would restrict polymer mobility thus hindering the helical complex formation of iodine with glucan polymers. We developed a novel technique using atomic force microscopy to reveal polymer mobility in starch lintners using insitu exposure to iodine vapor. Atomic force microscopy is an established technique providing three-dimensional images with resolution in the nano-scale. Atomic force microscopy, absorption spectra and wide angle x-ray powder diffraction were used in the present study to investigate the interactions of potato starch lintner with iodine vapor. Absorption maxima with peak at 480 and 520 nm suggests

the presence of 20-30 DP long segments that are mobile and able to form iodine-glucan polymer complex. Cloud like structures following exposure to iodine vapor were observed underneath the crystalline blocklets in atomic force microscopy suggesting the interaction of iodine with glucan polymers in the amorphous regions of the lintner.

Extensigraph dough preparation based on protein content and 10-g mixograph for limited sample size

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The Brabender extensigraph is one of several empirical rheological instruments used to determine dough extension characteristics to predict end-product qualities of wheat flour. The extensigraph method (AACCI 54-10) utilizes 450 g flour and a 50-g farinograph to estimate mix time and water absorption. However, the official method does not always meet the needs of breeding programs that need to evaluate numerous experimental lines. Therefore, this study was to modify the official method in order to make the test more useful in terms of sample size, test speed, and objective dough preparation. The 10-g mixograph was initially incorporated to estimate dough mixing time based on water absorption that was calculated from the formula: $y = 1.67 x + 42.9$ (where x = % flour protein content, 14% mb). Dough for extensigraph testing was then prepared in a 100-g pin mixer based on 10-g mixograph peak time plus 30 sec and the calculated water absorption. As a result, overall flour sample size was reduced to 110 g from approximately 450 g for the standard method and dough preparation time was reduced to approximately 20 min from 90 min for the standard method. This modified dough preparation for the extensigraph method was highly correlated with data generated by the official method. The correlation coefficient (r) for 99 pairs of each of six extensigraph dough characteristics for 33 different tested wheat samples grown in the Great Plains, were 0.87 for energy (area under the curve), 0.88 for resistance-to-extension, 0.90 for maximum resistance-to-extension (Rmax), 0.82 for extensibility, 0.87 for ratio of resistance-to-extension to extensibility, and 0.89 for ratio of Rmax to extensibility. This rapid dough preparation may be useful for breeding programs and may also be considered as an alternative to the standard method used by industry, research, and crop quality surveys.

Influence of different sugars on the behavior of Caco-2 cells

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Cereal Foods World 55:A42

The specific goal of this study was to understand digestion and absorption mechanisms of simple glycemic substrates at the level of the small intestine enterocyte. Caco-2 cells, which differentiate in vitro into small-intestinal enterocyte-like cells were used. Although sucrase-isomaltase (SI) is the only mucosal glucogenic enzyme expressed by Caco-2 cells (maltase-glucoamylase is absent), this enzyme complex has the potential to digest every type of glycemic carbohydrate except lactose. In this study, Caco-2 cells were incubated with the disaccharides maltose, sucrose, and isomaltose, with cells showing only minor sucrase and isomaltase activities comparing to maltase activity. Digestion rate of disaccharides correlated to apical to basolateral transport rate of the released monosaccharides. Quantitative real-time PCR (q-RT PCR) results demonstrated an increase in synthesis of SI and glucose transporters GLUT2 and GLUT5 when substrates were present with differing quantitative responses. Some coordination was observed between the expression of the SI gene and glucose transporter genes. Western blot analysis showed that maltose incubation of Caco-2 cells over time resulted in synthesis of a higher molecular weight form of SI. This stimulation effect was concentration-dependent with highest expression of the variant occurring at 24 h of feeding cells with maltose. This may result from a glycosylation modification of the protein. This suggests a complexity of response to sugar sensing of the intestinal enterocytes that may be substrate specific. Caco-2 cells appear to sense maltose differently compared to monosaccharides glucose and fructose resulting in a change to the maltose-digesting enzyme. This may lead to a new approach regarding the control of glycemic carbohydrate digestion and glucose release.

Quality effects of sugar replacement with alternative sweetener blends in lean yellow-shortened cupcakes over a 4-day storage period

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In lean yellow-shortened cupcakes, the multiple ingredient approach was used to replace 100% of the sugar in the control with a commercial sucralose/maltodextrin blend (Splenda®Granulated) and isomalt. Sugar substitutions were 100% Splenda®Granulated (SP100), and two ratios of Splenda®Granulated to isomalt, 40:60 (SP40) and 50:50 (SP50). Data were analyzed with Mixed Model ANOVA ($p < 0.05$). No treatment effects were found for batter specific gravity, volume and crumb color (except a*); crust color and water activity differed. Texture Profile Analysis conducted daily over a 4-day storage period revealed significant treatment × storage interactions with springiness and cohesiveness decreasing, and hardness and chewiness increasing with storage. Instrumentally, texture of SP100 was closest to the control. Numerical differences found for texture characteristics, while significant, were small. Descriptive sensory panelists (DSP) (n = 7) evaluated 8 texture and 11 flavor attributes 1 and 3-days post-bake. Treatment, but not storage, affected intensity of 10 flavor attributes. DSP found springiness, cohesiveness and moistness decreased while hardness increased over the storage period. Isomalt moderated differences in flavor and texture attribute intensities found in SP100, with SP40 exhibiting a product profile most similar to the control. Consumer panelists (n = 66) evaluated acceptability (1 = extremely unacceptable, 9 = extremely acceptable) of the control, SP40, and SP100 1-day post-bake. Acceptability of the control cupcake was 6.6 ± 0.20, SP100 was 5.2 ± 0.20 and SP40 was 4.9 ± 0.20. 86% of the variability in overall acceptability ($p < 0.1$) was accounted for by texture (69%), flavor (15%) and appearance (2%) acceptability. In SP40 and SP100, sugar reduction was 94 and 93%; calorie reduction was 13% and negligible, respectively. Gum incorporation may increase texture acceptability. Reformulation effects in high-ratio formulations should be investigated.

Derivatization of rice wine mill using commercial carbohydrase

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Cereal Foods World 55:A42

Rice wine mill (RWM) is the major by-product of the rice wine industry. RWM contains lots of nutrients such as carbohydrates, proteins, vitamin B, vitamin E, phytic acid and inositol et al. While the rice protein is regarded as a good source of protein with its non-allergic characteristics, its application in food industry has been limited to animal feed. Therefore, the objective of this study was to increase the amounts of insoluble rice protein in RWM by hydrolyzing remaining carbohydrates in RWM using various commercial carbohydrases. Six commercial carbohydrases (Termamyl, Fungamyl, Liquozyme, Promozyme, Celluclast, and Viscozyme) were used to hydrolyze carbohydrate in RWM. The RWM (32.5% protein, 61.5% carbohydrate, 4.3% fat and 0.4% ash) was hydrolyzed with carbohydrases at their optimum pH and temperature. Amylolytic enzymes (Termamyl, Fungamyl, Liquozyme) showed the highest hydrolyzation (13.2 ~ 27.6%). Cellulolytic enzymes (Celluclast, and Viscozyme) showed relatively low hydrolyzation (7.4 ~ 8.9%) and Promozyme, which has pullulanase activity, showed the lowest hydrolyzation (2.7%). Although three kinds of carbohydrases were sequently applied to RWM in the order of Termamyl, Viscozyme and Promozyme to increase the hydrolyzation of RWM, its hydrolyzation was not significantly ($P < 0.05$) increase compared to single carbohydrase (Termamyl) treated RWM. Overall, insoluble protein content of RWM increased from 11.3% to 38.2% after hydrolyzation with Termamyl. This study provides the basic information of RWM and its hydrolyzation behavior with various commercial carbohydrases.

Improvement of sponge cake baking test procedure for simple and reliable estimation of soft white wheat quality

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The sponge cake (SC) baking test provides a reliable estimation of overall end-use quality of soft white wheat for Asian markets, and is widely accepted as a standard quality test. The SC baking test is, however, lengthy and laborious, and requires substantial experience to conduct with accuracy and reliability, which make it unsuitable for the routine evaluation of a large number of wheat breeding lines. We simplified the SC baking procedure in the egg whipping step; improved its consistency by replacement of cake batter hand mixing with mechanical wire whip mixing; and modified it for baking a cake of 50 g flour instead of 100 g flour. Egg foam whipping, mechanical batter mixing and 50 g flour cake baking conditions were optimized by comparing egg foam density and sponge cake volume to those of the original procedure. Comparable egg foam density and sponge cake volume to the original procedure were obtained with modifications including extension of egg whipping time without heat input using a KitchenAid mixer, one time water addition at 3 min before the completion of egg whipping, and cake batter mixing using a KitchenAid wire whip. For baking a 50 g flour cake, egg foam of appropriate density was obtained with increased speed and shortened egg

whipping time. The modified SC baking procedure yielded similar egg foam density and cake volume to the original procedure, and effectively differentiated soft wheat flours of different quality. Sponge cake volume of four soft white wheat flours of varying quality ranged from 1013 to 1373 mL with the original procedure, from 1048 to 1362 mL with the modified procedure, and from 598 to 755 mL with the reduced size procedure of 50 g flour.

Effect of red sorghum bran and its phenolics on the conversion of fermentable sugars and free amino nitrogen during yeast fermentation

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The effect of red sorghum bran and its extracted phenolics during fermentation with *Saccharomyces cerevisiae* with the aim of producing bioethanol was studied. The evaluated treatments were: 1) red sorghum; 2) white sorghum; 3) decorticated red sorghum ; 4) decorticated red sorghum supplemented with sorghum bran free of phenolics; 5) decorticated red sorghum supplemented with red sorghum phenolic extract and 6) maize. Raw materials were ground, liquefied with thermostable α-amylase and amyloglucosidase and fermented with yeast. The kinetics of free amino nitrogen and fermentable sugar conversion into fusel alcohols and ethanol were determined throughout 72 hrs fermentation. Glucose was the main sugar in mashes (130 g/L) followed by maltose (6 to 7 g/L) and in lesser extent fructose and maltotriose. After 25 hr fermentation of all treatments, the ethanol concentration varied from 50 to 90 ml/L whereas propanol from 30 to 60 ppm, isobutanol from 90 to 160 ppm and amylic alcohols from 250 to 500 ppm. Final ethanol yields ranged from 360 to 450 L per ton of ground grain. Efficiencies of ethanol production at the end of fermentation were statistically similar for all raw materials. These results indicate that the sorghum bran and its phenolic compounds did not affect the performance of thermoestable α-amylase and amyloglucosidase during biocatalysis and yeast during fermentation.

Influence of damaged starch on flour solvent retention capacity

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Cereal Foods World 55:A43

Solvent retention capacity (SRC), developed for soft wheat flour, is being widely used for flour functionality. Four solvents are used for the test: 5% lactic acid, 5% sodium carbonate, 50% sucrose, and water. Lactic acid SRC predicts potential gluten strength, sodium carbonate tests damaged starch, sucrose evaluates pentosans, and water the overall water binding properties of these three polymers in flour. The four SRC tests maybe correlated. Increasing one component may increase all four SRC values. Therefore, if flour contains higher amounts of damaged starch, the increase of other SRC values (e.g. lactic SRC), may not be higher gluten potential but partially due to damaged starch (the same for sucrose SRC and pentosans). The objectives of this study are (1) to investigate the effect of damaged starch on SRC profiles; (2) to quantify the change of each SRC value due to damaged starch change. Pure native wheat starch will be ground to produce starch samples which contain various amount of damaged starch. These samples will be mixed with flour in 1:9 ratio. The mixed samples will have the same level of gluten, pentosan etc., the only variable is the amount of damaged starch. The samples will be evaluated with the microscope to observe damaged starch granule, SD Matic to analyze damaged starch content, and all four SRC solvents to evaluate changes due to the damaged starch. The results with pure starch showed that after 10 minutes of grinding, all four SRC values increased due to the damaged starch increase; lactic SRC increased from 70 to 81%, sodium carbonate from 71 to 81%, sucrose SRC from 79 to 88%, and water SRC from 70 to 80%. The data indicated that the change of one SRC solvent influenced other SRC values. Testing with flour samples that contain various amounts of damaged starch will yield more information on how damaged starch influences SRC values, and the quantity of the change.

Protein quality evaluation using rat bioassays of three new chickpea *Cicer arietinum L* varieties for the northwest of Mexico

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Cereal Foods World 55:A43

Chickpea is the third dry legume in importance for human consumption. Mexico is considered one of the major chickpea exporters worldwide. The northwest part of Mexico produces chickpeas of the highest quality, and over 80% of this production reaches the international market. The recognized quality of Mexican chickpeas is due to the successful improvement programs carried out by experimental stations. This presentation reports on the evaluations of the protein quality of three improved varieties of chickpeas by rat bioassays, in an attempt to provide the experimental stations with complementary information, from the nutritional standpoint, for a better selection of chickpeas varieties for human consumption. The improved chickpeas varieties HOGA 012, HOGA 021 and HOGA 508. A commercial variety, Blanco Sinaloa 92 was used as reference. Cooked chickpeas were further dried in an air tunnel (65°C) and milled to 60 mesh particle size. Experimental diets were prepared, in which chickpea flours supply 10% protein. 14-day feeding trials (bioassays) were conducted using Sprague dawley rats (45-65 g) and % digestibility (dry matter, apparent N and true N) and Net Protein Ratio (NPR) were determined, for each three experimental chickpea diets and the commercial variety (reference). A casein control diet and a N-free diet were also included. Results showed that the new chickpea varieties were very similar in the % digestibility and NPR, slightly better than the commercial variety Blanco Sinaloa. There were significant differences in protein quality when samples were obtain from different states, but not when samples belong to fields within each state. The information on the protein quality of these new chickpea varieties will complement the agronomic attributes for a better selection of improved chickpea varieties.

Physical-chemical evaluation of wheat triticale flour mixtures and its relationship with tortilla quality

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Two breeding lines and a cultivar of triticale (Triticosecale Wittmack) and one cultivar of wheat (Triticum aestivum) with two different protein contents were used to produce flour mixtures and then analysed for their physical, chemical and rheological characteristics, relating these to the textural properties of tortillas. Wheat flours from cultivar Tacupeto with low protein content (T1B) and high protein content (T3A) were used as well as triticale flour from Pollmer cultivar (Poll), and BTR3 and E11 breeding lines. Six mixtures of wheat/triticale (70-30%) were obtained and labeled as: mixture 1 (T1B-BTR3), mixture 2 (T1B-E11), mixture 3 (T1B-POLL), mixture 4 (T3A-BTR3), mixture 5 (T3A-E11), and mixture 6 (T3A-POLL). Chemical, physical and rheological quality analyses were performed on each mixture. From each mixture, tortillas were produced in a commercial tortillería establishment and firmness and rollability were evaluated at 2, 24, 48 and 72 hours after preparation. Overall, mixtures of wheat/triticale flours showed significant diffferences ($p < 0.05$) in the physical-chemical and rheological tests, however, these differences did not show in the final product. During storage, firmness decreased in the first 24 hours and then kept without significant changes at 48 and 72 hours, regardless of triticale cultivar and wheat protein content.

Effects of milled flaxseed and hydrocolloids on processing and qualities of wheat tortillas

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The effects of milled flaxseed were evaluated in hot-press wheat tortillas to improve the nutritional quality and provide functional benefits. Milled flaxseed (2.5%) was compared with a traditional cellulose-based gum blend (0.8%). Evaluation included mixing characteristics, dough machinability, tortilla extensibility and toughness, finished product characteristics (diameter, weight, moisture content, and appearance), and rollability during storage (21-days). Doughs prepared with milled flaxseed were cohesive and extensible and performed similarly to the cellulose-based gum blend. Hot-press wheat tortillas containing milled flaxseed or cellulose-based gum blend were consistently round, puffed, slightly browned, and of good quality. Tortilla diameter was significantly increased at equal dough weights (40 g) with addition of milled flaxseed (15.5 cm) versus control (14.7 cm) and cellulose-based gums (14.4 cm). Moisture contents were similar for all tortillas (27.0–29.1%). The rollability and extensibility of tortillas was retained longer with milled flaxseed and the cellulose-based gum blend. Toughness was significantly higher in control samples (1213 g) compared with milled flaxseed tortillas (1011 g) and cellulose-based gum tortillas (1017 g). Milled flaxseed tortilla samples were more tender (human sensory) throughout shelf-life compared with both the gum blend and control tortillas. Rollability of all tortillas decreased during shelf-life, and tortillas containing milled flaxseed and gum blend had increased rollability with decreased cracking compared with control tortillas after 21-days of ambient storage. Extensibility at 21 days was significantly greater in milled flaxseed samples (9.4 mm) compared with control (8.1). Milled flaxseed addition to wheat flour tortillas provides both

nutritional and functional benefits, including improved shelf-life, eating quality, dough handling, finished product texture, and tortilla diameter.

The secondary substrate binding site of GH11 *Bacillus subtilis* xylanase A significantly affects substrate binding and activity

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Endo-β-1,4-xylanases (EC 3.2.1.8, xylanases) are frequently used in cereal based processes to improve processing or product quality. The selectivity they display for water-extractable or water-unextractable substrates is a prime determinant for their functionality. Recently, a non-productive secondary binding site (SBS) on the surface of two glycoside hydrolase family (GH) 11 xylanases, *Aspergillus niger* ExlA and *Bacillus subtilis* XynA, has been discovered. The function of this SBS for these single domain GH11 xylanases may be analogous to the function of carbohydrate binding domains (CBMs) in GH10 xylanases. CBMs can increase enzyme concentration on substrate surfaces by keeping the enzyme in close proximity with the substrate and thus impact substrate selectivity. The importance of the SBS in GH 11 xylanases was investigated by engineering of the SBS in the *B. subtilis* XynA xylanase. A set of enzyme modifications was made. Screening of cell lysates showed that all modifications made resulted in a lower activity towards polymeric substrate when normalized on activity towards xylohexaose. A selection of these enzymes was purified and their binding onto different insoluble polymeric substrates was tested. The binding onto insoluble oat spelt and birch wood xylan was drastically decreased upon modification of the SBS. Binding tests with water-unextractable arabinoxylan of wheat flour showed, apart from a weakened SBS for most modifications, that the binding to this substrate was enhanced for a few mutants. These results suggest that the function of SBS in some GH 11 xylanases is indeed analogous to the function of CBMs in many GH10 xylanases. Impact on the substrate selectivity of xylanases and thus on their functionality can be expected.

Specialty wheat protein, resistant wheat starch, and white wheat flour application in popular ethnic food, wonton wraps

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Consumer demand has shifted toward value added products. With health benefits, whole grain and dietary fiber are preferred choices for value addition in flour based products. Global economic growth has contributed to the growth of ethnic foods, triggering a demand across the food market. In the US, ethnic food sales reached a record $2.2 billion in 2009, and are expected to grow by 20% by 2014. Wonton is one of the most popular ethnic foods in the U.S. and Asian countries including China, Korea and Japan. They are made with a pastry wrap consisting of flour, eggs, salt and kansui. Many wonton wraps are supplied as a thin dough sheet. Before serving, wontons are boiled, steamed or deep fried. The purpose of this research was to develop value-added wonton wraps using resistant wheat starch (RS wheat), specialty wheat proteins, commercial noodle flours and US grown white wheat flour. Rheological measurement using the Texture Analyzer (TA-XTPlus) showed that vital wheat gluten increased dough strength while specialty wheat proteins reduced strength and increased extensibility. Addition of wheat specialty protein reduced the gluten index from 98% to 63% at the 4% level. It decreased dough development time and mixing stability which is consistent with a weaker gluten. Addition of vital gluten had little effect on dough and gluten quality. RS wheat (5%) had minimal effects on dough strength, extensibility, dough development time or mixing stability. Effects of combinations of these treatments are being explored. Color measurement taken on wonton dough sheets (L*, a*, b*) over a 24 h period showed that RS wheat reduced wonton darkening. Processing of wonton wrappers requires great dough extensibility to achieve thin dough sheet which makes specialty protein more appropriate in wonton production. RS wheat fortification (5%) increased fiber content to 3 grams per serving making it a good source of fiber.

Structure-property characterisation of maize and potato starch of varying granule sizes

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Starch, the major storage polysaccharide of cereal grains and tubers, exists in a broad range of size distributions that markedly affect the granule properties. Maize and potato starches were separated into narrow granule size fractions based on Stokes' law of sedimentation, and their composition, physicochemical properties and digestion kinetics investigated. The study showed protein, minerals and lipid have a negative correlation with granule size, whereas a positive relationship was observed with amylose content. DSC studies showed no effect on gelatinization temperatures but enthalpy values were significantly higher ($p < 0.05$) for larger granules. This indicates an increase in degree of crystallinity with granule size, in agreement with XRD, FTIR and Raman spectroscopic analysis of these starch fractions. Chromatographic data showed that the size of both amylose and amylopectin molecules in potato starch increased with granule size, however no significant difference was observed for maize starch. In vitro digestion further confirmed that smaller granules have a faster digestion rate faster than larger granules. Microscopy of in vitro digested starch showed a uniform 'inside-out' digestion pattern in maize starch, whereas a heterogeneous and non-specific pattern was observed for potato starch granules of all size distributions. The first order digestion rate coefficient (K) showed an inverse square relation with granule size. The rate coefficients for potato were ca 20 times lower than for the same size maize starch, showing the difference between an external granule surface barrier (potato) and a surface that includes numerous channels (maize) with a much greater specific surface area.

Assessing flour quality and functionality of fall planted spring wheat

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Three Ontario adapted spring wheats were planted in fall and spring planting experiments at the Elora research station Elora, Ontario. Two winter wheat checks were included in the fall planting as a measure of winter survival and agronomic traits. Agronomic data showed significant differences in winter survival amongst the spring wheat varieties (from 38% to 16% compared to 95% to 89%). Yield parameters showed increased number of spikelets per spike and fertile florets per spikelet over the spring-planted spring wheats. There was no significant difference noticed in thousand kernel weights except for Hoffman; however, spring-planted wheats had significantly higher test weight (87.6 vs. 83.5 for fall-planted spring wheat) which is a common difference between winter and spring wheat in Ontario. Disease data indicated that the spring wheat showed increased disease tolerance. Quality analysis was also performed and significant difference was noticed in gluten aggregation properties measured by using the Gluten Peak Tester. Farinograph stability decreased in fall planted Winfield and Norwell, while it increased in Hoffman as compared to their respective spring planted crops. Extensibility ratio R/E decreased significantly in fall planted Hoffman and Winfield, while it increased in case of Norwell. Protein content showed variability but did not increase significantly in all wheat varieties. MVAG peak viscosity was less in fall planted Hoffman and Winfield but remained unchanged in Norwell wheat. SRC value for Lactic acid was significantly less for fall planted Winfield and Norwell but no change was observed in case of Hoffman. These results show that fall planting improved the agronomic traits and affected wheat flour quality and functionality although further research is underway to further investigate the environmental and genetic component of these attributes.

Antioxidant and biological activities of aqueous extracts from tannin sorghum (*Sorghum bicolor*) bran and marama bean (*Tylosema esculentum*) seed coat

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Sorghum (Sorghum bicolor) is an important food cereal in the semi-arid tropics of Africa and Asia and condensed tannin types are known to have high levels of phenolic antioxidants. Marama bean (Tylosema esculentum) is an underutilized legume plant native to the Kalahari region of Southern Africa whose seed coats, which are usually discarded, could be a potential source for the extraction of natural antioxidants such as phenolic compounds with health benefits. Aqueous extracts from condensed tannin sorghum bran and marama bean seed coat were studied to determine their antioxidant and biological properties. Marama bean seed coat extracts had higher total phenolics, condensed tannin content, protein precipitation capacity and antioxidant activity compared to sorghum bran extracts. Gastric pH extraction of marama bean seed coats gave extracts with lower total phenolics, condensed tannin content, protein precipitation capacity and antioxidant activity possibly due to degradation of tannins in acid conditions. There was no significant difference in phenolic content and antioxidant activity between water and gastric pH extracts from sorghum bran. Water and gastric pH extracts from marama bean

seed coats had higher protective effect against 2,2'-azobis(2-amidinopropane) hydrochloride (AAPH)-mediated erythrocyte hemolysis compared to corresponding extracts from sorghum bran. The results show that sorghum bran and marama bean seed coats may be considered as significant sources of natural phenolic antioxidants with potential health benefits and for use as ingredients in foods.

The influence of low nitrogen conditions on quality and nutritional values in Quality Protein Maize (QPM)

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Maize is the most important crop in South Africa, and malnutrition is a big problem especially in the rural areas. The tragedy of hunger is still a reality in today's world. The protein of maize and of most cereals is deficient in the essential amino acids such as lysine and tryptophan. As a result of increased demands on food production from escalating population growth and environmental degradation, interest in improved breeding strategies for agricultural crops is growing. Breeding for higher concentrations of proteins and minerals in food crops is one option for improving the health of humans suffering from the consequences of mineral deficiency. QPM maize with high levels of lysine and tryptophan are available in Southern Africa, but the small-scale farmers are not yet enjoying the benefits of this. The aim of this study was to evaluate high and low lysine and tryptophan maize genotypes under nitrogen stressed conditions, which is one the main constraints of small scale farmers, and to determine whether differences in the concentration of minerals (P, K, Mg, Ca, Mn, Na, Zn, and Fe) between QPM varieties are affected by N stress. Our data suggest that lysine and tryptophan as well as minerals were significantly influenced by the environment in which they were grown with QPM hybrids showing higher protein quality characteristic values than that of the normal checks under both conditions. Tryptophan and total protein content were decreased in low nitrogen conditions and tryptophan was more stable than the protein content in both low nitrogen and optimal conditions. Many of the minerals were increased under N stress, but Fe, which is one of the most important minerals, was reduced.

Fundamental study on the relationship between protein changes occurring during malting and malting quality in sorghum

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During germination, cereal seeds' biopolymers are hydrolyzed to provide nutrients for the growing embryo. Protein hydrolysis constitutes one of the most important endosperm mobilization processes as it influences the breakdown of other biopolymers. The relationship between proteolysis and malting quality was studied for eleven sorghum cultivars by SDS-PAGE and 2-dimensional isoelectric focusing × SDS-PAGE. Extensive proteolysis occurred in all the malts. The extent of hydrolysis however varied between the cultivars as did the digestion of the various protein fractions. Kafirins were most digested in the superior malting cultivars Phofu, Segaolane, and Lars Vyt. Overall, α-kafirin disappeared the least (57%) compared to β- (75%) and γ- (67%) kafirin which were the most digested monomers in 6 and 5 cultivars, respectively. Variety-based differences in rates of disappearance of different kafirin monomers indicate possible variations in their individual susceptibilities to the key proteolytic enzymes present in the different sorghum cultivars. Increase in protein values for some albumin bands suggests de novo enzyme synthesis as was confirmed by 2-D electrophoresis. The lower number and intensity of protein spots in 2-D gels, representing key proteases and carbohydrases in Mafia malt, compared to Lekgeberwa, Phofu and Segaolane, confirms Mafia's lower proteolytic and malting qualities.

Extruded products based on whole wheat and mesquite: Chemical, sensory, and nutritional quality

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Cereal Foods World 55:A45

An increase interest on the elaboration of high nutrimental value content products has risen in the food industry, such as the breakfast cereal elaborated by extrusion. In the present study, an extruded product based on whole wheat and mesquite flours was elaborated, with the purpose to select the most acceptable product among the consumers and to determine its protein quality. The source of mesquite flour was from mesquite pods without seeds. Three mixes were formulated with the following whole wheat/mesquite flours ratios: 90:10, 70:30, and 50:50. The mixtures were then extruded, using a Screw Brabender Model KE19 extruder. Once the extruded products (pellets) were obtained, the proximate analysis and digestibility in vitro was determined to flours and extruded products. Sensory evaluation was conducted to determine the level of preference. Total amino acids were calculated based on the addition level. In vitro digestibility showed results of 81.1%, 78.4%, and 75.9% for flours blends and 82.5%, 77.6%, and 76.0% for extruded products: 90:10, 70:30, and 50:50, respectively. Sensorial evaluation was performed using a hedonic scale showing that the 50:50 was the most accepted one. From that mixture, the proximate analysis showed results of 12.6% of protein, 2.1 of fat, and 3.9 of ash, and the amino acid content showed a good balance as recommended for adults per day by FAO/WHO/UNO. According to these results, the 50:50 whole wheat-mesquite extruded product represents a viable alternative for the preparation of high quality nutritional breakfast cereal.

Properties of water-dispersible carbon black prepared by steam jet cooking with corn starch

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Starch-lipid composites prepared by steam jet cooking have been developed as an environmentally friendly technology for delivering hydrophobic substances as starch-coated microdroplets into aqueous systems. It has been shown that starch and amylose-fatty acid inclusion complexes adhere to the surface of lipid droplets, preventing coalescence of the droplets. In this investigation carbon black was used as the hydrophobic included phase to determine whether a microparticulate hydrophobic material would serve as a substrate for starch deposition. Starch-carbon black composites were readily dispersible in water, as were freeze-dried samples. Several approaches were used to provide evidence that starch coated the carbon black particles in a manner similar to lipid droplets. Washing the carbon black solids repeatedly with water to remove all soluble starch did not cause clumping or aggregation of the particles. Washed carbon black fractions were shown to liberate glucose on acid hydrolysis or amylase digestion. Thermogravimetric analysis revealed a weight loss associated with the oxidation of starch as well as carbon black. Liquid composites were stable with long-term storage, with carbon black remaining finely dispersed. Surfaces coated with dried films of these composites completely released the carbon black on washing without detergents. These experiments indicate that jet-cooked starch could be used without any surfactant or emulsifier to manufacture water-based, washable printing inks or coatings with carbon black as the colorant.

Investigation of wheat quality requirements and Australian wheat suitability for the traditional Indian wheat food chapati

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Ninety percent of wheat produced in India is used to make their staple wheat food chapati. India is currently experiencing record yields of wheat, but wheat production has been forecast to stabilise and challenge India's ability to supply the increasing demand. Australia has been identified as a potential exporter of wheat to India. For Australia to provide suitable quality grain, understanding of India's major wheat end product is required. The aim of the study was to investigate the ability of Australian wheat varieties to make the traditional Indian wheat food chapati and to gain further understanding of the relationships between wheat quality and end product quality. Twenty four Australian wheat cultivars grown in two different locations in Western Australia were harvested from the 2008/ 09 season. Six Indian wheat cultivars, obtained from India, vary in chapati quality and were used as benchmarks in the study. Wheat samples were milled on a laboratory stone mill to produce whole wheat flour. Standard wheat quality tests were conducted to characterise flour quality. Chapatis, 150 mm in diameter and 2 mm thick were prepared. Chapati quality attributes were evaluated and included colour measurement using a Minolta chromameter, texture analysis using a texture analyser, Stable Microsystems and measurement of puffed height. Preliminary results indicate that water absorption, grain hardness and damaged starch are correlated to dough stickiness, dough rolling and chapati puffing characteristics ($P < 0.05$); and sieved flour yield correlated to flour, dough and chapati colour, ($P < 0.05$).

Characterisation of HMW-GS and LMW-GS in Australian and Indian wheat cultivars and their relationship to chapati quality

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Wheat storage proteins have been determined as a major determinant of quality for baked wheat foods. The high molecular weight (HMW) and low molecular weight (LMW) glutenin proteins in particular, have significant affects on dough rheology and are therefore important to end product quality. The association between HMW glutenin subunits 5 + 10 with good bread making is well documented. Chapati, however is an unleavened flat bread and has different protein quality requirements to pan bread. The research aims to identify glutenin subunits which have potential as markers of chapati quality. The research presented is part of a study investigating wheat requirements for chapati. The HMW and LMW glutenin proteins of twenty five Australian and six Indian wheat cultivars were characterised using matrix assisted laser desorption / ionisation time of flight (MALDI-TOF) mass spectrometry; chapati quality was previously determined. The glutenin proteins were extracted from whole wheat flour using 55% 2-propanol and 0.08M tris-HCl containing 1% dithiothreitol; acetone was used to precipitate proteins. The precipitated HMW and LMW glutenin proteins were dissolved in acetonitrile/ water (v/v 50:50) containing 0.05% v/v trifluoroacetic acid. A Voyager DE-PRO TOF mass spectrometer was used to perform MALDI-TOF mass spectrometric analysis. The HMW-GS and LMW-GS were identified from the mass spectrums. The genotyping results suggest that there are no strong correlations between HMW-GS composition and chapati quality attributes. Thus dough strength may not be critical for chapati making; instead dough extensibility may be of importance.

Studies on the improvement of the elastic component of corn zein doughs

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Cereal Foods World 55:A46

Non-wheat cereals are considered unusable for dough making due to the lack of viscoelastic structure, whereas wheat gluten forms a three-dimensional viscoelastic network upon hydration and mixing. Two protein fractions have been recognized to form the wheat gluten viscoelastic network; gliadins and glutenins. Gliadins are alcohol soluble proteins and believed to be responsible for viscosity and extensibility of dough. Glutenins are composed of low molecular weight and high molecular weight (HMW) subunits. The latter have been considered particularly important in determining gluten and dough viscoelasticity. Unlike wheat gluten, corn zein is not able to form viscoelastic dough at room temperature. However, zein was reported to form viscoelastic dough at >20% moisture content when held and mixed at 35°C, which is above its glass transition temperature (28°C). The purpose of this study is to improve viscoelasticity of zein doughs through increase of the elastic component. Starch (87%) and protein (13%) were mixed into dough in a 35-g Swanson mixograph (National Mfg. Co.) at 35°C. Small deformation oscillatory tests were performed using a rheometer (ARG-2 Model from TA Instruments, Newcastle, DE) within the 0.1–40% strain range to identify the linear viscoelastic region. Rheological results indicated that addition of small amount of HMW glutenin caused changes in elasticity of zein dough. Dough samples prepared with gluten exhibited a typical behavior of elastic material, where G′>>G″ as opposite to both samples containing zein. However, the use of HMW glutenin increased somewhat the elasticity of zein.

A simple, fast, and reliable method to predict pasta yellowness

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Cereal Foods World 55:A46

Pasta yellowness depends on the semolina carotenoid content, carotenoid degradation by lipoxygenase (LOX), and pasta processing conditions. In breeding programs, early generation lines are selected for high yellow pigment with the intent to improve pasta colour. This approach has been successful in improving the quality of Canadian durum wheat in the last few decades. In recent years, however, no relationship (r = 0.19–0.27) between pasta yellowness (b*) as measured by Minolta spectrophotometer and semolina yellow pigment content among the durum wheat lines were noted in advanced durum wheat lines evaluated in Canadian Durum Wheat Variety Registration Trials. Thus, total yellow pigment content in semolina cannot effectively predict yellowness of its end product pasta. Therefore, a fast and simple method was developed to predict pasta yellowness by measuring semolina dough sheet colour at different time intervals after sheeting (0.5, 2.0 and 24 hrs). Spaghettis were processed from the semolina samples at two drying temperatures (70°C and 90°C). There were significant correlations (r = 0.87–0.94) between dough sheet b* values at all three times and spaghetti b* values at both drying temperatures. Semolina dough sheet b* values can be used to predict pasta yellowness without making the end product which involves mixing, extrusion, and drying. In this study, we also found that dough sheet b* values increased with time after sheeting (up to 12 units from 0.5 hr to 24 hrs), and this increase was more pronounced in some breeding lines over the sampling intervals. This phenomenon appears to contradict the LOX catalyzed pigment degradation theory and the biochemical basis for increasing yellowness remains to be investigated.

Mixolab studies for Kansas wheat varieties dough systems with bran addition

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Mixolab measures real-time dough behavior at controlled mixing rate and temperature to analyze quality of the protein network, starch behavior and enzymatic activity. The aim of this study was to evaluate the effect of bran addition (0–10%) to four Kansas grown hard red winter wheats (Karl 92, Overley, 2137 and Santa Fe) at constant water absorption using Mixolab. The resulting mixing and pasting curves were analyzed using standard Chopin+ protocol. Water absorption (C1), mixing stability, protein weakening (C2), starch gelatinization (C3), amylase activity (C4) and starch gelling (C5) were determined. Slopes α, β, and γ are the indicators of protein weakening, starching speed and enzymatic degradation, respectively. The water absorption for four flour varieties (Karl 92-91.3%, Overley-89.3%, 2137-88.4% and Santa Fe-92.1%) was determined on dry basis for target consistency level (1.1 Nm) and kept constant to study the effect of bran addition. C1 of Karl 92 dough systems increased from 1.15 to 1.24 Nm as the bran addition increased indicating increase in water absorption capacity. Similar results were observed for all other varieties of flours. C2 increased from 0.45 to 0.64 Nm for all the flours with the increase of bran addition. Increase in C2 indicated less weakening effect of bran addition to flours under temperature increase. The stability improvement was higher in Karl 92 (9.3-11.0 min) and Overley (8.9-11.2 min) as compared to 2137 (9.2-9.9 min) and Santa Fe (8.7-9.7 min) with the addition of bran which confirms the protein network improvement. Increase in C3 accompanied by a reduction in C3-C4 difference was observed in all flours indicating starch stabilization and better heat resistance with bran addition except with 2137. Results indicated that Mixolab is a complex device that can be used to characterize the effect of bran addition in wheat varieties.

Monitoring the sodium content of foods including grain-based products

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The 2005 Dietary Guidelines for Americans includes the recommendation to consume less than 2,300 mg of sodium per day. For population groups at risk for hypertension, the recommendation is to consume no more than 1,500 mg of sodium per day. However, the mean sodium intake for people 1 year of age and older, based on the What We Eat in America, NHANES 2003-2006 (WWEIA), is 3,411 mg of sodium per day. Since most of the sodium in the diet comes from processed and restaurant foods, public health advocates are pushing for the voluntary reduction of sodium in these foods. In order to monitor changes in key contributors of dietary sodium, the USDA's Nutrient Data Laboratory has developed a plan to identify, rank, and monitor the sodium content of these foods. While 3,000 foods in the USDA National Nutrient Database for Standard Reference (SR) provide the basis for the nutrient content of the 7,000 foods reported in WWEIA, 2,000 single ingredient foods (e.g., fruits, meats) can be excluded since they are not processed with the addition of salt. Sodium data for the remaining 1,000 foods and amounts consumed in the 2005-2006 WWEIA surveys were used to rank the foods by sodium contribution to the diet. Approximately 60 generic foods contributed 50% of the sodium intake from all processed foods. Some of these foods may not be particularly high in sodium content, however they rank high in sodium contribution to the diet based on the large quantities consumed.

About 25% of these 60 foods are grain-based products, e.g., bread, rolls, flour tortillas, biscuits, pretzels, and tortilla chips. To maintain current and accurate sodium data in SR, plans have been made to monitor the sodium content of the top contributors based on selected analysis of foods and label claim information.

Roles of egg and egg-replacers in determining yellow cake quality

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Egg is commonly used as an ingredient in yellow cake, a common bakery product. When commodity prices are high, food manufacturers substitute eggs with egg replacers, to reduce production costs. The objective of this study was to evaluate the properties of yellow cakes made with egg and egg replacers, in order to evaluate the effects of these ingredients on product quality. Yellow cake samples were prepared using liquid whole egg and dry whole egg (controls) and a combination of dry egg with three different egg replacers; soy and wheat-based [R1], whey protein based [R2], and fiber and gum based [R3], while keeping other ingredients constant. Replacing eggs at 100% (w/w) did not produce acceptable product quality with any replacer. For evaluating the replacers, total egg contents were replaced at 15% (R3), 70% (R1) or 75% (R2) (w/w) levels, as determined by a series of preliminary tests. Batter preparation and baking conditions (176.7°C, 24 min) were equivalent for all samples. Texture, color, bulk density, and sensory properties of the samples were analyzed. Yellow cakes made with liquid and dry egg were more cohesive, compared to the other formulations. Liquid egg, dry egg, and R2 produced lighter surface colors (high L*) compared to R1 and R3. Liquid egg and R2 yielded more yellowish crumb color (high b*) cakes. Highest density was observed in R3 containing cake. Sensory analysis showed that control samples had a drier texture compared to those made with egg replacers, although the controls showed lesser bake losses. The overall flavor and sample acceptability were lowest for R1 containing cakes, while other specific sensory attributes were different ($p < 0.05$) among the samples. This study suggests that egg plays an important role in yellow cake, in determining specific product properties and sensory attributes.

Wheat characterization with the CD1 auto mill

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Cereal Foods World 55:A47

Raw material characterization in laboratories often requires transforming wheat into flour. The flour quality results greatly depend on the control of the milling process. The CD1auto mill is an automated laboratory mill which allows producing enough flour to realize laboratory and breadmaking tests. It is equipped with a breaking part (3 grooved cylinders) and a reduction part (two smooth cylinders) and two centrifugal sieving chambers allowing the separation of the milling products. The first objective is to estimate the impact of the semolina sieve size of the reducing part (310 µm or 360 µm), on the milling balance and the flours quality measured with Alveograph (54-30.02 & NF IN ISO 27971) and SDmatic (76-33.01). And the second one is to optimize the mill regulations (semolina flow, products progress on sieves, pressure between cylinders) to obtain with a 360 µm sieve, a higher extraction rate and an identical flour quality, to the test realized with a 310 µm sieve. In addition for this second part, breadmaking tests (NF V03-716) were performed. The first tests showed that 360 µm sieve allows increasing the extraction rate. It changes flour properties such as the damaged starch which is lower than with 310 µm sieve. The rheological qualities are also modified; the dough tenacity is lower. The second part of the study showed that the calibration of the CD1auto mill with the 360 µm sieve is possible by changing some settings. The flour quality is then similar to flour milled with the 310 µm sieve keeping the high extraction rate. With the optimization of the settings, the CD1auto mill can be equipped with 310 µm or 360 µm sieve, allowing obtaining identical quality flours and extraction rates in agreement with the laboratories needs.

Physical, alimentary and functional properties of chickpea (Cicer arietinum L) genotypes grew in northwest of México

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Genotype, growing location and genotype x growing location interaction effect over physical, physicochemical, functional characteristics and hardening propensity of chickpea genotypes grew at four locations in the northwest of México were examined. It was used 18 genotypes of chickpea grown in the location of Culiacan, Los Mochis, Hermosillo and Obregon. Chickpea seeds were hardened by accelerated storage under controlled conditions (37°C ± 1°C, RH = 100%, 8 days). A fresh and hardened seeds were evaluated for physical, physicochemicals, and functional properties, such as water absorption capacity (WAC) and cooking time (CT). Interaction genotype x location affected significantly ($p \leq 0.05$) physical, chemical and functional chickpeas seeds. In general, accelerated storage decreased ($p \leq 0.05$) the WAC and increased ($p \leq 0.05$) on CT chickpeas (WAC 99.53-126.04% fresh grain and grain hardened 83.43-111.7% TC, fresh grain 141.5 - 240.5 min and hardened grain 138.5-269.5 min), but some genotypes (Hoga-021, Hoga-508, House-607, Hoga-T180 and-PRO23 in all locations) were not affected. These genotypes may be used in breeding programs of this important legume. Genotype, growing location and genotype x growing location interaction significantly affected ($p < 0.05$) rehydration parameters (maximum water absorption capacity, water absorption constant, maximum water absorption rate) and the time needed to get half of the maximum water absorption capacity), calculated using Peleg model.

Distribution of non-starch polysaccharides in soft wheat pilot mill streams

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Cereal Foods World 55:A47

The general objective of commercial soft wheat milling for low water absorption flour is to optimize flour extraction while minimizing starch damage and arabinoxylan (AX) and protein concentration. Previous millstream analyses have used mills optimized for milling hard endosperm wheat for bread applications and have analyzed grain samples of either unspecified or identifiably hard endosperm. Yet the fracture properties of soft endosperm wheat kernels profoundly influence flow through the flour mill. Because of the different milling characteristics of soft wheat, industrial mills typically are optimized for this task. A cross-section of seven eastern U.S. soft winter wheat genotypes were milled on a Miag Multomat flour mill flowed for soft wheat milling. Flour yield, ash, protein concentration, and water-extractable (WE-) non-starch polysaccharide concentration were measured on all ten streams. Flour protein increased linearly across the three break streams, and increased linearly across all reduction streams. WE-Xylose concentration also increased linearly across the reduction streams. Variation among genotypes in WE-Xyl in the 2nd reduction stream largely predicted straight grade WE-Xyl. Flour ash, WE-galactose, and WE-glucose concentration, in contrast, increased exponentially across the reduction streams. WE-Glu is a sensitive measure of starch damage: genotype rankings for enzymatically accessible damaged starch (AACC 76-31) aligned with shape factors for WE-Glu. The ratio of Ara/Xyl, a measure of AX quality, declined exponentially across the reduction streams.

Validation of convenient methods for Food Allergen Management – ELISA and Lateral Flow Device Test Kits

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Cereal Foods World 55:A47

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. Cross contamination during production processes may occur so that residues of food allergens may be present in a variety of products. Allergens continue to be the largest single cause of global product recalls. The aim of this work was to validate commercial Test Kits like sandwich enzyme-linked immunosorbent assays (ELISA) and lateral flow devices (LFD) which can both detect food allergens in a wide range of food matrices. A lateral flow test kit using a new monoclonal gluten antibody, called G12, specific for a peptide sequence for the 33-mer of gliadin, was developed to detect the toxic fractions of gluten from wheat and other cereals such as barley, rye and, with a lower level of sensitivity, oats. The allergen ELISA test kits validated have quantitation ranges of 1-40 ppm (Peanut and Hazelnut), 4-120 ppm (Gluten), 40-1000 ppb (Soy), 0.4-10 ppm (Almond and Egg white), 2-60 ppm (Walnut) and 10-400 ppb (Beta-Lactoglobulin). The limits of detection are 0.1 ppm (Peanut), 0.3 ppm (Hazelnut), 0.6 ppm (Gluten), 16 ppb (Soy), 0.2 ppm (Almond), 0.05 ppm (Egg white), 0.35 ppm (Walnut) and 1.5 ppb (Beta-Lactoglobulin). Extensive validation studies indicated low detection limits,

good accuracy, precision and recovery between 60 and 122% on these test kits.

Antioxidative activity and quality properties of hard wheat flour dough and bread with the addition of different phenolic acids

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Cereal Foods World 55:A48

The purpose of this study was to investigate the effect of baking process on the antioxidative activity and quality properties of different phenolic acids. Four phenolic acids, caffeic acid, ferulic acid, syringic acid, and gallic acid, were mixed with wheat flour at a concentration of 4.44 μmole/g of flour. The addition of phenolic acids reduced the mixing time and mixing tolerance. The maximum resistance (Rmax) of the dough was most significantly reduced with the addition of caffeic acid and ferulic acid in both optimum and over mixed. Bread volume was most significantly decreased with the addition of caffeic acid. Type of phenolic acid and processing affected antioxidative activity. Of the phenolic acids, caffeic acid had the most pronounced antioxidative effect. The ranking of phenolic acids in terms of their antioxidative activity in fermented dough and bread was similar to that before processing, viz. syringic acid < gallic acid < ferulic acid < caffeic acid. The content of ferulic acid was greater than that of the other phenolic acids after baking. Antioxidative activity and free phenolic acid content were reduced by mixing, but recovered after fermentation and baking. The decrease in antioxidative activity in mixing can be explained by interactions between the thiol free radicals of gluten and phenolic acid in which phenolic acid acts as a reducing reagent. The increase in antioxidative activity of fermented dough indicates that bonds with antioxidants are hydrolyzed during fermentation, releasing antioxidants that scavenge free radicals. Free phenolic acid recovery after baking was 74–80%. Phenolic acids retain their antioxidative activity after the bread making process, which has potential health benefits for consumers. Elucidation of interactions between the bread making process and phenolic acids is important for the development of functional foods.

Physicochemical properties of high yield rice varieties in relation to rice noodle quality

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Tongil-type high yielding rice varieties derived from crosses between IR lines and Japonica varieties give yields 30% higher than the leading traditional varieties in Korea. The purpose of this study was to investigate the physicochemical and pasting properties of high yielding rice flour in relation to noodle quality. Five rice cultivars were wet milled (stone mill) and freeze dried into the flour to produce rice noodle. Grain hardness, particle size distribution and polarized microscopy of flour particle were analyzed. The starch properties studied were flour swelling volume, total amylose content, A to B ratio of starch and damaged starch content. Rapid visco analyzer pasting profiles were generated to examine the cold paste, hot paste, and set back viscosities of the flours. Steamed rice dough was extruded to rice noodle. Texture profile analysis, tensile strength and cooking loss was observed to evaluate the cooked noodle quality. The ash content was increased with increasing particle size and grain hardness. The content of damaged starch was showed high correlation with grain hardness, cooked noodle texture and cooking loss. Amylose content was highly correlated with flour swelling volume, noodle hardness and gumminess. Rapid viscosity analysis parameters and textural parameters of gels formed in the RVA were very well correlated with noodle textural properties.

Changes of physical properties of octenyl succinic anhydride rice starches by gamma irradiation

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Cereal Foods World 55:A48

The effect of gamma irradiation (0, 10, 30, 50 kGy) on the octenyl succinic anhydride (OSA) waxy and high amylose rice starches (amylose content 0 vs. 28%, respectively) were examined. For both of OSA waxy and high amylose rice starches, the pasting viscosity decreased with the irradiation dosage increase. For the pasting temperature, there was no difference between OSA waxy rice and irradiated OSA waxy rice starches, however, the irradiation lowered pasting temperature in OSA high amylose rice starch. Significant setback decrease was examined in the irradiated OSA high amylose rice starch, and this could be explained that irradiation degraded amylose chains, resulting in prevent of chain association during cooling. For the thermal properties, the gelatinization temperature significantly decreased in OSA waxy and high amylose rice starches with irradiation dosage increase, however, a little change in melting enthalpy was measured. Little decrease in crystalline peak was also observed in x-ray results, indicating the chain cleavages in OSA starch by irradiation were mainly happened in amorphous region. The emulsification capacity of OSA waxy and high amylose rice starches increased by gamma irradiation, and the highest emulsion capacity of OSA waxy and high amylose rice starches was obtained by 10 kGy irradiation.

A new technique to extract and dissolve starch from cereal grains for accurate structural analysis

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Cereal Foods World 55:A48

Starch structure analysis requires a complete dissolution of starch without degradation and removal of non-starch components that might interfere with the result. A new technique has been developed to extract and completely dissolve starch from cereal grains, which involves cryo-grinding, protease pre-treatment, dissolution in dimethyl sulfoxide solution containing 0.5% (w/w) LiBr (DMSO/LiBr) at 80°C, centrifugation, ethanol precipitation, and, finally, re-dissolution in DMSO/LiBr at 80°C. Rice, sorghum, wheat, and barley grains are used to test the effectiveness of the new technique for starch structure analysis. A brief cryo-grinding and the dissolution in DMSO/LiBr had negligible effects on the size distribution of starch molecules measured by size-exclusion chromatography. A minor starch loss (up to 15%) was observed after the extraction and dissolution; however, the ratio of amylose to amylopectin did not change significantly suggesting that the starch loss was not size-selective. The protein content of the sorghum sample was reduced to 2.7% from 11.2% by this technique, whereas that of the rice sample was reduced only to 4.4% from 6.1%. Although the proteins of some samples were not completely removed, the peaks of the non-starch components did not interfere with the amylose and amylopectin peaks in the size distributions confirmed by comparing with the amylose and amylopectin peaks of the wet-milled starches. The amylopectin components by the new technique also had larger hydrodynamic radii (peak Rh ~ 2000-2500 nm) than the respective counterparts obtained by conventional wet-milling (peak Rh ~ 300-1400 nm) and that obtained without protease pre-treatment (peak Rh ~ 800-1900 nm), suggesting that molecular degradation was reduced and molecular aggregation was not likely. This new technique allows a more accurate structural analysis of starch molecules from grains than conventional treatments.

Production of sourdough corn and barley breads using a starter culture

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Sourdough fermentation was used to improve the general characteristics of corn and barley breads. *Lactobacillus* sp. C1, a maltose-fermenting lactic acid bacterium, was isolated from a spontaneously fermented wheat sourdough. A starter culture containing C1 in MRS broth and *Saccharomyces cerevisiae* in Malt Extract broth was mixed with sterile water to a final concentration of about 10^7 cfu/g and added to the selected flour (wheat, corn or barley). The mix was incubated at 27°C for 8 h to form the sourdough. Breads were prepared by mixing (g) sourdough (500), flour (1350), water (925), skim milk (250), sugar (6), salt (18), instant yeast (7.5) and shortening (25) for 3 min with a Hobart mixer. After a floor time of 30 min at 28°C, the dough was divided into 90 g loaves and molded mechanically. The loaves were proofed in pans (60 min at 30°C) and baked at 190°C for 45 min. The doughs were analyzed for pH and volume increase after the proofing process. The breads were sensorially analyzed (taste and aroma) and their volume recorded using the rape seed displacement method. The final pH values of the sourdoughs were 4.46, 4.55 and 4.74 respectively for wheat, corn and barley. Only the wheat dough showed an increase in volume (95%). The breads of the two non-wheat flours were heavy and compact. Density values were 0.65, 0.89 and 0.92 g/cm^3 respectively for wheat, corn and barley products. All three breads were equally preferred when taste and aroma were sensorially evaluated and described as having homogeneous crumb structure.

A maize-based snack fortified with toasted chickpea flour: Evaluation of preference at the consumer level and protein quality by rat bioassays

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Snack foods industry is a continuously growing business, largely because the high level of preference of these products, especially among young people; even though these products are generally recognized as "low quality" from the nutritional standpoint. In Mexico, snacks made from maize are largely preferred, but their nutritional contribution to the diet is insignificant. A maize-based snack fortified with toasted chickpea flour was prepared in a commercial factory. Three levels of fortification were studied: 20, 30 and 40%, in terms of the % protein increase in the final product. A consumer preference test was also conducted in which consumers were asked to select the preferred level of fortification. These fortified snack were also evaluated in comparison to several commercial unfortified snacks. Protein quality evaluation through rat bioassays were determined in the consumer preferred fortified snack, using commercial snacks as references. 14-day feeding trials, using Sprangue dowley rats (45-65 g) were carried out, where experimental diets were adjusted to 10% protein, supplied by snack flours. Protein quality parameters measured were % N digestibility (apparent and true) and Net Protein Ratio (NPR). A casein-based diet (control) and a protein-free diet were also included for the bioassays. Consumer preference test showed that the consumers were not able to distinguish between fortified snacks with 20% and 30% toasted chickpea flour. However, protein quality, determined by bioassays, did show a significant difference between these two levels of fortification. Toasted chickpea flour (30%) is then recommended as an excellent ingredient for the improvement of the protein quality and nutritive value of maize-based snacks.

Whole wheat spaghetti contains more flavonoid glycosides and lignans than regular wheat spaghetti

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Cereal Foods World 55:A49

Consumption of whole-wheat products including whole-wheat spaghetti is associated with beneficial health effects. Flavonoids and lignans are antioxidant phytochemicals that have received much attention from researchers. Investigations were conducted on the flavonoid glycosides and the lignan, secoisolariciresinol diglucoside (SDG) as contributors to the health promoting properties of whole wheat spaghetti. Flavonoid glycosides present in the regular- and whole-wheat spaghetti samples were identified as 6-*C*-glucosyl-8-*C*-arabinosyl apigenin and the sinapic acid adduct of apigenin-*C*-diglycoside. The content of these compounds were found to be significantly higher in whole-wheat spaghetti (11.95 and 12.31 µg apigenin equivalent/g) compared to the regular brands (5.08 and 4.42 µg apigenin equivalent/g). SDG content was also found to be significantly higher in whole wheat spaghetti (41.83 µg/g) compared to the regular brands (12.87 µg/g). These findings lend further support to the notion that phenolic compounds along with dietary fiber are concentrated in the bran layers of the wheat kernel. Regular consumption of whole grain wheat spaghetti is therefore strongly recommended to obtain significant levels of health promoting phytochemicals.

The effects of prebiotic carbohydrates on the physical properties of commercial food prototypes subjected to various processing treatments

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Chicory inulin, short chain fructooligosaccharides (FOS), galactooligosaccharides (GOS), polydextrose, and resistant starch (RS) were formulated into seven reverse-engineered, cereal grain-based food models based on common industry standards. The effects of these prebiotics on the physical properties (color, matrix structure, and size) of the prototypes were studied. Each matrix was modeled to exhibit different combinations of fat content, moisture content, and processing conditions. White-pan bread containing FOS produced excess carbon dioxide gas, resulting in considerable volume loss during subsequent proofs. FOS bread also produced darker crust than the five remaining formulations including the control. Cookies formulated with FOS and GOS consistently exhibited smoother cookie tops. FOS, inulin, and polydextrose cookie formulations exhibited greater cookie spread with 8.17, 8.06, and 8.05 width-to-thickness ratios, respectively, when compared to the control ratio of 6.93. Notable differences in muffin internal color were not observed. Muffins formulated with RS exhibited tighter and more uniform air-cell infrastructure. Compression force, measured over a 7 day period, increased by 4.4 N/s after seven days when RS was added to the formulation. Texture analysis suggests inclusion of RS contributes to muffin staling, as indicated by the increase in force needed to compress muffins. Knowledge gained from these trials will provide the food industry with a valuable starting point for formulating prebiotic enhanced food products.

Hydrolysis of rice syrup mill using various commercial proteases

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Cereal Foods World 55:A49

Rice syrup mill (RSM) is one of the most abundant co-products in starch syrup industry. But, the most of all is just used for animal feed because there is a limitation to be used for food ingredients. Enzymatic treatment of RSM is the one possible way to improve the value of RSM and some enzyme treated RSMs are used in food industry. In spite of high protein content of RSM, limited information is available on the application of RSM protein in food industry. The objective of this study is to improve the potential of RSM protein in food industry by hydrolyzing RSM protein with various commercial proteases. The RSM was enzymatically hydrolyzed using eight commercial proteases (Protamex, Neutrase, Flavourzyme, Alcalase, Protease M, Protease N, Protease A, Molsin F) for 4 hr at optimum pH and temperature. Proteolytic hydrolysates were examined in supernatant and precipitate using lowry protein assay method and gravimetric method using weight difference before and after enzymatic hydrolysis. Although RSM contains high amount of protein (71.2%), very small amount of protein was hydrolyzed. Two proteases (Protease M and Protease N) were found to be the most effective in the hydrolysis of RSM protein. In lowry method, 57.5 and 59.0 mg protein/g RSM are hydrolyzed after Protease M and Protease N treatments, respectively. In gravimetric method, 80.0 and 85.4 mg protein/g RSM were hydrolyzed after Protease M and Protease N treatments, respectively. For synergistic effect, two or three effective commercial proteases (Protease M, Protease N and Protease A) were applied to RSM at one time. The highest hydrolysis of RSM protein was observed in both lowry protein assay (80.3 mg protein/g RSM) and gravimetric methods (153.2 mg protein/g RSM) when three commercial proteases were applied at one time suggesting synergistic effect of those proteases.

Using lateral flow devices for quantitative and semi-quantitative analysis of mycotoxins and GMOs

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Lateral flow devices are often used for rapid, qualitative testing for the presence of mycotoxins or GMOs in grains. These rapid tests are widely used in the field for screening purposes. These tests may be adapted for quantitative or semi-quantitative use by incorporating a strip reader to analyze the test strips. These tests are based upon ELISA principles. The presence or absence of a visual marker on the device is used to indicate the presence or absence of a toxin or GMO trait in the sample. The visual 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 quantitatively or semiquantitatively measure the toxin or trait in a sample. The use of digital imaging software with the reader allows for rapid, objective methods with results independent of the individual user and permanent digital records of the strip results. Validation studies on this technology were performed for the mycotoxins deoxynivalenol and fumonisin, and the GMO CP4 EPSPS. The mycotoxin methods were found to be quantitative over the ranges of 0.2–4.0 ppm (for DON) and 0.2–8.0 ppm (for FUM), when the tests are run at room temperature and the strips were incubated for 3 minutes. For example, a series of fortified samples within the quantification range on the DON lateral flow method for wheat showed recoveries between 90–115%, while the HPLC reference method showed similar results with recoveries between 70–95%. The GMO method was found to be semiquantitative over a range of 0.1%–3.0% modified seed in unmodified seed, when the test was run with temperature control in an incubator for 5 minutes. Based on the results of foritifed samples, GMO content can be semiquantitatively determined within ranges (for example, 0.1–0.5% GMO).

Testing for mycotoxins using LC/MS/MS

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Mycotoxins have traditionally been detected by a variety of methods, including rapid methods (test kits) and reference methods, such as HPLC and GC. Of the reference methods, GC can be limited due to the necessity of derivatizing the compounds of interest. This may also be required for some HPLC methods. However, liquid chromatography may be used in conjunction with a variety of detectors, including fluorescence, UV-VIS, and others, including mass spectrometers. The coupling of liquid chromatography with a mass spectrometer (or tandem mass spectrometers, 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. These methods also have the benefit of providing structural information on the target compound and the possibility of testing for many analytes in one run. Matrix effects and the effects of variations in sample preparation may be eliminated by the use of stable isotope-labeled internal standards. These features make LC/MS/MS methods useful and versatile in the detection of mycotoxins. 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 the 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 were 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. The results compared favorably, with only a 2% difference seen between the methods over concentrations ranging from 30 to 1000 ug/kg.

Comparing the fermentation power of wheat and apple sourdough starters using the Risograph

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Cereal Foods World 55:A50

Sourdough is traditionally a mixture of wheat or rye flour and water that is fermented by lactic acid bacteria and natural yeasts. Sourdough starters prepared from other sources (such as fruits) are also available because these materials carry different types of natural yeasts and flavors. Sourdough has been reported to improve dough properties and bread texture and flavor, delay staling process, protect bread from mould and bacterial spoilage, and probably enhance the human tolerance to gluten. In traditional sourdough baking industry, common quality control from culture elaboration to final dough fermentation is performed by visual inspection for appearance, smell and taste. There is no standardized method to accurately monitor each step of process and to measure sourdough fermentation power. The objectives of the study are: 1) to develop a novel method to accurately measure gas production of sourdough from culture elaboration to dough fermentation using the Risograph; and 2) to compare fermentation power of sourdough starters prepared from wheat flour and apple. Cultures prepared from wheat flour or apple exhibited stable fermentation power after 3 days of feeding. The apple culture produced 25% more gas than wheat culture. For sour starters, both showed stable fermentation power after 5 days of feeding, and the apple sour starter had 40% more gas production than wheat starter. In the final dough fermentation, the dough containing 25% apple starter produced over 100% more gas than that containing 25% wheat starter. Risograph proves to be a viable quality control tool in sourdough process. The apple sour starter demonstrated much higher fermentation power than the wheat starter; as a result, the apple sour starter produced larger volume of fermented products without using additional commercial yeast.

Bioactive compounds of bran in colored rice

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Cereal Foods World 55:A50

The bioactive compounds in rice bran collected from four domestic colored rice, Hualien Taibashu black rice (HB) and red rice (HR), western black (WB) and Guangfu red waxy rice (GR) were investigated. Two imported colored rice (TB and TR) from Thailand were also examined. The outer bran (OB) and inner bran (IB) of colored rice were collected by polishing brown rice by using a rice polisher to removing 10–19 wt% and followed by additional 6–11 wt%, respectively. Red rice OB had higher total phenolics than the black rice OB, in which the free phenolics of red rice OB were 2.8–6.5 times than those in black rice OB. The lower content of free phenolics of black rice OB was attributed to the low solubility of anthocyanins in ethyl acetate (pH 2.0), the extraction procedure carried out after the 80% ethanol extraction. The total flavonoids in red rice OB was slightly higher than those in black rice OB. The content of total flavonoids was correlated well with their DPPH radical scavenging capacity ($r = 0.921$). According to the analyses of HPLC-DAD/ESI-MS-MS, the predominant phenolic acids in black rice OB were protocatechuic acid, ferulic acid, and vanillic acid. On the other hand, ferulic acid, p-coumaric acid, and protocatechuic acid were main phenolic acids in red rice OB. These phenolic compounds existed mainly in bound form. The anthocyanins content of black rice OB was 16–37 times higher than those in red rice OB. No proanthocyanidins were detected in black rice bran, while there was 13–23 mg catechin equivalent/g dry bran in red rice bran. The dominant anthocyanins in colored rice were cyanidin-3-glucoside, peonidin-3-glucoside, and cyanidin-3-rutinoside. One novel phenolic compound, 3,4-dihydroxybenzaldehyde, was the first to be identified in the bound fraction of red rice OB.

Hydration characteristics of hybrid and pureline rice cultivars

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Cereal Foods World 55:A50

Hybrid rice is relatively new to the US food industry and knowledge of optimal processing procedures is limited. The objective of the study was to quantify the hydration characteristics of hybrid and pureline rice at different temperatures and soaking durations to better understand rice product performance in end-use processing operations, such as parboiling. The study included long-grain cultivars, two hybrid rice (CLXL 745 and CLXL 729) and two pureline rice (Wells and Francis). Rough and brown rice from each cultivar was hydrated at 50°C and 70°C for one, two, four, six, eight, and sixteen hours. Moisture uptakes were calculated by measuring changes in mass for each rice sample before and after soaking. Sample moisture contents were determined after soaking by drying 10-g samples for 24 hours in a conventional oven at 130°C. Rough rice of hybrid cultivars soaked faster than pureline cultivars at all temperatures and durations. However, brown rice from all cultivars showed no differences in soaking behavior at all temperatures and durations. The soaking behavior of rough and brown rice suggest that the differences in water absorption is probably due to hull structure and possibly due to the pubescence trait of hybrids.

Characterization of rice dietary fiber isolated from rice bran

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Cereal Foods World 55:A50

An effective manufacturing process was developed to stabilize rice bran for preventing rancidity and isolate rice dietary fiber (CJ Riber 50®) from rice bran. And optimum characteristics of rice dietary fiber were studied that can be applied to various processed foods. Rice bran was treated with hexane to extract rice bran oil which causes the rancidity and reduces storage stability of rice bran. In order to increase the contents of total dietary fiber (TDF), rice protein was extracted in alkaline solution. The roasting and pulverization processes of rice bran were performed for improving the microbiological safety and sensory preference in food application. Rice dietary fiber was composed of 50% TDF, 25% starch, 5% Phosphorus, 2.5% Potassium, 2% Magnesium and so on. More than 90% of rice dietary fiber was insoluble dietary fiber containing cellulose and hemicellulose. Its water holding capacity (WHC) and oil holding capacity (OHC) were 250~300% and 200~250% respectively. The length of rice dietary fiber was measured under 50㎛ and the 90% of particles passed through 100㎛. It showed high anti-caking effects with the same level of commercial chemical additives. The sensory properties of rice dietary fiber were analyzed by quantitative descriptive analysis (QDA) using 15 point category scale. Savory taste, roasted flavor and soft mouth feel resulted in the main attributes of sensory. Rice dietary fiber is expected to be applied in many food products extensively including whole grain breads, diet bars, low glycemic foods, ready-to-eat cereals, bakery mixes and meat products for the purpose of dietary fiber enrichment, texture improvement and anti-caking effect. CJ Riber 50® was GM-free certified, hypoallergenic and gluten-free.

Lipid effects including a monoglyceride stabilized shortening alternative on structural features of flour proteins assessed by front-face fluorescence

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Cereal Foods World 55:A50

Front-face fluorescence was used to assess changes to structural features of proteins in wheat flour dough with the addition of different exogenous lipids, including a monoacylglycerol stabilized shortening alternative (MAG gel) at different concentrations. The structural changes resulting from solvation of proteins and from mechanical deformation of proteins in dough or dough containing lipids were measured. Solvation of wheat flour proteins was investigated by intrinsic tryptophan front-face fluorescence in dough with increasing water content. The effects of lipids on changes in overall protein surface hydrophobicity were estimated by titrating flours, mixed with water and varying lipid levels, with increasing concentrations of the fluorescence hydrophobic probes 1, 8 anilino-napthalene-sulfonate (ANS) and Thioflavin T. This approach allowed concomitant determination of the overall binding capacity and of the apparent affinity of the probes to proteins in dough containing MAG gel or a mixture of its unstructured components. Intrinsic differences in flour type relating to their protein quality and quantity affected their affinity for probe binding. Lipid type and level modified probe exposure to solvent differently with flours of different affinities. Effects of lipids were more apparent with flour containing more spread of low affinity sites on protein surfaces. The dough was characterized with constant water and concentration of ANS and Thioflavin T with varying lipids and levels

mechanical stress from mixing in a Farinograph. The MAG gel showed a shift toward longer wavelengths with high protein content flour where the mixture of its unstructured components showed a shift in wavelength toward longer wavelengths with low protein content flour, suggesting differences in protein coating effects with the structure of the lipid and protein quality.

Investigating of the structural organization of proteins and polysaccharides in rice pasta

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The consumption of rice pasta in Europe is showing a sharp increase. Processes that allow production of rice pasta with improved sensory and texture properties are expected to expand this market further. In this frame, processes for rice pasta were developed, that use pre-treated grains and result in products with the desired features. We studied the physical and chemical properties, as well as the structural organization of macropolymers in various types of starting flour used and in the resulting rice pasta. Process-dependent changes in inter-protein interaction was assessed by evaluating their solubility in the presence/absence of chaotropes, and the accessibility of reactive aminoacidic sidechains. Pretreatments had an high impact on the interactions among proteins, that were essentially unaffected by the pasta-making process. The overall structure of the polysaccharides components was assessed by studying their accessibility to specific hydrolytic enzymes (amylase and pullulanase), and by evaluating the nature and size of the resulting hydrolytic fragments by means of Light Scattering/SEC. Grain pre-treatments increased accessibility to hydrolytic enzymes, but in pre-treated whole grain amylopectin was not accessible to the action of pullulanase. This suggests that other components in whole grain prevented the structural changes required for pullulanase to act. The pasta-making process induced further changes in the structural organization of polysaccharides, that were comparatively most evident in the samples made form untreated rice. The amount of large-sized fragments generated by the action of pullulanase on the various samples was consistent with the accessibility data. This approach was not feasible with amylase, that quickly broke down the fragments generated in a first hydrolytic step.

Gelatinization behavior of organic and conventional rice starches assessed by rheological and thermal analyses

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The organic food industry has grown rapidly ($24.6 billion sales in 2008) since the launch of the National Organic Program (NOP). Manufacturers utilizing conventional rice starch as an ingredient may want to substitute the organic equivalent to attain organic certification. The objective of this study was therefore to compare gelatinization properties of commercially available organic and conventional rice starches using rheological and thermal analyses. Starch was mixed in distilled water (5% w/w) and analyzed by Differential Scanning Calorimetry (DSC) to obtain the starch gelatinization temperature range. The starch slurry was also subjected to temperature sweeps (50–95°C) on a rheometer to evaluate the change in complex viscosity during gelatinization. DSC showed that the organic and conventional rice starches had similar gelatinization temperature range (58–69°C for organic, 60–72°C for conventional starch). Rheology also displayed similar onset and peak temperatures of gelatinization (64°C and 92°C for organic, 65°C and 90°C for conventional starch). However, the swelling rate was lower for the organic rice starch compared to the conventional starch. This decrease in gelatinization rate may be attributed to differing reaction rate of starch components with water as well as the physical-transformation rate, such as the melting of crystalline regions. The complex viscosity was lower for the conventional (3.1 Pa.s) than for the organic rice starch (5.5 Pa.s), suggesting varying structural properties, such as molecular composition and chain length distribution within the starch granules (currently being investigated). These results indicate that organic rice starch can be substituted for the conventional counterpart in organic foods but may require a change in formulation or processing to achieve equivalent products.

Gluten-free breads and cookies of raw and popped amaranth flours with good technological and nutritional qualities

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Gluten-free bakery products are based on flours with low-content and poor-quality proteins plus additives to improve their viscoelastic properties. Frequently celiac disease children in a strict gluten-free diet are undernourished because of the reduced intake of energy, protein and minerals. Therefore, they require gluten-free foodstuffs with high nutritional quality ingredients as those of the amaranth grain. The aim of this study was to evaluate the properties of raw (RAF) and popped amaranth (a commercially available product made similarly to popcorn in a stovetop kettle) (PAF) flours and to optimize bread and cookies formulations. The water absorption capacity of amaranth flour mixes increased when the PAF content was increased. The viscoelastic properties of the amaranth flours were evaluated by the National Mixograph. The doughs for bread-making and cookies preparation were mixed according to the optimum mixing time. The bread prepared with 60 to 70% PAF and 30 to 40% RAF, and the cookies formulated with 100% PAF resulted in products with better characteristics than other published gluten-free foodstuffs, avoiding the use of hydrocolloids. The diameter of the amaranth cookies was significantly lower than the control, but there were no differences on the expansion factor. The amaranth cookies required less force to break than the control cookies. The cookies elaborated with PAF have acceptable characteristics for this kind of products. The gluten content in the final breads and cookies was lower than 20 ppm as the *Codex Alimentarious* recommends. Formulations including 30–40% RAF and 60–70% PAF for breads or 100% PAF for cookies were suitable to obtain good technological and nutritional quality gluten-free breads and cookies for celiac disease patients.

Effect of different emulsifiers on mechanical resistance of proofed dough and specific volume of white pan bread with and without fat

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Currently, the use of additives is a common practice in the bakery industry. Emulsifiers are added to improve dough handling properties and bread quality. Mechanical abuse can occur in craft bakery or bread industry production lines. In this work, the effect of the emulsifiers sodium stearoyl lactylate (SSL), calcium stearoyl lactylate (CSL), diacetyl tartaric acid esters of mono and diglycerides (DATEM), polysorbate 80 and soy lecithin on specific volume of white pan bread prepared with and without fat and submitted to mechanical abuse after proofing was studied. All emulsifiers were tested at 0.125, 0.250 and 0.500%, flour basis. Fat dosage in bread with fat was 3.0%, flour basis. White pan breads were produced according to the modified straight dough method. After an 80 min proofing period, 3 loaves of each batch were submitted to mechanical abuse. This procedure involved letting the proofed dough pieces in pans fall from a 10 cm height support. Specific volume of loaves was determined by seed displacement. Samples without mechanical abuse, with added fat and emulsifiers presented the highest specific volumes. The best result for formulations with fat and emulsifier, and no mechanical abuse, was with 0.5% CSL (6.58 mL/g). After mechanical abuse, the best result was with 0.5% DATEM (5.32 mL/g). The best result for formulations without fat and with emulsifier, and no mechanical abuse, was with 0.5% polysorbate 80 (5.53 mL/g). After mechanical abuse, the best result was still with 0.5% polysorbate 80 (4.75 mL/g). In the samples without fat the effect of the different emulsifiers was more evident. It was concluded that the effect of the different emulsifiers on mechanical resistance of fermented dough and bread quality depended on the emulsifier used, its dosage and on the bread formulation (with or without fat).

Physicochemical properties of water-and enzyme-extractable arabinoxylans from hulless barley

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Arabinoxylans (AX) are important, but less known, components of dietary fiber in hulless barley. The content of AX in hulless barley (4–6%) depends on genetic and environmental factors but appears to be less variable than that of β-glucans (4–11%). In contrast to β-glucans, a major portion of AX in barley is water insoluble. The objective of this study was to unravel the physicochemical properties of AX readily extractable with water compared to a population extractable with the aid of various enzymes. A sequential extraction was carried out to examine the water-extractable (WE-AX) and enzyme-extractable AX (EE-AX). The degree of branching was greater for the water- (Ara/Xyl ratio: 0.72-0.79) than for the enzyme-extractable AX (0.50-0.58). Both populations of AX exhibited high molecular weights, but generally the EE-AX had higher molecular weight than the WE-AX.

Sequential fractionation of AX with ammonium sulfate yielded fractions with unique molecular structure, ferulic acid content and monosaccharide composition The fractions obtained at 50% saturation (F_{50}) of the salt exhibited a low Ara/Xyl ratio (0.50), a high ratio of singly to doubly substituted Xyl residues (1.43) and very high content of ferulic acid (12 µg/mg). The fractions obtained at 60% saturation of ammonium sulphate (F_{60}) exhibited much lower ratio of singly to doubly substituted Xyl residues (0.43) and a lower content of ferulic acid (3 µg/mg), but comparable amounts of unsubstituted Xyl residues (65%) and similar molecular weight (300,000) to F_{55}. Aqueous solutions of F_{55} (2% w/w) in the presence of H_2O_2/peroxidase formed very strong gels as indicated by high values of the elasticity modulus G' (~1.5 kPa) compared to G' (~0.1 kPa) for F_{60}. These studies showed that certain populations of barley AX exhibit unique physicochemical properties compared to those previously reported for wheat AX.

Pasting properties of wheat flour with the addition of whole grain wheat flour

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The demand for whole grain products is growing. However, the presence of fibers causes some difficulties for the use of whole grain flour in bakery products. The evaluation of flour rheology is vital for its application. Among the analyses available to evaluate dough properties is the analysis of pasting properties. The aim of this study was to analyze the influence of the replacement of refined wheat flour (WF) by whole grain wheat flour (WGWF) at 0, 20, and 40% levels on the pasting properties of flour. The analysis was carried out in a Rapid Visco Analyser. The parameters analyzed were: peak viscosity, breakdown and setback. Peak viscosity values were 2334.33 ± 40.28, 2135.00 ± 63.55 and 1992.67 ± 91.59cP, breakdown values were 906.00 ± 50.74, 853.33 ± 6.81 and 766.33 ± 26.08cP and setback values were 1259.33 ± 65.16, 1258.33 ± 98.21 and 1220.67 ± 16.17cP, for 0, 20, and 40% WGWF samples, respectively. Peak viscosity of 0% WGWF differed significantly ($p < 0.05$) from the others. However, 20 and 40% WGWF samples did not differ between each other. The decrease in peak viscosity with the increase of WGWF can be explained by the dilution of starch in flour, due to the presence of the outer layers of the grain. Samples with 0 and 20% WGWF did not differ in relation to breakdown, but differed significantly ($p < 0.05$) from the 40% sample. The presence of fibers resulted in a decrease in breakdown values, probably due to the resistance they offer during the permanence of the system at 95°C, besides being responsible for higher water absorption. Because of these same characteristics, setback values were not different among samples, as they also failed to release water during the cooling stage. The addition of WGWF caused a decrease in all parameters, mainly in peak viscosity and breakdown. Acknowledgments to CNPq, Capes, and Moinho Anaconda S/A.

Total phenolics, flavonoids and antioxidant capacity of young rice

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Numerous studies have shown that the essential phytochemicals in fruits, vegetables and cereal grains, including rice, are significantly associated with reduced risk of developing chronic diseases. Young rice is a less ripe grain of rice and it is believed to contain various bioactive compounds. However, limited information is available on the physiological properties of young rice. Therefore, physiological characteristics of young rice are investigated to provide the fundamental information of physiological property of young rice and to show the potential of young rice as a functional ingredient. Young rices were collected after anthesis (9, 11, 14, 16, 18 days) and separated into juice and hulls. Bioactive compounds were extracted from young rice hulls with 80% methanol and 80% ethanol, respectively. Total phenolics (TP), flavonoids (F) and antioxidative capacity (AC) of young rice juice and hull extracts were determined. Young rice juices showed very small amount of TP (3.0-16.1 mg GAE/100g sample) and F (0.1-0.7 mg CE/100g sample) as well as very low AC (0.3-1.8 mg AEAC/100g sample) which are much lower than milled rice extracts (TP 25.4-30.7 mg GAE/100g sample, F 6.7-20.6 mg CE/100g sample, AC 4.8-5.8 mg AEAC/100g sample). Young rice after 11 days of anthesis showed the highest TP and F contents and AC. Both young rice hull extracts with 80% ethanol and 80% methanol showed much higher amount of TP (100.2-142.6 mg GAE/100g sample) and F (15.7-65.3 mg CE/100g sample) as well as AC (38.6-51.9 mg AEAC/100g sample) indicating that most of bioactive compounds are located in the hull of young rice. Young rice hull extract with 80% ethanol showed relatively higher TP and F contents and AC than its extract with 80% methanol suggesting that 80% ethanol is more effective extraction solvent.

Relationship of tortilla quality to flour and dough properties

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The current methods for screening wheat lines suitable for tortilla are time consuming, costly and require at least 1 kg of flour. Thus, this study investigates the potential of dough and flour properties to predict tortilla quality. A sample set of 32 wheat flours was analyzed. Correlations and prediction models for tortilla quality were determined. Flour properties studied were protein content, insoluble polymeric proteins (IPP), high molecular weight (HMW-GS) and low molecular weight glutenin subunits (LMW-GS) ratio, gliadin/glutenin ratio, and mixograph mixing time. Dough stress relaxation and a modified dough extensibility tests were conducted using a texture analyzer. Tortilla parameters measured were diameter and rollability at day 16 (indicator of shelf stability). Mixograph mixing time and dough resistance to extension (from extensibility test) significantly correlated with tortilla diameter ($r = –0.64$ and $–0.86$, respectively, $P < 0.01$). IPP significantly correlated with tortilla diameter ($r = –0.68$, $P < 0.01$) and rollability at day 16 ($r = 0.73$, $P < 0.01$). Stepwise multiple linear regression showed that tortilla diameter was best explained ($R2 = 0.81$) by dough resistance to extension and flour protein content. Rollability score at day 16 was best predicted ($R2 = 0.70$) by IPP, flour protein and relaxation time (from stress relaxation). The two important tortilla quality parameters (rollability and diameter) can be predicted using simple methods that require a small amount of flour sample. Their prediction models will potentially provide an easy and fast tool for tortilla manufactures and wheat breeders to screen wheat lines for tortilla production.

NAD(P)(H) hydrolysing enzymes of *Triticum aestivum* L.: Identification, characterisation and application in breadmaking

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Very recently, we showed that NAD(P)(H) coenzymes have the potential to affect the quality of dough and bread during breadmaking. We put the hypothesis forward that the coenzymes function as substrates or cofactors of three competing reaction types during the breadmaking process that eventually affect the formation and quality of the gluten network formed. One of these reactions is coenzyme hydrolysis by natively present NAD(P)(H) hydrolysing enzymes in wheat flour. Two formerly unknown NAD(P)(H) hydrolysing enzymes of wheat were identified, recombinantly expressed and characterised. The first enzyme, which belongs to the nucleotide pyrophosphatase/phosphodiesterase (NPP) family, occurs as an oligomeric transmembrane metallo-protein, while the second enzyme, a nudix hydrolase, after purification occurs as a monomeric enzyme. The characterisation of both enzymes, screening of EST databases of wheat and a literature review revealed the occurrence of a wide range of nudix hydrolases and NPP type of enzymes in wheat which in vivo probably cover a wide range of physiological functions. These NAD(P)(H) hydrolysing enzymes may impact the effect of the coenzymes during breadmaking. The characterisation of this type of enzymes and their supplementation during breadmaking present valuable insight into the effect of both coenzymes and coenzyme hydrolysing enzymes during breadmaking.

Relative healthful potential of extruded lentil snacks

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Cholesterol lowering and cancer prevention potential of 5 lentil snack formulations un-extruded (controls) and extruded (treatments) were evaluated by their relative in vitro bile acid binding. The controls and their extruded treatments (E) were 100% lentils (L100), L100E; 69% lentils (L69), L69E; 57% lentils + 12% high protein supplement (L57S), L57SE; L57S with 125 µg Chromium (L57SC1), L57SC1E; L57S with 536 µg Chromium (L57SC5), and L57SC5E. The relative in vitro bile acid binding on an equal dry matter (DM) relative to cholestyramine (bile acid binding, cholesterol lowering drug), was L100 (6%), L100E (20%), L69 (6%), L69E (17%), L57S (11%), L57SE (26%), L57SC1 (13%), L57SC1E (22%), L57SC5 (7%) and L57SC5E (19%). Replacing 12% lentils with high protein supplements (L69 vs. L57S) resulted in nearly doubling in bile acid binding potential, suggest that the supplement appears to have higher bile acid binding capacity than that of lentils. On an average, extruded lentil snacks had significantly higher bile acid binding (20.8%) compared with their un-extruded formulations (8.6%). Extruding L57S (L57SE) resulted in highest bile acid binding (26%). Extruding with added chromium containing yeast resulted in lower bile acid binding in a dose dependent manner: L57SC1E (22%) and L57SC5E (19%).

The results demonstrate the relative health promoting potential of L57SE > L57SC1E > L100E = L57SC5E > L69E > L57SC1 = L57S > L57SC5 = L69 = L100 as indicated un-extruded formulations. Most healthful lentil snack was produced with the addition of high protein supplement without added chromium-containing yeast (L57SE).

Relationship between solution and gel behavior of arabinoxylans: Effect of structure on properties in aqueous systems

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Oxidative gelation of arabinoxylans, by the formation of covalent crosslinks between ferulic acid moieties using enzymes such as peroxidase/H_2O_2 and laccase/O_2 has been widely studied. In addition to the chemical crosslinks, the presence of physical interactions amongst the arabinoxylan molecules in wheat arabinoxylan gels has been suggested. However, in the present study with corn arabinoxylan gels, a temperature sweep profile (from 25°C to 65°C) in small amplitude oscillatory shear measurements suggested no such physical interaction in the gel state. This difference in physical interaction among the polymer molecules in the gel state may be related to the observable differences in the behavior of these molecules in solution. Dynamic light scattering and SEC-MALS analysis indicated that corn arabinoxylans have weak aggregation behavior in solution as compared to wheat arabinoxylans. Also, concentration dependence of zero shear viscosity (eta zero) of these polymers above the critical overlap concentration showed that eta zero is proportional to $C^{2.77}$ and $C^{3.4}$ for corn and wheat arabinoxylans, respectively, suggesting that wheat arabinoxylans have stronger chain entanglement than corn arabinoxylans at high concentrations. The differences in solution behavior, extrapolated to gel behavior, of these arabinoxylans probably stems from the differences in their structure. Corn arabinoxylans have less unsubstituted regions on the xylan backbone than wheat arabinoxylans; this explains the weaker tendency for intermolecular association in solution and the absence of physical interactions in the gel state. Thus, a clear link between the solution behavior and gel behavior of arabinoxylans was established in the present study, with a strong indication that the structure of arabinoxylan molecules affects its behavior in both solution and gel systems.

Phenolic acids in cereal grains and their effect on starch liquefaction and saccharification

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The presence of phenolic acids in cereal grains is thought to influence efficiency of starch amylolysis during liquifaction (by thermostable alpha-amylase) and saccharification (by amyloglucosidase) of whole grain flours. The objective of the study is to understand how different types and contents of phenolic acids, individually and collectively, influence amylolysis. The types and concentrations of phenolic acids in whole grain flours of barley, corn, wheat and triticale, were analyzed by HPLC. The total phenolic acids contents were 3155, 2667, 1732 and 1171 µg/g, respectively. Of the total, >90% were found to be in the bound form (89.5%, 90.3%, 95.6% and 95.4%, respectively). The types and concentrations of individual phenolic acids varied among grains. Ferulic acid, coumaric acid and protocatechuic acid were the major phenolic acids in triticale and wheat, whereas epicatechin, catechinhydrate and hydroxybenzoic acid were predominant in barley, and courmatic acid, catechinhydrate, naringin, epicatechin and ferulic acid in corn. Based on the above information, pure commercial samples of major phenolic acids were purchased and added individually and collectively to purified native starches in order to investigate the effect of phenolic acids on amylolysis. Addition of phenolic acids to isolated starch at levels equal to or times three to that of present in the whole grains significantly decreased the degree of starch hydrolysis by alpha-amylase (liquefaction) and amyloglucosidase (saccharification). The effect was more pronounced when phenolic acids were added collectively.

Human acute leukemia anti-cancer properties of peptides obtained from heat stabilized defatted rice bran

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Rice bran is an underutilized co-product of rough rice milling. Having approximately 20% protein after de-fatting, this may be a cheap source of bioactive peptides. Identifying and characterizing rice bran peptides that can arrest human cancer cell proliferation formed the basis of this study. The specific objectives were to extract, evaluate and characterize rice bran peptides for leukemia anti-cancer properties. Heat stabilized defatted rice bran was treated with alcalase. The resulting hydrolysates were treated with simulated gastric and intestinal juices to obtain resistant peptides. The peptides were fractionated into >50, 10-50, 5-10, and <5 kDa using ultrafiltration. Preliminary studies revealed that the <5 kDa peptide fraction showed anti-cancer properties on human colon, breast and liver cancer cell lines. In this study human leukemia cells (CCL-119 Acute myeloblastic leukemia; CRL 2725 Acute lymphoblastic leukemia) were grown to test the efficacy of rice bran peptides for leukemia anti-cancer properties. A cell titer assay that uses the tetrazolium dye (3-(4,5-dimethylthiazole-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium, inner salt (MTS) and an electron coupling reagent, phenazine ethosulfate (PES) was conducted to assess the anti-proliferative effects of the peptides. Proliferation of the leukemia cell lines were inhibited by the <5 kDa fraction to nearly 45% compared to controls. Characterization and isolation of a peptide from the <5 kDa fraction revealed a pentapeptide with sequence Glu-Gln-Arg-Pro-Arg that caused nearly 60% inhibition to leukemia cell lines. Characterization was done employing reverse phase HPLC, amino acid analysis and Mass spectrometry. The peptides from rice bran have the potential to be used as functional food ingredients for health benefits particularly against acute leukemia.

Enzyme optimization during high solids fermentation in corn dry grind process

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In conventional dry grind process, high glucose concentrations (>15% w/w) and liquefaction viscosities restrict slurry solids contents to 30 to 32% w/w. High slurry solids fermentations (above 33%) are important in reducing energy costs; decreased water input results in less evaporation, dehydration and distillation. The objective was to determine an economical and process efficient enzyme combination to be employed during simultaneous saccharification and fermentation (SSF) to improve fermentation efficiencies at 35% solids. The enzyme combination we considered for this study consisted of granular starch hydrolyzing enzymes (GSHE) and glucoamylase. In our earlier study, we showed that using low temperatures (55°C) and a combination of phytase and α-amylase during liquefaction reduced slurry viscosities at 35% solids by 85% compared to a conventional process. In this study, eight SSF enzyme treatments were employed to optimize GSHE, GSHE α-amylase and glucoamylase dose. These SSF enzyme treatments included two enzyme combinations: 1) glucoamylase and GSHE and 2) glucoamylase and the α-amylase component of GSHE, with different levels of enzyme concentrations. For all treatments except control, liquefaction (55°C for 90 min) was conducted at 35% solids using a formulation of α-amylase and phytase. SSF (32°C for 72 hr) was carried out using eight enzyme treatments, urea and yeast. The treatment containing 0.5 µL glucoamylase and 1.25 µL GSHE per g dry corn resulted in the highest fermentation efficiencies (92%) and ethanol yields (2.80 gal/bu). The control treatment resulted in the lowest fermentation efficiencies (84%) and ethanol yields (2.55 gal/bu). The above mentioned enzyme treatment also resulted in 34% lower peak glucose concentrations (8.8% w/v) compared to control treatment (13.3% w/v).

Application of visible and near-infrared reflectance spectroscopy (Vis/NIRS) to determine anthocyanin contents in leaf and stem of purple corn

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Cereal Foods World 55:A53

The leaf and stem of purple corn samples were studied to predict anthocyanin contents using visible and near infrared spectroscopy (Vis/NIRS). Anthocyanins are a class of flavonoids that are the most widespread secondary metabolites in plant tissues. A total of 77 purple corn samples were obtained at the National Agricultural Research Center for the Kyushu Okinawa Region in 2007 and 2008. The leaf and stems were first pulverized by a crushing mill and then sifted through a screen (φ = 2.0 mm). Prior to the chemical analysis, the powder samples were individually treated with 4 mL of water-concentrated trifluoroacetic acid (99/1, v/v) for 24 hr at room temperature. Then, 6 mL of water was added to the mixture, and the samples were filtered through a membrane (0.45 µm). Anthocyanin contents were calculated using a calibration curve for cyanindin-3-o-glucoside at 520 nm with a UV-vis spectrometer. About calibration set, mean value was 8.54 and range was 34.04. About prediction set, average was 8.64 and range was 31.16. Data analysis was performed with Vision software (Foss NIRSystems Co., Laurel, U.S.A.). The spectral were pretreated with a multiple linear regression (MLR) analysis, and then were pretreated with second derivative (segment = 20 nm, gap = 0 nm) in the wavelength of 400-900, 700-2500, 900-2500, 1100-2500 and 400-2500 at a 2 nm interval using an NIR spectrophotometer model

NIRSystems 6500 (Foss NIRSystems Co., Laurel, U.S.A.). From this study, the calibration that calculated from 400-2500 nm provide the lowest SEP (Standard error of prediction, 4.19 µmol cy3-glu eq/g D.W.) rather than other wave ranges. The correlation, RPD and Bias were 0.93, 2.71 and 0.12, respectively. The present results indicated that prediction of anthocyanins contents using the whole wavelength region was superior to the short wavelength region.

Protein interactions of soy protein isolate obtained by high moisture extrusion process (HMEP)

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The objective of this study was to obtain textured products with fibrillar structures of Soy Protein Isolate (SPI) using high moisture extrusion process (HMEP) in a twin screw co-rotating extruder. An experimental design was used with temperatures (°C) of 120, 140 160, Moisture Content (%) (MC) of 50, 62.5 and 75 and screw rotation (rpm) of 270. Products were analyzed by scanning electron microscopy (SEM), Protein Dispersibility Index (PDI), Water Absorption Capacity (WAC), Nuclear Magnetic Resonance (NMR), Infrared Spectroscopy (FTIR) and Differential Scanning Calorimetry (DSC). The configuration of the twin screw provided greater influence on the expected outcome in terms of physico-chemical properties and texture, the stainless steel matrix developed allowed a linear cooling process to obtain fibrillar structures of good quality. In the texture profile, it was found that higher moisture as well high temperatures significantly affected the texture of product. In the WAC was observed that the temperature and moisture had significant effects on this property. High moisture and low temperature provided the greatest value of PDI. SEM showed the intercross of protein structures that were dispersed in high moisture and high temperature to form a homogeneous fibrillar structure. NMR showed higher percentage of rigid structures and smaller percentage of less rigid structures, where the T_1 varied between 770 ms and 828 ms. FTIR revealed small differences in vibration of amide I peak at 1650 cm^{-1} and amide II at 1550 cm^{-1}. DSC showed the presence of endothermic peaks for the textured samples, indicating that the 7S globulin was denatured and 11S globulin has not been altered with T_d in the range of 185°C to 190°C. Textured products indicate a consistent and fibrillar texture, where chemical bonds contributed to the texturing of soy protein providing properties similar to the structures of "meat analog".

Influence of A/B-type granule ratio on cross-linked wheat starch properties

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Wheat starch comprises two populations of granules (A- and B-type), which possess differing starch characteristics and properties, as well as reactivities to modifying agents. The objective of this study was to investigate impact of wheat starch A/B-type granule ratio in cross-linking reactions with both phosphorus oxychloride ($POCl_3$) and sodium trimetaphosphate (STMP). Waxy and normal soft wheat starches were separated into their respective A- and B-type granule fractions, after which the purified granule fractions were reconstituted (within a genotype) according to defined A/B-type granule ratios (100:0, 90:10, 80:20, 70:30, 0:100 by weight). Reconstituted waxy and normal starch granule mixtures were cross-linked with either $POCl_3$ (0.05% and 0.01% [s.b. or dry starch weight basis], respectively) or STMP (0.20% and 0.07% [s.b.], respectively). The modified and reaction control starch granule mixtures were assessed for swelling, gelatinization and pasting properties. Cross-linking reduced the swelling factors of all modified starch granule mixtures relative to their reaction controls. However, swelling capacities of both cross-linked and reaction control starch granule mixtures (of a genotype) generally increased with increasing B-type granule content. For modification levels in this study, gelatinization properties of both cross-linked and reaction control starch granule mixtures were generally similar, though gelatinization patterns varied across A/B-type granule ratios of both modified and reaction control granule mixtures of a genotype. Moreover, all pasting property attributes (i.e., peak, final, trough, breakdown, final, setback) decreased with increasing B-type granule content for both cross-linked and reaction control granule mixtures (especially for B-type granule contents over the range of 0–30%). Thus, cross-linking modification alone does not completely override the property differences inherent to a given wheat starch A/B-type granule ratio.

Derivatization of rice wine meal using commercial proteases and characterization of rice wine meal hydrolysates

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Rice wine meal (RWM) is the most abundant byproduct in rice wine industry in Korea. Despite the high nutritional value, there is a limitation in its utilization as food ingredients. In case of brewer's spent grain, there are many researches on its utilizations. However, limited information is available on utilization of RWM. To transform the rice protein from insoluble to soluble in order to increase the industrial utilization of RWM, RWM was derivatized using commercial proteases and their RWM hydrolysates were characterized. Eight commercial proteases (Protamex, Neutrase, Flavourzyme, Alcalase, Protease M, Protease N, Protease A, Molsin F) were used as single or combined for enzymatic hydrolysis of RWM. Degree of hydrolysis was determined in two ways; 1) soluble protein in supernatant using lowry method, 2) gravimetric method using weight difference before and after enzymatic hydrolysis. Three proteases, Protamex, Alcalase and Protease N, are found to be the most effective for enzymatic hydrolysis of RWM. In lowry protein assay method, 88.4, 117.4 and 88.5 mg protein/g RWM are hydrolyzed after Protamex, Alcalase and Protease N treatments, respectively. In gravimetric method, 149.1, 198.5 and 170.3 mg protein/g RWM are hydrolyzed after Protamex, Alcalase and Protease N treatments, respectively. Although, there was some gab between lowry protein assay and gravimetric methods, there was a similarity between those two methodolgies. When three enzymes were applied to RWM at one time, no significant difference was observed compared to single protease application in both lowry protein assay and gravimetric methods ($P < 0.05$) indicating no synergistic effect of three kinds of proteases.

Acid-hydrolysis of various starches for blocklet isolation

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Nano-sized blocklets in native starches from different botanical sources and amylose contents were characterized after the acid-hydrolysis. It was possible to identify the crystalline blocklets after 7 days of the hydrolysis with 3.16M sulfuric acid. The yield for the blocklet isolation based on the initial starch weight was 12.5~37.5 wt %. According to SEM observation, the blocklets are similar in shape but different in size among the starches tested. Particle size in diameter ranged from 61 to 91 nm for high amylose and normal maize starch blocklets. Waxy maize and mungbean starch blocklets were much larger (237 to 240 nm), and potato starch blocklets were the largest (374 nm). The blocklets retained the same X-ray crystalline pattern as their native counterparts with increased diffraction intensity. The acid hydrolysis had a pronounced effect on the melting characteristics in aqueous medium; DSC endotherm was significantly broadened and endotherm peak temperature was increased. Melting enthalpy of the blocklets was lower than that of the counterpart starch.

Effects of hydrocolloids on the pasting and paste properties of commercial pea starch

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Starches can interact with hydrocolloids (HCs) and change the rheological properties of their pastes. The objective of this study was to determine interactions of commercial yellow pea starch with HCs and effects of molecular weight (MW) of the HCs on paste parameters as determined using a Rapid Visco Analyzer (RVA). Five families of HC products were used in a 19:1 w/w ratio of starch to HC. Results are compared with those for pea starch alone. None of the HCs used in this study produced detectable viscosity in the RVA when used alone in the same concentration. For starch-HC composites, xanthan produced less breakdown and setback. Medium- and high-viscosity types of carboxymethylcellulose (CMC) produced increased peak and final viscosities. Likewise, guar gum products, even low-viscosity types, increased peak and final viscosities. Three viscosity types of methylcellulose (MC) possessing the same methyl ether content were used. The lowest viscosity type slightly increased the peak viscosity, while the final viscosity was unchanged. Increases were seen in peak and final viscosities as the MW of the MC increased, perhaps due to thermal thickening. Five types of hydroxypropylmethyl-cellulose (HPMC) with different amounts and ratios of methyl and hydroxypropyl ether groups were used. The high- and the two medium viscosity types produced slightly greater final viscosities, while the two low-viscosity types produced a decreased final viscosity. Trough viscosities were unchanged. Only a little variation was found in peak viscosities. Overall, the enhanced paste viscosities of the starch-HC composites (except for the lowest viscosity types) indicate synergistic interactions between yellow pea starch and the HCs roughly in the order: guar gum (all MWs) > MC (higher MWs) > CMC (higher MWs) > xanthan > HPMC.

Naked barley – Opportunities for food with more than taste

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With the upcoming Health Claim within the EC for beta-glucans to maintain normal blood cholesterol concentrations, an increased demand for these soluble cereal fibers is foreseen. Furthermore, consumers start to take a second look on the list of ingredients and choose foods containing ingredients they are familiar with. Barley is one of the important sources for beta-glucans and is available either as grain or in terms of enriched flour fractions or extracts with different technological properties and health related functionalities. Naked barley varieties offer theoretically enough beta-glucans to fulfill the Health Claim requirements in cereal based products. Consequently, to use naked barley as main ingredient technologists must bridge the latter with the sensory expectations of the consumers. Bread, pasta and extrudates were used as model food to implement the requested content of beta-glucans through naked barley flour fractions. The influences of added naked barley flour fractions on the product specific physical and sensory properties were investigated. The results showed that a replacement of up to 80% of wheat flour results in sensory palatable products. Thus, it is possible to produce naked barley products with a relevant amount of beta-glucans. Utilizing colored varieties, containing anthocyanins and phenolic acids may broaden the diversity in nutrition and consequently add further health beneficial substances into staples.

Distinction of spelt and wheat by means of specific proteins

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Cereal Foods World 55:A55

Since more than ten years spelt has gained new popularity as an "ancient cereal" with distinct health effects, i.e. spelt can be consumed in the case of wheat intolerance. Therefore, production is increasing and spelt and its products yield a substantially higher price as compared to common wheat products. On this background, it is of great interest whether commercial spelt products have been mixed with common wheat. Protein composition of spelt and wheat flour was quantified by subsequent extraction of flour by a modified Osborne procedure and quantitation of proteins by HPLC on C8-silica gel using a water/acetonitrile gradient with 0.1% trifluoroacetic acid and UV detection at 210 nm. Analysis of the reduced gliadin fraction was most suitable to detect differences between spelt and wheat. 48 spelt cultivars were classified into five groups with group 1 representing typical spelt cultivars and group 5 representing spelt cultivars closely related to wheat. Individual peaks or groups of peaks were used as markers for classification. Whereas groups 1 and 2 showed three markers the following groups 3 and 4 contained two markers. In spelt cultivars belonging to group 5 only one marker was left, which was, however, not sufficient to distinguish these spelt cultivars from wheat. All spelt cultivars belonging to group 5 were known to be wheat-spelt crossbreeds. Furthermore, omega-b-gliadins were found to be typical proteins for wheat, which are not present in spelt. This type of protein is 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. The amino acid sequence of cysteine-containing peptides from omega-b-gliadins of wheat has been determined and will be used as the basis of an ELISA test and a LC-MS method to specifically detect and quantify portions of wheat in spelt and spelt products.

Development and characterization of a new G4-amylase for antistaling

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Antistaling amylases are instrumental for prolonging shelf-life and improving quality parameters of industrially baked bread. Principally, they reduce starch retrogradation by hydrolysing amylopectin and amylose in and around the gelatinising starch granules during baking. Over the last decades numerous amylases from microbial and plant sources have been tested for antistaling. The most widely used amylases today have a high degree of exo-specificity, i.e. G4-amylase and maltogenic amylase. Based on model system investigations and extended baking trials, we have analysed the functionality of the existing amylases as first step to develop an antistaling amylase with improved performance, i.e. longer shelf life extension and better quality preservation. Thermostability and exo-specificity were identified as key parameters. Extensive engineering of G4-amylases has succeeded in increasing thermostability by >30°C and exo-specificity 5 times leading to a next generation G4-amylase for extended shelf-life. The engineering and screening program, model system testing and enzyme substrate functionality of the new G4-amylase will be described.

Effects of specialty proteins from high selenium wheat on dough properties

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Selenium is a mineral element that has nutritional and disease preventative attributes in the human diet. It is the only mineral that qualifies for an FDA-approved qualified health claim for general cancer reduction incidence. A level of one microgram per gram (1 ppm) Se in the flour is considered to be a good starting point for food processing. Previous work at South Dakota State University provided data on the range of Se occurrence in the wheat crop as well as the distribution of the element within the kernel. Wet and dry processing, namely, milling, aqueous and ethanolic extraction schemes were explored to produce wheat fractions with predictable Se content. Information on grain Se concentrations of the 2008 and 2009 crops harvested at high selenium regions were used to formulate wheat composites (High Se, Medium Se and Low Se). Protein concentrates (WPC) and isolates (WPI) were developed from ground whole wheat and pearled wheat. Wheat with Se concentrations of 3.5, 5.2, and 10.3 ppm yielded WPC with Se concentrations of 16.8, 22.6 and 46.1 ppm, respectively. WPI of 15.78, 21.2 and 43.8 ppm Se were produced from the same wheat. WPC had protein content range of 74.7–76.0% where as WPI had a protein content range of 83.2–85.0%. WPC from high, medium and low Se wheat showed significantly different rheological properties (strength and extensibility) as judged by a Texture Analyzer. Such differences were not explained by protein content alone. Substitution of flour using 5% WPC and WPI resulted in a significant increase in bread selenium concentration (1.5 micrograms Se/100 g) while unfortified bread had a content of 0.23 micrograms Se/100 g. Gluten Index and mixing behavior are being explored to study the contribution of selenium in dough functionality.

Influence of extrusion process conditions on the properties of buckwheat products

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Cereal Foods World 55:A55

Extrusion has an important role as a manufacturing process in the food industry; it is used to obtain a great variety of products such as baby foods, breakfast cereals, snack foods, pasta, instant powders, modified starches, etc. However, as regards cereals, few studies have examined the application of the extrusion process on less common materials, such as minor cereals and pseudocereals, of interest for their nutritional value. Buckwheat, for instance, is rich in antioxidants, contains rutin, and has a good aminoacid profile; moreover, it does not contain gluten proteins, therefore being suitable for the diet of people with celiac disease. The aim of this research was to investigate the influence of different extrusion process conditions (barrel temperature, screw speed, feed moisture) on the chemical-physical characteristics of extruded products obtained from buckwheat. A high fiber buckwheat flour and broken kernels of dehulled buckwheat were used, in order to evaluate the effect of both the fiber content and the particle size of the raw materials on the extrudates' properties. A 3-factor, 3-level Box-Behnken Experimental Design was applied for finding out the relationships between the chemical-physical properties of the extruded samples and the process variables. The barrel temperature and the screw speed each positively influenced the starch damage content and the expansion ratio of the products and negatively influenced their texture, while the feed moisture negatively influenced the expansion of the extrudates. Moreover, for all experimental conditions, good results could be obtained from broken kernels, indicating that starting materials do not necessarily need to be in powder form (e.g., flour).

Improved extraction and functionality of α-zein from corn gluten meal and dry-grind distillers' grains with solubles

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The commercial extraction of corn zein from corn gluten meal (CGM) uses 88% w/w aqueous isopropanol and 0.25% NaOH isolating α-zein. Besides low yields of ~20–24% w/w db, this zein is highly pigmented. We compared solvents in different combinations to extract high amounts of α-zeins. Solvents of 70% w/w aqueous isopropanol, 55% w/w aqueous isopropanol, 70% v/v aqueous ethanol, and a new solvent mixture that was 70% w/w aqueous isopropanol with 30% glycerol and water (22.5% glycerol, 7.5% water) were tested. An alkali treatment of 0.25% NaOH and a reducing treatment of 0.5% sodium bisulfite were performed with the extraction. The separation of zein fractions was affected by modulation of solvent proportions and cold precipitation at –20°C. The α-zein yields with reducing treatment were higher for all samples than without. The α-zein extractions with 70% w/w isopropanol and 70% v/v ethanol were the highest at 36% and 34% w/w CGM (db), respectively. The α-zein yields for 88% w/w aqueous isopropanol with and without reducing treatments were 23% and 22%, respectively. Yields for solvents were all very high with reducing treatments; however, without the treatment, isopropanol solvents yielded more (29% w/w) α-zein compared to 21% for 70% ethanol. The solvent containing 70% isopropanol and glycerol performed poorly yielding only 11% α-zein. DDGS also contains functional zein; preliminary extractions with 70% w/w isopropanol, and 70% ethanol yielded α-zein fraction at 6–8% w/w DDGS (db). The α-zein extracted from DDGS dissolved in 90% v/v ethanol and cast into a transparent film. More extractions on DDGS are planned with 88% w/w isopropanol, 70% w/w isopropanol, and 70% v/v ethanol to increase yield of α-zein. A cellulase and pectinase pretreatment of DDGS is expected to further increase the α-zein extraction yields.

Effects of flour particle size and autoclaving on physicochemical and functional properties of dough and Cretan barley rusks

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The objective of this work was to evaluate the influence of flour particle size and autoclaving on the molecular and physicochemical properties of barley β-glucans during Cretan rusk production. Rusks from barley flour fortified with 15% wheat gluten were made using a coarse (d_{50} 350 μm) and a fine (d_{50} 200 μm) flour stream without (control) or with prior autoclaving at two moisture levels. HPLC-SEC of the flour and rusk β-glucans revealed a shift of the elution profile towards a lower molecular size range upon rusk making. The Mw of β-glucans in the products was maintained by flour autoclaving at 13–14% moisture. The elasticity, resistance to deformation and zero shear viscosity of flour doughs, as determined by oscillatory and creep tests, were higher ($p < 0.05$) for the autoclaved flours than their control counterparts (G' = 89 vs. 60 Pa, J_{max} = 3.0 vs. 4.4 × 10^{-5} Pa and η_o = 8.4 vs. 5.2 × 10^6 Pas, respectively). Dough hardness of autoclaved flours (compression and stress relaxation tests) was higher ($p < 0.05$) compared to the non-autoclaved flours (7.7 and 4.9 N vs. 4.2 and 3.0 N, respectively). With decreasing flour particle size there was a significant decrease ($p < 0.05$) of dough hardness and consistency. Products made from the fine flour showed enhanced loaf volume (2016 vs. 944 cm^3), decreased rusk hardness (39 vs. 65 N) and improved crumb structure; however, autoclaving of the fine flours had adverse effects on these attributes. *In vitro* assays showed higher viscosities of extracts derived from the coarse flour rusks (5-9 mPas) compared to the fine flours (4-5 mPas), and decreased starch digestibilities (27 and 41%, respectively); similar effects had flour autoclaving. Overall, particle size and autoclaving of barley flour both had a large impact on dough rheology and quality parameters of rusks as well as on molecular and physical properties of the barley β-glucans.

Impact of molecular structure of cereal β-glucans on anti-inflammatory activity in human aortic endothelial cells

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The inflammatory process, in terms of the interaction of endothelium with the immune system, seems to play an important role in the atherogenesis. In this study, the anti-inflammatory activity in human aortic endothelial cells (HAEC) of β-glucans isolated from barley (BGL) and oat (OGL), and the possible molecular structure-function relations have been explored. Molecular characterization of β-glucans was carried out with HPLC methods combined with lichenase digestion. The molecular weight (Mw) of BGL and OGL samples varied in the ranges of 71–242 and 36–255 × 10^3, respectively, while β-glucans from both origins differed structurally, with BGL having a higher amount of 3-O-β-cellobiosyl-D-glucose segments in the polymeric chains than those of OGL. Since the endothelial cell expression molecules have been recognized as an early step in inflammation, the effect of BGL and OGL preparations (3.75-200 μg/ml) on the expression of vascular cell adhesion molecule (VCAM-1) and intracellular cell adhesion molecule (ICAM-1) in HAEC, stimulated by tumor necrosis factor alpha (TNF-α) (1 ng/ml), was studied by a cell-ELISA method. The analysis of variance showed that β-glucans decreased significantly ($p < 0.05$) the TNF-α induced endothelial expression of VCAM-1 and ICAM-1. All the examined factors (concentration, Mw and structure) found to affect significantly the expression of VCAM-1. The inhibition of the VCAM-1 expression was larger for BGL than for OGL samples, displaying a maximum for polysaccharides with 140 × 10^3 Mw. The reduction of VCAM-1 expression was also dose-dependent in the tested concentration range of β-glucans. On the other hand, for most of the samples the expression of ICAM-1 was suppressed significantly only at the highest polysaccharide level and did not seem to be affected by the Mw and structure of the polysaccharide.

SDmatic test: Boric acid substitution by citric acid

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Various standard methods allow measuring starch damage of flour. Among these methods, the Amperometric analysis, using the CHOPIN Technologies SDmatic, is the quickest and simplest one suitable for industry to test large number of samples within a short time. The SDmatic test (AACC 76-33.01) requires the preparation of a solution with 120 ml distilled water, 3 grams Potassium iodine, 3 grams Boric acid and 1 drop of Sodium thiosulfate. In order to solve supplying difficulties, some SDmatic users would like to replace Boric acid with Citric acid. The objective of this study is to determine the substitution procedure that permits to keep optimal performances. 1 flour sample has been analyzed successively with the standard procedure (3 g of boric acid), then with different Citric acid quantity (from 0,2 g to 3 g) in replacement of boric acid. These tests show that using 1,5 g citric acid permits to obtain the same result than using 3 g boric acid. In order to confirm these first results, 21 flours, covering a large range of starch damage, are successively analyzed with AACC 76-33.01 method (3 g of boric acid) and with alternative method (1,5 g of citric acid). Obtained results show it exists a strong relationship (r^2 = 0,99) between these 2 methods, even if it exists a slight deviation between them. Additional tests proved that this standard deviation was corrected if the SDmatic was first calibrated using alternative procedure (citric acid). Our conclusion is that 1,5 g of Citric acid can easily and efficiency replace 3,0 g of boric acid during SDmatic test, on condition to realize an adequate device calibration.

Rye and mixed rye-wheat flour: Mixolab investigations

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Of the cereal flours, only wheat (Triticum aestivum) and rye (Secale cereale) can be used successfully in the production of leavened bread. Rye is considered inferior to wheat in the production of high-volume pan bread because its dough lacks the essential elasticity and gas retention properties. Rye flour can be used alone to produce the so-called "black" bread consumed extensively in eastern Europe and parts of Asia. In many countries, "light-rye" breads are made from rye and wheat flours mixed in varying proportions. The objective of this study is to evaluate with Mixolab the rheological properties (dough development, starch gelatinization and retrogradation) of rye and mixed rye-wheat dough. Ten rye flours from 3 different origins (BID, RUP and SKR) are analyzed with Mixolab (Chopin+ protocol). Tests made first with pure rye flours, then with different rye-wheat mixes (5/95, 10/90, 20/80 and 50/50 rye/wheat ratio). Obtained results show it exist significant differences between pure BID, RUP and SKR rye flours. These differences appear both on the protein part (RUP stability is around 9 minutes against 3 minutes for SKR and 1 minute for BID) and on starch part (C3-C2 difference is around 1,60 Nm for BID, against only 1,15 Nm for RUP and SKR). Furthermore, rye addition alters rheological behavior of wheat flour. These alterations change according rye proportion in the mix. If the rye quantity is low (less than 10% of the weight), modifications mainly concern starch part (C4 and C5 decrease). Beyond 10% of rye, modifications concern both protein (water absorption capacity increase) and starch part. The results showed high variability due to origin and proportion of rye flour, which suggest that Mixolab could be efficiency use to determine rye and mixed rye-wheat flour quality.

Proteolysis of defatted rice bran using commercial proteases

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Cereal Foods World 55:A56

Defatted rice bran (DRB) is a high volume byproduct from cooking oil industry. Despite of high concentration of proteins and carbohydrates, there is

a limitation in the application of food industry. Enzymatic hydrolysis of DRB is the one way to improve the nutritional values and limited information is available on enzymatic hydrolysis of DRB. The objective of this study was to increase the amounts of soluble protein using commercial proteases. The DRB was enzymatically hydrolyzed using eight commercial proteases (Protamex, Neutrase, Flavourzyme, Alcalase, Protease M, Protease N, Protease A, Molsin F) for 4 hr at optimum pH and temperature. Proteolytic hydrolysates were examined in supernatant and precipitate using lowry protein assay method and gravimetric method using weight difference before and after enzymatic hydrolysis. In lowry protein assay method, 8.5 ~ 39.4 mg protein/g DRB was hydrolyzed after eight commercial proteases treatments. Among them, two proteases (Alcalase and Protease N) are found to be the most effective enzymes resulting in 39.1 and 39.4 mg protein/g DRB. In gravimetric method, 60.6 ~ 118.3 mg protein/g DRB was hydrolyzed after eight commercial proteases treatments. Similar to lowry method, 118.3 and 107.1 mg protein/g DRB are hydrolyzed after Alcalase and Protease N treatments, respectively. When two or three effective proteases (Protamex, Alcalase and Protease N) were applied at one time to obtain synergistic effect, significant increase ($P < 0.05$) was observed when three proteases were applied at one time (63.4 mg protein/g DRB in lowry method and 204.5 mg protein/g DRB in gravimetric method). This result suggests that Alcalase and Protease N are the most effective enzymes for proteolysis of DRB and three commercial enzymes (Protamex, Alcalase and Protease N) show the synergistic effect on the hydrolysis of DRB.

Different human pancreatic α-amylase digestion property of highly branched starch

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Cereal Foods World 55:A57

Amylopectin contains α-1,4 linked linear chains of different lengths with α-1,6 branched linkages creating a range of structures with different starch properties. Previous research showed that increased ratio of α-1,6 branched points resulted in a slower digestion rate. We hypothesized that enzyme-modified starch using glycogen branching enzyme (GBE) and β-amylase for regulating α-1,4 and α-1,6 linkage ratios would be digested differently by human α-amylase due to lack of hydrolysis activity on the α-1,6 linkage. In this research, enzyme-modified starch was dissolved in phosphate buffer (pH 6.9) and reacted with human pancreatic α-amylase for 48 h. The hydrolyzed starch structures by α-amylase were analyzed by high performance anion-exchange chromatography. Chromatography profiles showed two types of oligosaccharides released after α-amylase treatment that correspond to α-limit dextrin, the linear (mainly DP 1-3) and branched oligosaccharides (> DP 4). Notably, the DP distribution of the α-limit dextrin branched oligomers increased as the α-1,6 linkage ratio was increased. This result proved that structurally changing degree of branching points results in different α-amylase digestion products. We hypothesize further that there is an increase in slowly digestible structures from the highly branched dextrin at the level of the small intestine mucosal enzymes.

Application of binomial and multinomial probability statistics to the sampling design process for a global grain tracing and recall system

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A sampling process for the grain traceability system employing a coded tracer was designed by applying binomial and multinomial probability statistics aiming to collect sufficient tracers during grain sampling for grain identity under multiple scenarios and assumptions. This sampling process was verified by conducting a probability sampling test at the dispensing rate of 3 tracers per kg of grain and sampling grains at predefined sampling points in a commercial scale grain elevator under an assumption to identify five different sources of grains. This enabled us to understand a difference between theoretical sampling design process and real practice. The statistical results showed tracers were not heavily segregated, but rather evenly distributed in an elevator bin and a grain transport. The binomial probability sampling test for identification of a single field or location of grain origin showed that the range of average tracer concentration at sampling points was within the confidence interval estimated by the probability statistics. In the multinomial probability sampling test for identification of more than two sources of grains, all five grain sources were identified by sampling the amount of grains estimated by the probability statistics in a truck while a bin sampling failed to identify all the sources of grains, implying that a grain transport vehicle is a better place for tracer sampling than an elevator bin. The predetermined sample size for transport sampling appeared to be enough to collect tracers from all sources of grains which even were not homogeneously mixed. The sampling process based on the probability statistics was proved to be applicable for the proposed traceability system, which may facilitate a sampling procedure for collecting a safe number of tracers for grain identity and reduce a risk of economic loss due to inappropriate sampling.

Relationships between anthocyanin content and composition, and antioxidant activity of four hulless barley genotypes of different seed color

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Pigmented grains of corn, rice and wheat are rich in anthocyanins and are used in the manufacture of unique food ingredients and products as natural food colorants. Anthocyanins are also recognized as potential antioxidants and free radical scavengers. Barley genotypes of various seed color are also available, but little used as foods. We determined the total anthocyanin content and composition of four hulless barley genotypes of various seed color including black, blue, purple and yellow, along with their antioxidant activities, to explore their potential as functional food ingredients. The total anthocyanin content of whole grain was 35.1, 80.9, 764.6 and 6785.3 μg/g in yellow, black, blue and purple barley genotypes, respectively. Bran fractions contained more than twice as high anthocyanins as whole grain in black, blue and purple barleys. The purple barley contained 11 anthocyanins, whereas only one type of anthocyanin, peonidin derivative, was detected in blue, black and yellow barleys. Cyanidin-3-glucoside, cyaniding 3-(6"-succinyl) glucoside and two unknown peonidin derivatives were the major anthocyanins detected in purple barley. DPPH and superoxide radical scavenging activities and total antioxidant activity of acetone extracts were highest in purple barley, which also showed the highest total anthocyanin content, followed by black and blue barley. Yellow barley was lowest in total anthocyanin content and antioxidant activities of acetone extracts. DPPH radical scavenging activities of water extracts were much lower than those of acetone extracts, but differences in total antioxidant activities between acetone and water extracts were small and inconsistent.

Effects of microwave treatment with different acids on normal corn starch

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Microwave heating is more efficient process than the traditional heating and has been used to accelerate chemical reactions and hydrolysis. In this study, microwave heating was utilized to modify starch granules in different acid solutions with water content about 40%. Normal corn starch granules were impregnated with different diluted acid solutions and the damped powders were heated in domestic microwave oven for 30 seconds. The temperatures of samples after heating were around 56°C which was below the gelatinization temperature of native starch granules. The starch granules were slightly hydrolyzed by this microwave assisted acid treatment and the recovery were 99.2%, 97.7%, 91.2% and 88.9% for samples treated in 0.1M of acetic, phosphoric, hydrochloric and sulfuric acid, respectively. The yields were also higher than 98% for those treatment conducted in high concentration of acetic acid. The treatment caused birefringence loss and partially swelling around the hilum of starch granules with extent correlated to acid strength. Although the starch molecules were only slightly degraded, the crystallinity of granules was significantly reduced revealed by X-ray diffraction and size-exclusion chromatographic analysis. The swelling temperatures of treated samples were slightly altered but the pasting viscosity was significantly reduced similar to the properties thin boiling starch.

The differential roles of the four mammalian mucosal glucosidase subunits in starch digestion

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Previous studies from our group on starch digestion at the human intestinal mucosal enzyme level showed that the four mucosal glucosidase subunits can digest, in addition to α-limit dextrin (LDx), raw starch and starch molecules. They also digest α-LDx's of various starches differently. In this study, the waxy corn α-LDx was applied as the substrate to test the hypothesis that

certain α-LDx structures are digested slowly by human enzymes, and to explore further the digestion roles of individual mucosal glucosidase subunit. Waxy corn α-LDx was incubated with four mucosal glucosidase subunits separately. Glucose production and the real-time structure changes were examined. Ranking of degree of glucogenesis was C terminal maltase-glucoamylase (C-MGAM, 70% of starch mass), C-sucrase-isomaltase (C-SI, 65%), N terminal SI (N-SI, 57%) and N-MGAM (38%). The combination of four subunits reached maximum glucogenesis of 75% in the system. N-MGAM mainly digested linear oligomers (DP 2-4) and had very limited access to the highly branched structures of α-LDx. Other subunits digested linear oligomers and the branched structures as well. The four subunits had maltase activity, but N-SI was the only one that can release glucose from isomaltose. We hypothesize that C-MGAM, C-SI and/or N-SI are able to attack the branched LDx structure and may cleave the α-1,4 linkages randomly and result in partial digestion of highly branched structures. This study for the first time directly shows the role of individual mucosal glucosidase subunits in starch digestion and reveals the potential of developing slow glucose release dextrins.

Physical, nutritional and sensory properties of cookies, pasta and expanded snack products made of the legumes common white beans, peas and lupines

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Cereal Foods World 55:A58

Legumes are a valuable source of dietary fiber, minerals and vitamins and have a good amino acid profile. Despite that, the consumption of legumes decreased in Western countries over the last decades. To increase the consumption, quick-to-prepare or ready-to-eat products with excellent sensory properties have to be developed. In the present study the effect of common white bean, pea and lupine flour on the physical, nutritional and sensory properties of buckwheat cookies (0, 50 or 100% legume flour), wheat pasta (0, 50 or 100% legume flour) and expanded wheat/maize snack products (15, 30, 45 or 60% legume flour) were analyzed. Crispness of pure legume cookies was higher than that of cookies with buckwheat flour. Cookies with lupine flour were the crispiest ones and had the highest spread factor. The color differed from yellowish (bean) to orange (lupine) and green (pea). The sensory panel rated the cookies with lupine and bean flour better than with pea flour. Cooking weight and cooking loss of pasta with legume flour were higher compared to wheat pasta. Texture of bean and pea pasta was comparable to wheat pasta. The sensory properties of the legume pastas were not as good as those of wheat pasta. Texture values of bean and pea snack products decreased with increasing bean or pea content. Pea snack products had higher texture values than bean snack products. The expansion index tended to decrease with increasing legume content. The protein and dietary fiber content of all products could be increased by the addition of legume flour. To conclude, the addition of bean, pea or lupine flour effects the physical, nutritional and sensory properties of cookies, pasta and snack products to varying degrees. From a technological point of view the addition of legume flour can be achieved without major problems. But further research is necessary to improve the sensory properties of these products.

Properties of high amylose starch-beeswax inclusion complexes prepared by steam jet cooking

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Amylose is known to form inclusion complexes with a large number of polar and non-polar organic compounds including fatty acids. Amylose inclusion complexes are proposed to be employed as carrier for delivering ligands with desired functional properties in food and nutritional supplement products. In this study, high amylase starch-beeswax inclusion complex is made by excess steam jet cooking. The inclusion complex is characterized by light microscopy, scanning electron microscopy (SEM), X-ray diffraction, light scattering techniques. Rheological measurements of aqueous solutions of high amylose starch beeswax inclusion complexes formed at their starch concentrations are also conducted to evaluate their flowability and changes in viscosity under different pH and electrolytes conditions.

Crackers which contain fibre and resistant starch show positive effects on microflora and satiety

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Obesity is one of the major public health problems all around the world. In order to manufacture less energy dense food, fibers are a good alternative. At the same time, they increase satiety and also they can act as prebiotic which are basically fermented ingredients that confers changes in gastrointestinal microflora producing positive effects on host. Bacillus coagulans (BC) is a probiotic which is enclosed by a protective shield. This protective layer helps this probiotic to survive the acids in the stomach in order to arrive intact to their intended target where it produces the favored L (+) optical isomer of lactic acid. In this research, a cracker which contains BC and a special modified starch (RS4), with outstanding prebiotic and satiety properties, has been developed. A packet, which includes 3 portions, contains 20 gr of fiber (80% RDI), which means that can be labeled as “High in Fiber”. Each portion contains 3 * 108 BC CFU. Besides that, this cracker is low in Sodium and has no added fat and sugar. Satiety was determined in 10 subjects who consumed a portion/day during a week, recording it food intake. Additionally, it was register the subjective satiety/hunger level in a visual scale analogous of 10 cm. Also, the changes in feces have been studied, where positives changes in microflora, pH and SCFA content have been observed. In conclusion, a cracker with a highly nutritional value (high fiber, probiotic content, low Sodium) has been developed. This could be used as daily snack in order to prevent obesity and problems related to gastrointestinal diseases.

Effect of β-amylase treatment on resistant starch formation in high amylose corn starch

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Cereal Foods World 55:A58

Reassociated amylose is resistant to digestion by amylolytic enzymes, which is known as resistant starch type III. This study was designed to explore the effect of β-amylase treatment on the formation of resistant starch type III in 70% high amylose corn starch. High amylose corn starch was first gelatinized and then hydrolyzed by β-amylase to varying degrees. The resultant hydrolyzed starch was debranched with isoamylase prior to autoclaving and storage at 95°C for 24 hours. Controls were also prepared with and without the β-amylase treatment. The treated starches were tested for their thermal properties and rapidly digestible, slowly digestible, and resistant starch fractions. High amylose corn starch that was treated with β-amylase (up to 16%hydrolysis), and isoamylase had a higher resistant starch content than those only debranched or hydrolyzed. The slowly digestible starch fraction gradually decreased with increasing β-amylolysis. The β-amylase treatment decreased the enthalpy of the low temperature transition (100–120°C), but increased that of the high temperature transition (150–160°C). The temperature range of the high temperature transition was significantly reduced with the β-amylase treatment. The results suggest that a β-amylase treatment can be used to increase resistant starch content in high amylose corn starch.

Physico-chemical properties of African rice (Oryza glaberrima) varieties

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Cereal Foods World 55:A58

The Africa Rice Center (AfricaRice) has developed the NERICA rice varieties, which are crosses between Oryza sativa and Oryza glaberrima and these are being cultivated in many African countries. Africa is the only continent using Oryza glaberrima in rice breeding programs but the grain quality of Oryza glaberrima remain largely unknown. The physico-chemical properties of over 470 O. glaberrima varieties were determined and compared to a check O. sativa variety, IR 64. Apparent amylose content was determined according to Juliano (1971), gel consistency according to Cagampang et al. (1973) and viscosity profiles determined using a Rapid Visco-Analyzer. Amylose content for the O. glaberrima varieties ranged from 8.7 to 27.6% compared to 22.5% for IR64. The gel consistency of the glaberrimas was from 30 to 100 mm as against 85 mm for IR64. Short, medium and long grain lengths were observed as this ranged from 4.90 to 6.72 mm. Although glaberrimas are generally known to swell less than sativas, considerable variations were found in their viscosity profiles. Peak viscosity, breakdown and setback values for IR64 were 3163cP, 1433cP and 160cP respectively. Corresponding values for the glaberrimas ranged from 784 to 2345cP, 47 to 766cP and 247 to 1993cP respectively.

Einkorn, from kernel to bread: Technological and nutritional aspects

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Cereal Foods World 55:A58

Einkorn (*Triticum monococcum* L. subsp. *monococcum*) is an ancient wheat, strictly related to durum and common wheat, regarded as a high-nutritional value cereal, for its high proteins (15.5-22.8% dm), carotenoids (5.7-13.6 mg/g dm) and tocols (61.4-115.8 mg/g dm) content. Current trends towards low-impact and sustainable agriculture as well as an increase in the utilisation of "functional" products suggest that this cereal may still play a role in human consumption. To better understand the potential of this ancient wheat, two einkorn accessions (*cv* Monlis and ID1395) were considered, and their properties were evaluated starting from the kernels (hectoliter weight, 1000 kernels weight, *etc.*), going on with flours (milling yield, chemical composition, gliadins to glutenin ratio, SDS sedimentation, enzymatic activities, pasting properties; lutein content), dough and bread properties evaluation (height, specific volume, moisture, crumb cells size, crumb hardness, lutein content and heat damage indices, *etc.*), both after baking and during storage. A bread wheat (*cv* Blasco) was the reference. Einkorn breads were characterized by similar or higher specific volumes than wheat bread, a higher amount of alveoli (and of bigger size), and a softer crumb in spite of the lower moisture content. The same trend was observed even after 52 hours of storage at 25°C and 60% RU. This behaviour could be ascribed to the higher amount of protein (involving the lower presence of starch) and fiber (due to the less refined einkorn flours) in einkorn bread, all fundamental factors in slowing down the bread staling phenomena. From einkorn flour to bread, a decrease in the lutein content was observed, as a consequence of the technological process; however, the residual amount of this important component was still significantly ($p < 0.05$) much higher in einkorn breads in comparison to the reference bread.

An automated classification model based on NIR spectra to predict the technological quality of common wheat

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Cereal Foods World 55:A59

Empirical testing methods on wheat flour have been performed since the early days of cereal science: they provide useful information and are widely accepted for wheat flour characterization and quality control. However, they frequently involve a large number of experimental measurements, generally expensive and time-consuming, and characterized by a rather complex and prone to subjectivity interpretation of results. In this context, the aim of this research was to develop a new and automated method based on FT-NIR spectra, able to predict - in short times and with low uncertainty - the technological quality of common wheat flours "as a whole", differently from the usual quantification of single physical or chemical properties. An extensive preliminary work was done to objectively define the instrumental measuring conditions leading to the highest information and the lowest noise, considering the nature of the sample (kernels, whole meal flour, flour), different sampling tools (fiber optic, integrating sphere, transmission unit), and 2 independent laboratories using 2 Bruker MPA FT-NIR spectrometers. Results confirmed that optimal measuring conditions can vary depending on the type of analyzed matrix, and allowed in the selection of the NIR sampling tools for the subsequent acquisition of a wide spectral dataset. According to these findings, the FT-NIR spectra of 303 bread wheat samples, harvested in 2007–2008 years and representative of the different Italian wheat varieties and of the different soil and climate areas, were collected in parallel in the 2 laboratories and submitted to data processing. Automated classification models, based on PLS-Discriminant Analysis, were developed to predict new common wheat quality classes, based on the reference experimental parameters and the FT-NIR spectra acquired on the same samples.

Investigation on starch and protein organization in semolina pasta

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The cooking behavior of pasta is generally associated with the protein characteristics of durum wheat semolina. Nevertheless, starch can assume different structures according to the pasta-making conditions, influencing both cooking quality and digestibility of the product. The aim of this work was to investigate starch and protein organization in pasta samples. Two commercial semolina samples (organic-O and conventional-C), different in protein and starch characteristics, were processed in a pilot-scale plant. Two different drying technologies were applied: low (LT-50°C for 14 hours) and high temperature cycle (HT-90°C for 8 hours). The four pasta samples obtained (O_LT; O_HT; C_LT; C_HT) were analyzed using both conventional and new approaches. Starch organization was studied by using DSC and X-ray diffraction. Gluten network properties were investigated by Gluten Peak Tester® (GPT). Rheological properties of dough during heating and cooling were evaluated using a MicroViscoAmilograph® and a Farinograph® connected to a waterbath. Sample O_LT presented the lowest gelatinization temperature (52.8°C) and the highest enthalpy value (7.3 J/g): these results account for a different starch organization during the drying phase. Moreover, starch isolated from pasta samples presented a different affinity for iodine vapor. Regarding gluten, GPT highlighted a stronger protein network in C_LT sample: during the test the torque measured for this sample continued to increase until 6 minutes of analysis. A different macromolecular organization was also showed by the innovative Farinograph test, that allows to measure changes in consistency under heating and cooling. These preliminary results suggest that there are differences in the starch and protein properties between pasta sample according to the quality of the raw material and the drying cycle. Moreover, starch and protein interaction requires further studies.

Analisis and labeling of commercialy available foods with and without gluten, from Florianópolis – Brazil

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Celiac disease is a genetic condition responsible for gluten intolerance which causes flattening of the intestinal villi and interferes with dietary nutrient absorption. The only available therapy is a gluten-free diet. According to the Codex Alimentarius, gluten free labeled products contain <20 ppm if they are derived from foods/ingredients that don't contain prolamin and <200 ppm if they contain ingredients derived from wheat, barley, rye and oats that have been rendered gluten free. In reality, it is the prolamin fraction of gluten from wheat, barley, rye and related crosses that cause the intolerance. Cross-contamination with a gluten source can easily happen during harvesting, transportation, or processing. To verify if the labeling of food products followed the correct guidelines, 54 food items commercialized in Florianopolis/SC/Brazil, were analyzed. 14 items were labeled as containing gluten and 40 as gluten-free. Among them were: 22 corn chips (curls) of which 13 were labeled as containing gluten and 9 labeled as gluten-free; 10 whole grain cookies labeled as not containing gluten;14 gluten-free granola samples and 8 samples baking mixes of which only 1 was labeled as containing gluten. The prolamins were buffer extracted with a commercially available ELISA kit and analyzed according to AOAC 991.19 method. Of all the items analyzed, only 1 labeled as containing gluten had more than 200 ppm, even though, 3 samples, derived from foods/ingredients that do not contain prolamin, presented values between 20 ppm and 200 ppm. In conclusion, of the 14 items labeled as containing gluten, only one was correct. The others were wrongly labeled as containing gluten, possibly to prevent any legal action against the manufacturer. However, this policy is quite common among Brazilian food companies, and it reduces the options available for those afflicted with celiac disease.

Effect of planting date on cornstarch structures and properties

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Because of unexpected weather conditions during planting season, many growers have to plant corn before or after the optimal planting date. A significant delay in planting corn reduces grain yield, but the effect on starch structure and properties is not well understood. We obtained grain of B73 and a commercial corn hybrid planted at Ames and Nashua, IA at three to five planting dates from April 16 to June 11 of 2008. Structural and functional characteristics of isolated starches were studied. Starch from corn planted on April 16 and April 30 contained a significant number of large granules with diameter >20 μm, whereas corn planted on June 11 had homogeneous granule size distribution with fewer large granules. The apparent amylose content of starch, determined by measuring iodine affinity of defatted starch, decreased with the delay in planting time from 25.4% to 24.6%, and 24.3% to 23.4% for the commercial hybrid and B73, respectively. For the commercial corn, there was a decreasing trend in the average chain length of amylopectin from 21.1 to 20.0 with delayed planting dates, with the exception of the corn planted April 16 (19.8) as determined by fluorophore-assisted capillary electrophoresis. The molecular weight of amylopectin, measured by HPSEC, was not significantly affected by the planting dates. The onset, peak, and final gelatinization temperatures of the commercial hybrid starch decreased with the delayed planting from 62.7°C to 60.7°C, 68.1°C to 65.5°C, and 72.3°C to

71.1°C, respectively. The pasting temperature and setback viscosity of the commercial hybrid starch decreased from 70.2°C to 69.5°C, and 96.1 RVU to 91.3 RVU, respectively, but the peak viscosity increased from 162.0 RVU to 177.3 RVU with the delayed planting. The enzyme hydrolysis of starch showed that corn samples planted earlier were less digestible than those planted later.

Texture evaluation of wheat flour tortillas using the shear and extensibility methods

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Texture is a very important property in assessing the quality of wheat flour tortilla. This study addresses this matter, evaluating shearing and extensibility methods in commercial wheat flour tortillas. Tortillas were randomly selected and stored for 2, 24, 48 and 72 h before evaluation. Physical tests were thickness, diameter, weight, and rollability. Texture was measured by shearing and extensibility methods, using Instron 4465 texturometer. The firmness of tortillas was measured through the Kramer shear cell, and the extensibility cell, measuring extensibility (CME). Both cells report measurements of maximum force, displacement, Young modulus, and stress. The measurements from both cells showed changes in the tortilla texture; the slope method from the shear cell, and the displacement for the extensibility cell, showed also significant differences ($p < 0.05$) caused by changes during the controlled storage of tortillas. The use of these two cells is highly recommended because they provide reliable information on the strength and extensibility, as well as textural properties of wheat flour tortilla.

Effect of the Hofmeister series on gluten aggregation measured using a torque-based technique

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Cereal Foods World 55:A60

Gluten aggregation using the Hofmeister series has been studied over many decades, but previous research has been limited to using large sample sizes, involved long sample preparation, or used already formed gluten. The current study involves small sample sizes and rapid preparation time to investigate gluten aggregation. The Gluten Peak Tester (GPT) mixes flour (8 g) and aqueous solution (10 g) at 2750 rpm to create a gluten network. The strength of the aggregate is measured by torque created on a spindle upon formation of gluten. The parameters of interest include maximum torque (MT) and time to maximum torque (peak maximum time, PMT). Gluten aggregation of two flours (Ibis, 15.1% protein; Diamant, 10.6% protein) was tested in the GPT using anions and cations of the Hofmeister series at various concentrations (0.1 to 1M). The PMT of both anions and cations followed the Hofmeister series with PMT decreasing as the series moves from kosmotropic to chaotropic ion at each concentration. With increasing concentration, the kosmotropes resulted in increasing PMT while the chaotropes decreased gluten aggregation time. The torque created by gluten aggregation also followed the Hofmeister series with torque decreasing as the series moves from chaotrope to kosmotrope. For all salts, as the concentration increased, the torque increased except for the kosmotropes on Ibis which resulted in constant torque at all concentrations. The results highlight the validity and sensitivity of the instrument to detect small differences in gluten aggregation that may be due to compositional differences of the gluten fractions (i.e. gliadin and glutenin). Small sample sizes and quick results allow for further studies on gluten aggregation to understand which gluten fractions participate in gluten formation and how it translates to gluten quality for baking applications.

Rheological and structural properties of waxy corn mutant starches as hydrolyzed by isoamylase and beta-amylase in the granular state

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The gelation properties of starch are important to the texture and stability of starch based food products. The objective of this work was to study the alteration of amylopectin structure on the flow and gelation properties of waxy starches. Two waxy corn mutant starches (Hsyn73 *wxwx* and Hsyn73 *duwx*) were treated with either isoamylase or beta-amylase to various extents to alter their amylopectin structures. The resultant treated starches were tested for rheological properties by rotational and dynamic tests using a rheometer and for structural characteristic by HPLC with MALLS and IR detectors. The treated starches exhibited a shear thinning behavior with more significant differences observed in those treated by isoamylase than those treated by beta-amylase. The changes in the index behavior and consistency index were greater for the *duwx* and for those treated with isoamylase. In the frequency sweeps, G' was significantly higher than G" for all the samples, and the gels obtained from the *wxwx* were softer than those from the *duwx* for both enzymatic treatments. The decrease in the molar mass with hydrolysis was greater for the *duwx* and for those treated with isoamylase. The results demonstrate that changes in amylopectin branching degree had more significant impacts on the flow and gelation properties of waxy corn mutant starches than changes in amylopectin chain length.

Consumer acceptability of pumpkin-spice muffins prepared with spice combinations varying in total phenolics

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Cereal Foods World 55:A60

In grain-based products, spices-- concentrated sources of phenolics-- may provide protective/preventative health benefits along with appealing flavors. Total phenolics in 3 spices commonly used in grain-based products (nutmeg, cloves and cinnamon), and the spice contribution to total phenolics in a food system (pumpkin-spice muffin) were investigated. Spice sample suites included a popular brand name of unspecified origin and 2-3 gourmet samples of known origin. Total phenolics were determined with the Folin-Ciocalteu assay in triplicate, after hexane extraction. Phenolic values (mg GAE/g) for the cinnamon suite ($n = 4$) ranged from 44.0 ± 1.12 to 136.8 ± 4.51; cloves ($n = 3$) from 142.1 ± 15.96 to 166.7 ± 5.43; nutmeg ($n = 3$) from 15.2 ± 0.89 to 19.3 ± 0.83. Three muffins in which amounts of all ingredients were constant were baked. The control contained popular brand name supermarket spices commonly used by consumers; muffins also were reformulated to minimize and maximize phenolics contributed by the spices in each formulation by combining those with the lowest or highest mg GAE/g in each sample suite. The spices contributed 74, 62 and 79% of the expected total phenolics in the control, low and high phenolics muffin, respectively. A consumer sensory panel ($n = 134$) assessed intensity of muffin characteristics with a just-about-right-scale (JAR) where 1 = too low, 5 = too high and 3 = just about right. JAR LS-means ± SE for pumpkin flavor (2.5 ± 0.06), sweetness (2.8 ± 0.05) and spice intensity (2.7 ± 0.81) did not differ ($p > 0.05$) with formulation. Spice selection impacted JAR assessments for exterior and interior color ($p < 0.05$). When ranked for preference, all muffins were equally preferred ($p = 0.93$), and 42% of these panelists were willing to pay 20–40% more when an antioxidant claim was present.

Microscopic and spectral analysis of soybeans with differing protein subunit composition

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Cereal Foods World 55:A60

Soybeans contain two major proteins, glycinin and β-conglycinin, which together constitute up to 70% of the seed protein. Both proteins are composed of a number of subunits. The quality of the seed protein is a major factor influencing the end use of soybeans in various soy foods. Samples of Harovinton, a commercial tofu-type soybean, and a range of lines derived from Harovinton with differing protein subunit composition were processed for light microscopy using conventional fixation and embedding, as well as a microwave protocol. In samples prepared using the conventional fixation/embedding protocol, differences were observed in the size, shape and staining characteristics of protein bodies in the cotyledons. In some areas of the microwaved samples, some fusion of protein bodies within cells, as well as cell ruptures with fusion of the contents of adjoining cells were observed, indicating damage induced by the microwave protocol. Protein isolates from Harovinton, as well as some of the lines with differing subunit composition, were analyzed using mid-infrared spectroscopy. Although no distinct differences were detected in the two main protein bands (Amide I, 1636 cm-1, C = O stretch; Amide II, 1526 cm-1, N-H bending), Fourier self-deconvolution of the Amide I band showed quantitative differences in secondary/tertiary structure among the samples.

A reinterpretation of SKCS Crush Response Profiles

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The modern version of the Perten Single Kernel Characterisation System (SKCS) allows the individual Crush Response Profile (iCRP) for each kernel in a sample to be retrieved, and the averaged Crush Response Profile (aCRP) for the sample to be calculated. The aCRP typically exhibits an initial small

peak followed by a trough and then a larger, dominant peak. Previous work has interpreted the curve as reflecting "shell" breakage (i.e. breakage of the outer bran layers) in the initial peak, followed by endosperm breakage in the dominant peak. The current work shows this interpretation to be erroneous, and presents an alternative interpretation. The initial peak indicates the initial elastic deformation and fracture of the kernel, with the breakage force determined not by the presence or characteristics of bran but by the crease morphology. The subsequent peak relates to the post-failure behaviour and further breakage of the particles. The value of "post-failure slope divided by kernel weight" is correlated with the SKCS Hardness Index.

A novel approach to predicting the glycemic impact of oats applied to a breeding population

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Cereal Foods World 55:A61

The effect of processing rolled oats to porridge on their glycemic impact and glycemic index, and on the rapidly digested (RDS), slowly digested (SDS), and inaccessible digestible (IDS) starch fractions that determine the glycemic response, was measured by a novel *in vitro* method. The method measured glycemic impact as the balance between carbohydrate release in digestion, expressed as glycemic glucose equivalents (GGE), and estimated blood glucose clearance in response to the GGE dose, for each of 23 oat lines from a breeding programme. The difference between the GGE release and blood glucose clearance curves provided curves of netGGE against time which mimicked blood glucose response curves. Comparing the incremental area under the curves (iAUC; as in clinical glycemic response determination) with that of a glucose reference showed that, on average, the glycemic impact of a 50 g serving of uncooked rolled oats was 10.1 g of GGE (SD ± 2.9, range 8.9 g) compared with 21.7 g (SD ± 1.5, range 5.9 g) after the oats had been made into porridge. By comparing the oats iAUC with the iAUC for a glucose reference of equal available carbohydrate content glycemic index (GI) values were calculated. The uncooked rolled oats had a mean GI of 38.3% (SD ± 11.1, range 33.5) compared with a GI of 82.4 (SD ± 5.7, range 22.4) after cooking. Of the 23 oat cultivars tested all but two of them fell into the low GI category as rolled oats, but after cooking as porridge all but one were in the high GI category. The findings are consistent with published clinical measurements. It is concluded that the glycemic impact of rolled oats may be substantially manipulated by the choice of method used to prepare them for consumption.

Beverage of high nutritional value based on extruded quality protein maize flour and toasted chickpea flour

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Malnutrition is one of the principal causes of death in children in developing countries, including Mexico. One strategy to fight against malnutrition in developing countries is the development of new products using cereals or legumes, important part of these countries diet. The objectives of this work were produce a beverage with high nutritional value from a mixture of extruded quality protein maize flour (EQPMF) and toasted chickpea flour (TCF), and evaluate the physicochemical, functional and nutritional properties of EQPMF, TCF, mixture EQPMF/TCF mixture and the beverage. QPM grits were mixed with lime and water. The treated grits were extruded with a single screw extruder operating at 85°C and a screw velocity of 240 rpm. The chickpea grains were toasted throughout a traditional process using a temperature/time ratio of 150°C/10 min. The chemical composition and energetic content of the beverage were 1.59 g of protein, 0.83 g of lipids, 0.24 g of ashes, 11.68 g of carbohydrates and 60.53 kcal per 100 mL of beverage. Levels of essential amino acids were greater than levels recommended by WHO. Proteins of the beverage had chemical score, in vitro digestibility and C-PER values of 110%, 80.6% and 2.42, respectively. The beverage was evaluated using a trained taste panel as rated as acceptable. These kind of beverage, with high nutritional value and sensorially acceptable, would be used in national programs to improve health and also to prevent overweight and obesity in infant population.

Effect of nixtamalization and extrusion process on ferulic acid content in pigmented Mexican maize

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The effect of traditional nixtamalization and extrusion cooking on the ferulic acid content (free, conjugated and bound form) of Mexican pigmented maize (white, yellow, blue and red) processed into tortillas were performed. Both processes (nixtamalization and extrusion cooking) caused a significant ($p < 0.05$) decrease on amount of ferulic acid content when raw maize was processed into tortilla. Tortillas made from nixtamalized maize flour had the greatest negative impact on total ferulic acid contents stability. The percentage retention of total ferulic acid content of tortilla elaborated from nixtamalization maize flour were from 21 to 56%, being the highest content of ferulic acid for blue maize (56%). However, tortillas made from extruded maize flour had reduced amounts of ferulic acid loss. Tortillas elaborated with extruded flour of blue maize (97%) had the highest retention of total ferulic acid content. The results on this study clearly indicate that tortillas from both processes contained higher amounts of bound ferulic acid than raw maize, which can be due to heat processes of baking complexed ferulic acid. However, the product obtained with extrusion process can be considered as a whole grain food. Furthermore, the results in this study indicate that the extrusion cooking is an alternative to obtain products with high levels of ferulic acid in all maize genotypes.

Low-trans, low-sat, fiber enriched chocolate chip cookies

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The development of food products with health benefits is a major trend in the food industry, and the reduction of trans fats and saturated fats, as well as fiber enrichment are current issues. The objective of this study was to develop low-trans, low-sat, fiber enriched chocolate chip cookie formulations, with good sensory acceptance. A 2^2 central composite design was followed, with the percentages of low-trans low-sat fat reduction (0 to 15%, flour basis) and of the soluble fiber polydextrose addition (0 to 24%, flour basis) as the independent variables. Fat replacement at a 1:1 level was done using orange fiber and water. The responses evaluated were: instrumental color, instrumental texture, cookie diameter and sensory acceptance scores for appearance, aroma, taste, texture and global impression. Lightness (L) values varied from 57.49 to 63.74; firmness from 5105.35 to 19633.12 g; cookie diameter from 2.8 to 3.1 cm; appearance acceptance from 4.9 to 7.3; aroma acceptance from 5.2 to 7.4; taste acceptance from 5.4 to 7.1; texture acceptance from 2.6 to 7.8 and global impression acceptance from 4.0 to 7.4. It was possible to obtain response surfaces for the responses cookie diameter and appearance, texture and global impression acceptance scores. Polydextrose increased cookie diameter, whereas orange fiber and fat reduction tended to reduce it. Cookie appearance was influenced negatively by polydextrose addition. Texture and global impression had similar response surfaces, with intermediate polydextrose percentages (12%) and lower fat reduction levels yielding better acceptance scores. From these results, two low-trans, low-sat, fiber enriched chocolate chip cookie formulations were selected for a final sensory acceptance test: a "regular" (30% fat and 14.1% polydextrose, flour basis) and a "light" version (21.5% fat, 0.85% orange fiber and 13.5% polydextrose, flour basis).

Distribution of granule channels, protein and phospholipid in triticale and corn starches as revealed by confocal laser scanning microscopy

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Bio-conversion efficiency of starch greatly depends on the botanic origin, structure and composition of starch. The objectives of this study were: a) to study the chemistry of starch channels and the association between starch molecules and non-starch components such as protein and lipid, and b) to evaluate the effect of chemical and protease treatments on the removal of protein and phosphorus and subsequent starch hydrolysis. The morphology and microstructure of starch granules from two varieties of triticale (Pronghorn and Ultima) and from regular corn were characterized using scanning electron microscopy (SEM) and confocal laser scanning microscopy (CLSM). The effects of chemical and protease treatments on starch enzymatic hydrolysis also were evaluated. Numerous pores were distributed randomly on the surfaces of corn starch granules. Markedly fewer pores were observed on the surfaces of starch granules from Pronghorn triticale, and even fewer on the granule surfaces of starch from Ultima triticale. After staining, CLSM

revealed the microstructure of granules and the distribution of granule channels, along with the presence of protein and phosphorus. Starch-associated protein was predominately distributed on the granule surface and in the internal channels of both triticale and corn starches, and also in the central region of corn starch granules. Phosphorus was located mainly on the granule surface but also in channels and throughout granules in triticale starches, while mainly in the channels of corn starch granules. Chemical and protease treatments resulted in partial removal of protein and phosphorus from the granule surface and channels, indicating that they are strongly bound to starch molecules. There were no trends observed between the changes in the contents of nitrogen and phosphorous due to different treatments, and the extent of amylase hydrolysis at sub-gelatinization temperature.

Compositional and structural characterization of hulless barley lines of variable β-glucan content

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Cereal Foods World 55:A62

Increasing demand for nutritious fiber-rich food products has made barley an ideal candidate for grain-based functional food. Among the diverse barley genotypes, hulless barley holds great potential in food processing as it can be directly processed into flour, flakes or grits without dehulling. The objectives of our research were to understand the kernel characteristics of hulless barley lines and to determine the association of β-glucan content with various food processing parameters. Seventeen hulless lines with β-glucan content ranging from 5.6 to 9.8% were evaluated for hardness index (HI), vitreousness, and protein and amylose content. HI ranged from 54.0 to 69.5 and L*, measured as an indicator of vitreousness, varied from 54.9 to 61.1. Protein and amylose contents ranged from 13.4 to 17.8% and from 8.4 to 26.3%, respectively. HI, L*, and protein and amylose content showed no significant association with β-glucan content. Three high β-glucan and three low β-glucan lines were examined for endosperm structure using light microscopy (LM), and evaluated for flour particle size (PS), pearling properties, water absorption and cooked kernel texture. Endosperm cell wall thickness measured using LM ranged from 3.62 to 5.91 µm in the high β-glucan lines, while it ranged from 3.57 to 5.65 µm in the low β-glucan lines. Average PS >106 µm was 43.8% for the high β-glucan lines and 40.8% for the low β-glucan lines, and was significantly higher for the former. Average pearling loss after six min pearling was 25.3% in high β-glucan lines and 28.8% in low β-glucan lines and was significantly greater in the low β-glucan lines. Water absorption of kernels soaked for 8 hr and texture of kernels cooked for 40 min were not significantly different between high and low β-glucan lines. The results indicate that β-glucan content of barley kernels influence particle size distribution of barley flour and pearling property of barley grain.

Effect of annealing on segmental mobility of polymers in starches from different botanical sources

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Annealing of starches is associated with improving the compaction of starch granule architecture. This compaction could potentially affect the mobility of granular starch chains and consequently, the extent of iodine complexation by the linear chains in native granules. In this study, Waxy corn (WCS), Normal corn (NCS), Chick pea (CPS), High Amylose corn (HACS), Discorea alata (DAS), Normal Potato (NPS), Waxy rice (WRS), Normal rice (NRS) and Cassava (CVS) starches were annealed and equilibrated to final a_w of 0.33, 0.75 and 0.97. Starches were then exposed to iodine vapour at respective a_w values and analysed by using spectrophotometry and X-ray diffraction. At 0.97 a_w and λ_{max} = 550 nm, K/S absorption exhibited this order: NCS > HACS > DAS > NPS > CPS > NRS > CVS > WRS > WCS. This indicates higher and lower relative polymer mobility in NCS and WCS, respectively. Relative crystallinity (RC) for annealed NPS and HACS decreased upon iodination at all a_w values. The widths of characteristic X-ray peaks of all starches were calculated. At 0.97 a_w, widths of peaks for HACS at 2θ°: 5.7°, 14.9°, 17.3°, 20° and 22.5° decreased by up to 18% upon iodination. Other starches showed variable trends. Both annealed and annealed then iodine exposed CVS and DAS showed no V-type (20° 2θ) peak at all a_w. WCS and CPS followed the similar trends except at a_w 0.97. At 0.97 a_w, V-type peak area of annealed NCS, NRS and WRS more than doubled upon iodination. These observations suggest that molecular mobility of linear polymer segments in some annealed starches is more restricted than others and that these features are indicative of differences in the polymer organization with granules.

Determination of nutritional potential of germs from various maize hybrids

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The existing problems of food insecurity, malnutrition and escalating population have urged to explore unconventional food sources to incorporate in diet formulations to bridge the ever increasing gap b/w food demand and production. Germs from promising maize hybrids were separated and characterized for chemical composition. Based on compositional analysis, one hybrid (Pioneer 32-F-10) was selected, defatted and processed to produce food grade meal; used for in-vivo protein quality evaluation in rats and also analyzed for functional properties. Germ samples were found to be the excellent sources of fat (32.1 ± 1.15 to 38.8 ± 0.65%) and protein contents (16.34 ± 1.44 to 20.96 ± 0.56%), while dietary fiber, crude fiber, ash content and the mineral constituents like P, K, Mg and Fe were also present in appreciable quantities. Although significantly different ($P \leq 0.05$), yet all the tested samples contained substantial quantities of linoleic acid, oleic acid and tocopherols. The germ samples showed good potential as a source of all the essential amino acids (33.3 ± 0.08 to 39.04 ± 0.13 g/100 g) especially lysine (5.79 ± 0.41 g/100 g). The results of amino acid score and in-vivo biological assay for protein quality parameters like TD (87.1%), NPU (76.7%), BV (88.06%), PER (2.15) and NPR (5.12) of defatted maize germ were momentously higher ($P \leq 0.05$) than that of wheat flour and comparable with casein protein. The functional properties of germ flour i.e. water absorption capacity (383%), oil absorption capacity (180%), emulsion capacity (63.6%) emulsion stability (58.5%) and least gelation conc. (4%) were also significantly higher ($P \leq 0.05$) as compared to wheat flour (85%, 75%, 50%, 47.4% & 14%, respectively). However, defatted germ flour was less white, more reddish and yellowish in color than that of wheat flour. The information derived from the present study can be used by the processors and food technologists to assess the potential of maize germ and/or its fractions in food formulations.

Determination of wheat type ratio in noodle flour by analyzing protein composition with high performance liquid chromatograph (HPLC)

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It's a common practice in Japan to blend Dark Northern Spring (DNS) wheat and Australia Standard White (ASW) wheat to mill flours for the production of dried white salted noodles. The wheat ratio in the blend will significantly influence the texture of cooked noodles. An equal blend of DNS and ASW was milled in Buhler test mill. Individual flour streams were analyzed for gliadin composition by reversed-phase HPLC method (C18, 4.6 mm i.d. × 250 mm). Although from the same wheat blend, early flour streams with lower flour ash content contain higher percentage of ASW than the tail flour streams with higher ash as revealed by gliadin protein composition. Results showed that ASW represents 30% to 60% in different flour streams. It was significantly different from the original ratio in wheat blend (50% ASW). Attempts were made to reduce the differences in kernel hardness between the two types of wheat during milling by tempering DNS and ASW at different moisture contents (DNS 18% and ASW 14%). Results showed that the discrepancy in wheat ratios was a bit smaller among the flour streams. Analysis of protein composition in flour streams by HPLC is a useful tool as part of quality control to monitor the wheat ratios in different flour streams. This information is useful in designing wheat blends and flour blends to produce noodle flours with desirable quality.

Development and evaluation of an allergen-free and gluten-free cake

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More than 20 million people are currently affected by food allergies and intolerances in both the U.S.A. and Europe. Because of the absence of any treatment, food allergic and/or intolerant individuals need to avoid the food(s) they are allergic and/or intolerant to. In addition, these individuals have been reported to be consuming less than the recommended amounts of fiber and whole grain servings among other nutrients. To the authors' knowledge, no development and/or evaluation has been reported on both allergen-free and gluten-free cakes. In addition, most studies on gluten-free products reported to-date are based on alternative refined and unfortified gluten-free flours. The goals of this study were to investigate the effect of roasting whole quinoa on the consumer acceptance of an allergen-free chocolate cake formulation with a good source of fiber, and on several quality parameters such as weight, height,

firmness, L*a*b* color, and water activity by using standard laboratory methods. Four cakes including non-roasted (NR) and roasted quinoa for 15 (R15), 30 (R30) and 45 (R45) min, respectively were evaluated by 45 untrained panelists, using a 9-point hedonic scale. The ballot card included parameters such as appearance, color, texture, flavor and overall acceptability. In terms of overall acceptability, cakes made with NR quinoa had the highest mean score (6.4), although this was not significantly higher than R15 and R30 (5.8 and 5.7, respectively). These were, however, significantly higher than R45, which had a mean overall acceptability of 4.8. R15 cakes had the highest mean appearance and color scores (6.7 and 6.9, respectively), while NR cakes had the highest mean texture (6.4) and flavor (6.3) scores. Data from objective evaluations will also be presented. These results should be relevant to the allergen-free and gluten-free baked goods industry.

Microstructure and composition of white and whole wheat flours from two Brazilian lineages (Triticum aestivum)

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Nearly 10 million tons of wheat are consumed yearly in Brazil. Of these, 47% is used in bread production. As in the U.S., interest in incorporating whole grain products to the diet has increased as a means of adding more fiber and bioactive compounds to the diet, and for weight reduction purposes. However, whole grain flour is often substituted with white flour to which bran has been added. This study compared both white and whole wheat flours to determine the effects of mechanical shearing on microstructures and their distribution on both products. This knowledge may help in adapting current quality methods for white flours for whole wheat flours and products. White and whole wheat flours obtained in a Quadrumat Senior mill from two Brazilian lineages from EMBRAPA-TRIGO of Passo Fundo were analyzed for chemical composition and particle size distribution according to AACC methods. The overs of sieves 30, 40, 60, 80 and 100 mesh and the pan content of all flours were examined by fluorescence and scanning electron microscopy to determine their microstructural composition and the influence of the outer grain layers on the breakage and separation of the particles. There were no significant differences between the two lineages in their chemical composition for both kind of flours. In general white flours had 0.36% lipids, 10% proteins, 0.4% ash, 79% total starch and 1% dietary fiber. The whole wheat flours had 1,2% lipids, 12% protein, 1.8% ash, 63% total starch and 13% total dietary fiber. Whole wheat flour micrographs revealed a coarser structure with numerous chunks or aglomerates and very little residue of the outer layers in the smaller size fractions. It seems as if the presence of the outer layers reduces the shearing of the endosperm. In general, the whole wheat flours had a particle size distribution towards larger particles.

Effect of the cooking on physicochemical and digestibility properties of two varieties of common bean (*Phaseolus vulgaris* L.)

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Growing and cooking conditions influence the quality and nutritional value of beans. The objective of this research was to determine the effect of cooking on physicochemical and digestibility properties of two varieties of bean grown under different water regimes. Black 8025 and Pinto Durango cultivars were grown in irrigated and temporal (rain fed) conditions in two locations of Guanajuato, Mexico. For temporal conditions in Ocampo, they were planted in July and harvested in October, 2008. The same varieties grown under irrigation conditions in Celaya were planted in February and were harvested in June, 2008. The cooking procedure affected proximate analysis as a result of partial solubilization of some of the macromolecules during boiling. Changes in starch molecular weight were investigated using HP-SEC, which showed depolymerization of amylopectin fraction. The starch granule was partially resistant to destruction by cooking due to entrapment by the cell wall or protein matrix, which can be seen by scanning electron microscopy. The pasting profiles of the cooked beans showed a significant decrease in viscosity. The peak temperature of the cooked beans was about 20 times lower and the cold paste viscosity was about 45 times lower than raw beans. The DSC showed higher gelatinization temperatures and enthalpy in raw beans. The enthalpy of the raw and cooked beans ranged from 2.75 to 3.95 and 0.62 to 0.97 respectively. The rapidly digestible starch and slowly digestible starch increased, while resistant starch was lower in cooked samples. Black 8025 beans had lower glycemic index (GI) than Pinto Durango grown in irrigations and temporal conditions but, showed no significant differences ($P < 0.05$) between water regimes. These indicated that the variety of bean had more significant effect on digestibility properties than water regime.

Starch characteristics of bean (*Phaseolus vulgaris* L.) grown in two different localities and under rain fed or irrigation conditions

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Starch is the most abundant carbohydrate in the seed and is used as an ingredient to modify the texture of food products. Information on starch characteristics in the starch-water system is important to improve the texture of food products. Bean starch is digested slowly and has relatively low glycemic index value due to its physicochemical properties. The bean variety, enviromental conditions (locality) and growing conditions (irrigation or rain fed) have an effect on these properties. The digestibility and physicochemical properties of starch isolated from Black 8025 and Pinto Durango beans grown in two different environmental conditions were evaluated. Black 8025 and Pinto Durango grown under rain fed conditions in Ocampo, Guanajuato, Mexico, without irrigation, were cultivated in July and harvested in October 2008. The same varieties, grown under irrigation conditions in Celaya, Guanajuato, Mexico, with pre-plant irrigation and three irrigations during the crop cycle were planted in February and harvested in June of 2008. Black 8025 and Pinto Durango starches with irrigation conditions showed higher starch content (91.91 and 95.28%) than starches from beans grown in rain fed conditions (91.69 and 88.56%). Amylose content was significantly different between bean variety and locality. The pasting properties of bean starches obtained under rain fed conditions were higher that the starches from beans grown in irrigation conditions. The gelatinization and retrogradation enthalpy was not different between bean variety and locality. Native starch from bean varieties grown under irrigation conditions exhibit high resistant starch contents and low glycemic index compared with starch from bean varieties grown in rain fed conditions. These study demonstrated that the variety of bean, locality and rain fed or irrigation affected some physicochemical and digestibility properties of bean starch.

***Zymomonas mobilis* as non-conventional leavening agent of bread dough**

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Cereal Foods World 55:A63

Zymomonas mobilis is an anaerobic, Gram-negative bacterium which received the GRAS status by FDA. It is able to produce ethanol from glucose via the Entner-Doudoroff pathway. Since ethanol and CO_2 are the main products of catabolism, this microorganism was expected to be employed as a dough leavening agent. In recent years several studies have been evidenced that *S. cerevisiae* may be involved in food-related allergic disorders in sensitive people, due to the glucomannan component present in yeasts cell wall. For these consumers, the need of alternative special baked products has been suggestied the research to assess the applicability of *Zymomonas* in leavening doughs. The strain was grown in liquid cultures, employing different culture formulations for comparison purposes. The biomass was tested for the evaluation of CO_2 production ability, up to 12 days storage at 5°C. Trials were performed employing standardised procedures, carried out either in model systems, by suspending the strain in sugar liquid solutions, and in bread-making dough. Data were analysed through the DMFit software. *Z. mobilis* was found to possess a leavening ability similar to that of *S. cerevisiae*. In particular, in the dough system after 120 min incubation, 187 and 212 CO_2/g were produced employing *S. cerevisiae* and *Z. mobilis* respectively. The results of the rheofermentometer test confirmed that *Z. mobilis* can be proposed as a valid alternative to *S. cerevisiae* to be employed as leavening agent in baked-products. Preliminary experiments evidenced the absence of off-flavours in dough obtained with *Z. mobilis*, which where found not to be different from the traditional doughs obtained with *S. cerevisiae*. The economic aspects related to this fermentation process will be the focus of future research.

Effect of kneading speed on thermomechanical properties of flour doughs

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Cereal Foods World 55:A63

The bread-making process consists of three main steps: Mixing, fermentation and baking. Mixing transforms the combination of flour and water into a viscoelastic dough, develops the dough and helps the air occlusion. Dough

mixing is one of the most important ways to characterize the quality of wheat flour samples. Proper dough development is affected by mixing intensity (kneading speed) and work imparted to the dough. The objective of this research was to study impact of mixing speed on thermomechanical properties of hard red spring flours using Mixolab. Tests were carried out at the constant water absorption (98% db) and varying mixing speed (60–250 rpm). 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). Dough consistency increased while the stability decreased with increasing kneading speed. C2-C1 difference increased indicating progressive protein weakening at elevated mechanical energy input. Maximum viscosity increased possibly due to quick rupture of starch granules leading to lower pasting temperatures and higher paste consistency. Results indicated that the speed at which dough is deformed during mixing can cause it to develop differently.

Enhancing the functionality of corn fiber gum as an emulsion stabilizing agent by conjugation with whey protein isolate

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Corn fiber, a byproduct of the corn wet milling industry was processed to obtain corn fiber gum fractions (CFG I and CFG II) with different chemical structures, using the alkaline hydrogen peroxide method. The CFG II fraction show a potential to stabilize cloudy beverage emulsions due to the higher amount of protein associated with the hemicelluloses in the fraction CFG II compared to CFG I. Gum arabic is used widely at present in the beverage industry for such a purpose, and it is hypothesized that its functionality is due to the proteins associated with hemicelluloses as well as uronic acid residues. In this work the functionality of CFG I was improved by conjugating it with whey protein isolate (WPI). The conjugation process times investigated were 0, 1, 3, and 7 day at four different temperatures (60, 70, 80, and 95°C) combinations. The material following the conjugation process was analyzed using HPLC with MALLS and RI detectors. The presence of an additional peak with higher molecular weight supported the hypothesis on the formation of a conjugate. The improvement in functionality was measured in terms of turbidity and average droplet size of a standard beverage. Measurement of turbidities showed that CFG I and WPI conjugates prepared under a temperature of 80°C and for 3 days resulted in significantly improved functionality when compared with untreated CFG I. Further, the improved functionality of CFG I and WPI conjugate was found to be better than commercial gum arabic. These results show that corn fiber conjugation could be a viable option for the corn wet milling industry and the beverage industry can utilize a readily available alternative to gum arabic which is mostly imported and with fluctuating prices. This process also has potential for exploring alternate applications of corn fiber gum which is a good soluble dietary fiber.

Nondestructive single kernel DON analysis of wheat for FHB resistance evaluation

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Single kernel analysis of DON levels can provide detailed information on the concentration and distribution of DON levels among kernels in a bulk sample when used in evaluation of wheat varieties for Fusarium Head Blight (FHB) resistance. Using our single-kernel near infrared (SKNIR) instrument we estimated single kernel DON levels in 500-kernel samples each from four wheat varieties from a FHB screening trial, and sorted kernels into one of four bins. Kernels sorted into Bin 1 were regarded as sound and those in Bins 2 - 4 were regarded as Fusarium damaged kernels (FDK). Kernels sorted into Bins 2 - 4 had increasing levels of predicted DON concentrations. The number and weight of kernels sorted into each bin was recorded. The average weight of kernels in each bin was used to estimate the DON content in single kernels in µg/kernel. Using the weight and estimated DON content, bulk DON levels of the 500-kernel samples were estimated. Varieties Everest, Heyne, Overley and Truman had 13.8, 25.7, 28.4 and 13.8 ppm of bulk DON, 15.0, 26.2, 30.2 and 14.8% of FDK and 10.3, 19.8, 25.1 and 9.7% FDK by weight respectively. Single kernel DON levels were numerically sorted and plotted against cumulative percentage of kernel number to observe the distribution of DON levels among varieties. All varieties had 1–2% kernels with DON levels > 300 ppm. Higher bulk DON levels in Heyne and Overley compared to Everest and Truman were due to higher proportion of infected kernels probably due to their lower type II resistance compared to Everest and Truman. The possibility to exclude a variety with high DON level caused by only a small percentage of kernels with high DON concentration or to accept a low DON variety with a large percentage of low DON kernels at initial varietal screening for FHB resistance can be minimized by use of this technique.

Changes of rheological behavior of dough from durum wheat to produce pizza

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The rheological behavior of wheat dough is provided by the characteristics of its gluten protein matrix that can be modified through the use of enzymes. The partial hydrolysis of the durum wheat proteins by trypsin-like enzyme from gut of marine species apparently improves some functional properties in the formation of bread dough; however the effect of the trypsin on the pizza dough has not been well defined. The aim of this study is to investigate the influence of enzymatic treatment on the rheological properties of pizza dough using the flour functionality tests commonly used, such as farinograph, alveograph and rheofermentometer, and results were correlated with the physical characteristics of the product, such as diameter and thickness of the pizza crust. The crumb grain was observed of digital image field of view relative to a complete cross section of pizza crust. Two enzyme doses (0.14 and 0.28 U) from sierra (*Scomberomorus sierra*) guts and two wheat flours - commercial all-purpose flour (CAPF) and *Triticum durum* flour (TDF) - were used. A control was prepared without enzyme. Results show a good relationship between the changes in the rheological behavior of the dough and the characteristic physical of the flat bread base. Generally, it can be stated, that the enzyme trypsin from gut of *Scomberomorus sierra* has an improve effect of the rheology characteristics of pizza dough. 0.14 enzyme dose in CAPF dough be make pizzas with thick crust. TDF dough with 0.28 enzyme dose gives a thin crust.

Effects of sorghum decortication and protease addition during liquefaction on bioethanol, free amino nitrogen and fusel alcohol production

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The aim was to study the dual effect of sorghum decortication and protease treatment prior to liquefaction with thermoresistant alpha amylase on free amino nitrogen (FAN) and fusel alcohols during the steps of ethanol production. A bifactorial experiment with a level of confidence of $P < 0.05$ was designed to study differences among maize, whole sorghum and decorticated sorghum and the effectiveness of the protease treatment prior to starch liquefaction. Sorghum was decorticated 9.7% to remove most of the pericarp and part of the germ and increase starch concentration. The decorticated sorghum had significantly higher protein hydrolysis compared to the whole kernel. The protease treatment prior to liquefaction (0.5 mL Neutrase® 0.5L/ 150 g grain meal) improved rate of FAN production in all grains. Maize yielded hydrolyzates with the highest amount of FAN followed by decorticated and whole sorghums. The maize and sorghums hydrolyzates treated with protease contained about 60 and 30% more FAN compared to the untreated counterparts. Decorticated sorghum treated with protease had the highest final concentration of propanol, isobutanol and amyl-alcohols (20, 60 and 217 ppm, respectively). Protease improved fusel alcohols profile in all cases and did not have an adverse effect on ethanol generation and concentration in maize treatments. Decortication and protease treatment had a positive synergistic effect on ethanol yields in the case of sorghum (0.402 L/kg grain meal). Both sorghum decortication and protease treatments prior to hydrolysis with α-amylase are recommended to produce mashes with higher FAN content which is considered as an important yeast substrate.

True inline analysis of flour using high resolution diode array spectrometry

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Processing industries have for years relied on laboratory methods. Production lines get bigger and bigger and there is a constant pressure to optimize quality and to reduce production costs. Analytical measurement must move out into the process line. A high resolution diode array sensor (1 pixel / nm) has been used for direct analysis of the finished flour quality. No bypass has been used. The high speed of the sample and the turbulence of flour inside the pipe decrease effects from particle size generally obtained during static laboratory measurements of flour. A new scan qualification algorithm based on “X-Residual maximum Distance” is used to qualify the scans that should be used

for predictions of result. The new algorithm is quite sensitive and it is possible to eliminate all situations where the sample density in front of the sensor is too low for obtaining a reliable result. The scan qualification system will mark all non-qualified samples as outliers in the result table. Results are also presented in a trend chart – in this only qualified results is presented meaning that a calculation of a moving average is calculated only on qualified results. A "do it yourself" calibration tool, has been used. This feature facilitates the rapid implementation of the system in new process environments. Existing calibrations from laboratory NIR instruments can efficiently be transferred to this online analyzer. Results from transferred calibrations will be compared with calibrations specifically developed for the analyzer. Results obtained by measuring directly in the pipe show an accuracy that is equal to present rapid laboratory methods. An example of results obtained will be included: The system is approved for dust applications to the highest level of security, i.e. ATEX 20/20 or corresponding for the IECEx system.

Using Super Heated Steam as a pre-frying step for the preparation of deep fried battered snacks with low oil content and high crispness

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Deep-fried battered snacks are liked because of their soft, juice inside that contrasts with a crispy outside. They are typically pre-fried, frozen and final fried before consumption. During pre-frying and final frying oil acts as a heat transfer medium but also enters the food. Public awareness of the desirability of reducing the fat content has lead to a demand for healthier food. An alternative to reduce the oil content is to replace the pre-frying step by heat treatment in super heated steam (SHS). The advantage of using SHS is to produce snacks with reduced oil content while maintaining crispness. The high heat transfer of SHS allows pre-treating the batters giving an appropriate consistency without using oil. Battered meat was prepared by pre-treating the samples for 1, 2 and 3 min in SHS in comparison to 1 min pre-frying in oil. Final frying was done for 3 min in oil for all samples. Pre-frying in oil and treatment in SHS were compared in terms of moisture, oil content and crust crispness. 1 and 2 min SHS increased the water content and decreased the oil content of the final fried crusts. Longer treatment in SHS led to a larger dehydration of the crusts which had similar water content but less oil than the ones pre-fried in oil. Crispness of the crust was determined by analyzing the sound produced during fracture of the snacks. In spite of the higher moisture, initial crispness of the 1 and 2 min SHS samples was not significantly different than for the samples pre-fried in oil. 3 min SHS increased initial crispness of the crusts. Retention of crispness at 20 min after frying showed that 2 and 3 min SHS gave same crispness than pre-frying in oil, samples with 1 min SHS showed lower crispness retention. The overall results showed the suitability of using SHS as a pre-frying step to produce crusts with lower oil content and same crispness than the samples pre-fried in oil.

Variation in oxidative gelation among wheat mill streams

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Batter viscosity is an important quality trait of wheat flour. Water-extractable arabinoxylans form oxidative gels which contribute to variation in viscosity. The purpose of this study was to investigate the oxidative gelation potential of wheat flour mill streams to better understand sources of variation in batter viscosity. Thirty-one genetically pure soft, hard and club wheat varieties were milled on a Miag Multomat pilot mill. Ten flours (mill streams) per variety were analyzed for water-extractable (WE), water-unextractable (WU), and total (TO-AX) arabinoxylan content, and for oxidative gelation potential (+/– peroxide-peroxidase) (POx). WE-AX content varied greatly among flour streams ($F = 619$) and less among varieties ($F = 152$). Variation for endogenous oxidative gelation potential, as evidenced by Bostwick consistometer viscosity, was greater among mill streams ($F = 627$) than among varieties ($F = 117$). Variation for oxidative gelation with POx decreased for both flours steams ($F = 141$) and varieties ($F = 97$). Mill stream X variety interactions were small but significant for all traits, and were considered an inconsequential source of overall variation. WE-AX and TO-AX were significantly but not strongly correlated ($r = 0.66$) overall. Oxidative gelation without POx had similar correlations amongst WE-AX ($r = –0.65$), WU-AX ($r = –0.71$), and TO-AX ($r = –0.72$). Oxidative gelation with POx decreased the correlations amongst WE-AX ($r = –0.49$), WU-AX ($r = –0.36$), and TO-AX ($r = –0.38$). The relationship among WE-AX, WU-AX, TO-AX content and oxidative gelation potential for mill streams may indicate the molecular structure of AX, i.e. degree, pattern, and frequency of arabinose and ferulic acid substitution, is important.

Impact of rosemary extract or mixed tocopherols on the flavor, aroma and oxidative stability of an extruded oat cereal

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The aim of this study was to compare the differences in the oxidative stability of extruded oat cereal treated with concentrated rosemary extract or 70% mixed tocopherols as compared to untreated cereal during ambient storage (23°C) for one year. Tocopherols were applied at 0.04%, and rosemary extract was applied at 0.05%. The primary factors which influence the shelf life of cereal are primary oxidative by-products (peroxide value), and most importantly, sensory attributes (aroma and flavor). Peroxide values (PV) were determined by Saftest™ (MP Biomedicals). The sensory attributes of the cereal were analyzed by descriptive analysis using a trained sensory panel ($n = 12$). Two replicates of each treatment were produced at the University of Nebraska-Lincoln. Samples were packaged in individually sealed low density polyethylene bags, and they were stored in the dark. Two-way analysis of variance of PV showed a significant impact of time and treatment ($p < 0.05$) but no interaction ($p = 0.47$). PV were significantly lower ($p < 0.05$) for the rosemary treatment. There were differences ($p < 0.05$) in PV from d 265 onward. Sensory evaluation of oxidized flavor showed a significant effect of treatment ($p < 0.05$), as oxidized flavor decreased in the order of untreated > rosemary extract > mixed tocopherols. Oxidized aroma also had a significant effect of treatment ($p < 0.0001$), again with oxidized aroma decreasing in the order of untreated > rosemary extract > mixed tocopherols. The impact of treatment on oxidized flavor and oxidized aroma became significant on d 182 ($p < 0.05$), and d 108 ($p < 0.01$), respectively. These results showed that treatment of an extruded oat cereal with either rosemary extract, or mixed tocopherols, provided improved resistance to the development of oxidized flavors and odors over an untreated cereal, with mixed tocopherols maintaining the most desirable flavor and odor profile.

Predicting the milling yield of wheat kernels based on their morphology

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Cereal Foods World 55:A65

Flour yield is an important economic factor in milling and plays a role in wheat marketing. The amount of endosperm, which is affected by size and shape of grain, thickness of bran, and size of germ, has been known to influence flour extraction rate. Sieve size test (Shuey, 1960) is the only method currently used for calculating theoretical flour yield. This study aims at developing mathematical models to predict flour yield of different wheat varieties based on kernel morphology. Kansas grown hard red winter wheat samples were cleaned and characterized through test weight and thousand kernel weight. Kernel fractions were obtained using sieve stacks of Tyler # 6, 7, 8, 10, 12, and 14 using Ro-tap sieving system. Single kernel characterization system (SKCS 4100, Perten instrument) was used to determine the mean values of kernel weight, size, moisture content and hardness index of each fraction. X-ray microtomography (Skyscan 1072) images of representative wheat kernels were obtained to measure bran thickness and the volume fractions of bran, germ and endosperm. Optimum tempering of 15.5% was determined based on flour color and extraction percent. 250 g samples were milled using Brabender Quadrumat Sr experimental mill. Flour extraction rates of each kernel size fraction along with that of original bulk samples were recorded. Flour color was determined using Agtron (AACC 14-30). Flour particle size index was determined by laser powder diffraction according to modified AACC approved method 55-40. The milling results for four size fractions (overs 6, overs 7, overs 8, thrus 8) and the original wheat samples were ranged from 65% to 76%. Bigger and homogeneous kernels expectedly provided higher extraction rates as well as higher Agtron color values. Extraction rate of control sample was measured to be 71.98% which was close to predicted extraction rate of 70.67%.

Effect of genotype and environment on wheat flour water absorption tolerance

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Water absorption tolerance is an important parameter in commercial bread production. Hard red winter (HRW) wheat flours show variation in water absorption tolerance. Although studies show genotype and environment factors affecting optimum water absorption, mixing time and dough strength; factors responsible for water absorption tolerance using Mixograph® are unknown. This study identified high and low absorption tolerance behavior in five HRW varieties (Jagger, Jagalene, Fuller, 2137 and Overley) grown in six locations (Garden City, Labette, Republic, Thomas, Manhattan and Coldwell) within Kansas in 2009. Milling, wheat and flour quality tests, solvent retention capacity (SRC), damaged starch, protein composition, gluten index, flour and

starch particle size distribution tests were conducted and analyzed. Jagger grown at Garden City possessed the highest water absorption tolerance range while the lowest values were observed for Fuller grown at Manhattan and Coldwell. Protein content was significantly higher for all varieties grown at Garden City and lowest at Coldwell. Jagalene grown at Garden City showed highest kernel hardness (SKCS) while Overley grown at Coldwell had the lowest. SRC evaluation showed moderate correlation between water absorption tolerance and lactic acid and deionized water. Large particle size intervals in flour and starch showed a moderate and low correlation, respectively, with water absorption tolerance. Protein content, gliadins, SDS extractable, SDS unextractable (HMW glutenins) and kernel hardness showed high correlation with water absorption tolerance.

Heat transfer fouling: Evaporation in bioprocessing

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During processing of cereal and other agricultural crops into food and industrial products, evaporators are used to remove water. Heated surfaces become coated with deposits; this results in increased energy use. Future bioprocesses likely will use water to produce biofuels and food products; evaporation will remain a method for water removal in these processes. Despite its importance in economic operation of bioprocesses, heat transfer fouling is not well understood. A probe was used to quantify fouling tendencies of fluids passing over heated surfaces. Three streams were evaluated: original thin stillage, diluted thin stillage (DTS) and permeate from microfiltration of thin stillage (MFP). In additional experimentation, we examined the relative fouling tendencies of individual components of thin stillage (e.g., ash, sugar contents) to determine which components caused increased fouling. Reductions in solids concentrations and changes in composition resulted in reduced fouling rates and fouling resistances. At 10 h of fouling, 50 and 90% reductions in fouling resistance were observed in DTS and MFP streams, respectively, although both streams had similar solids level decreases from 7.2 to 3.5%. In DTS and MFP, induction periods were prolonged by factors of 4.3 and 9.5, respectively, compared to the induction period for thin stillage fouling. Mean fouling rates were decreased by factors of 2.3 and 23.4 for DTS and MFP, respectively. Fouling of MFP took twice the time to reach a probe temperature of 200 degC than did thin stillage (22 vs 10 h, respectively). Reduced solids content alone did not explain decreased fouling tendencies in microfiltered stillage.

Formulation and physicochemical and sensorial evaluation of corn tortillas supplemented with chia (*Salvia hispanica* L.) flour

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The purpose of the present study was to develop a tortilla formulation with good acceptability and evaluate the effects of chia seed flour supplementation on physicochemical and sensorial characteristics of the obtained tortillas. Chia seed were prepared as fine flour and used at different levels of Nixtamalized Corn Flour (NCF) substitution for corn tortilla formulations. The effects of chia seed flour supplementation on physicochemical and sensorial characteristics of tortillas were evaluated using standard methods. Ash (08-01), fat (30-25) and protein content (46-13) were analyzed with AACC methods. *In vitro* rate of hydrolysis was evaluated using hog pancreatic α-amylase. Predicted Glycemic Index (pGI) was calculated from the α-amylolysis curves. The protein content (9.41 – 12.48%) was significantly affected ($p < 0.001$) with respect to the level of chia flour added to the tortilla. Ash contents varied from 1.29 – 1.76%, and non-significant differences ($p > 0.05$) between control tortillas and those containing chia seed flour. Tortillas with 5 g and 20 g/100 g chia flour showed the highest scores for sensorial attributes, respectively. The reduced enzymatic starch hydrolysis rate and pGI recorded for the chia seed-added tortilla indicated slow digestion features. The supplementation seems to be suited for NCF substitution and it is possible to obtain tortillas with value-added food ingredient within the standards.

Phenolic compounds and antioxidant capacity of raw and processed Andean indigenous crops

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Quinoa (Chenopodium quinoa), kañiwa (Chenopodium pallidicaule) and kiwicha (Amaranthus caudatus) are remarkably nutritious grains that originate from South America. They have a high content of good quality proteins and are also potential sources of bioactive compounds. The aim of this study was to determine the total phenolic content and antioxidant capacity of raw and processed quinoa, kañiwa and kiwicha. The grains were processed by cooking and roasting. Two methods were used to extract antioxidant compounds: chemical and enzymatic and the antioxidant capacity was determined with the DPPH and FRAP methods. The amount of total phenolic compounds in raw grains varied between 93 and 254 mg determined as gallic acid per 100 g and between 17 and 282 mg gallic acid per 100 g in processed grains. Kañiwa had the highest antioxidant capacity and total phenolic compound content followed by quinoa. Processing did not affect negatively the antioxidant capacity of Andean grains. Our study demonstrates that Andean indigenous crops, and especially the less-known kañiwa, are excellent sources of antioxidant compounds and that common processing methods do no affect their antioxidant capacity.

Ancient grains of Andes as sources of bioactive compounds

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Quinoa (Chenopodium quinoa), kañiwa (Chenopodium pallidicaule) and kiwicha (Amaranthus caudatus) are very nutritious grains grown in the Andean highlands. In this study, the content of dietary fiber, phenolic acids, flavonoids and betalains was determined in white and coloured varieties of quinoa, kañiwa and kiwicha. The content of total dietary fiber in these three crops varied from 6 to 13%. The total amount of phenolic acids varied from 17 to 60 mg/100 g and the proportion of soluble phenolic acids varied from 7% to 61%. The phenolic acid content in Andean crops was low compared with common cereals like wheat and rye, but was similar to levels found in oat, barley, corn and rice. The flavonoid content of quinoa and kañiwa was exceptionally high, varying from 36 to 144 mg/100 g. Kiwicha did not contain quantifiable amounts of these compounds. Only one variety of kiwicha contained low amounts of betalains. These compounds were not detected in kañiwa or quinoa. Our study demonstrates that Andean indigenous crops have huge potential as sources of health-promoting bioactive compounds such as flavonoids. They are also excellent sources of dietary fiber.

Brazilian human feed: Standards for a new concept

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With the steady growth of nutritional awareness and the trends to high fiber, whole grain foods a new concept in food supplementation, "Human Feed", was launched this year in Brazil and has become one of the most procured health food items. Some of its nutritional attributes include gastrointestinal benefits and weight reduction. The basic formulation of human feed consists of whole grains, cereal germ and protein sources, however, there is no standardization in the combination or amounts of these ingredients. The formulation might even include brown sugar and ground guaraná which could be a health risk to some consumers, especially to diabetics and hypertensive individuals. In order to establish the variability in "human feeds" commercialized in Brazil, seven products from different brands commercialized in different regions of Brazil were analyzed according to the official AACC methods. Analysis of Variance and Tukey's test ($p < 0,05$) were used to analyze the results using STATISTICA 7®. In general, the chemical composition (g/100g) of the human feed samples differed as follows: carbohydrates 25 - 44; protein 19- 24; lipids 6-13; soluble dietary fibers 4 - 6; 1insoluble dietary fibers 15-25; beta-glucans 0,3 – 1,5; ash content 3-5. Except for beta-glucans, all samples differed significantly in all parameters tested. Even though, human feed seems to be a good way to introduce high fiber and whole grain ingredients in the regular diet. The extensive variability in formula, ingredient composition, and labeling information confirmed by our study, coupled with the lack of product definition by food authorities, however, represent a potential health risk to some consumers.

Thermal and mechanical properties of whole and milled pulses

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Pulses are protein- and fiber-rich crops, and are consumed as staples in many parts of the world. As the global food demand increases pulse milling and processing technologies evolve. Pulses are primarily consumed whole,

however fundamental physical, thermal and mechanical properties of pulse flours have to be readdressed based on market class and processing requirement. In this study thermal, mechanical, chemical and physical properties of whole pulse and pulse flours were examined and characterized according to milling, hydration and heating processes. The objective of this research was to 1) characterize the thermodynamical and mechanical properties of whole pulses and pulse flours, including yellow field pea, green field pea, navy bean, pinto bean, black bean, lentil, and chickpea; and 2) examine the effects of milling, hydration and cooking processing conditions on pulse flour properties. Pulses were milled with Fitzpatrick Milling equipment (DAS-O6) at 7200 RPM mill speed and 24 RPM feed screw speed. Whole pulses and pulse flours were subjected to property analysis, which included moisture content, water activity, color (Hunter L, a, and b), unit density, bulk density, compressibility, angle of repose, particle size distribution, thermal diffusivity, thermal conductivity, thermal-mechanical analysis, and Mixolab analysis. Thermal conductivity ranged from 0.05-0.06 W/mC; thermal diffusivity ranged from 0.15-0.21 mm2/s; bulk density ranged from 0.77-0.85 g/cc and water activity scores ranged from 0.34-0.49. Angle of repose of pulse flours ranged from 44.02-53.42 deg. and packed bulk density ranged from 0.72-0.85 g/cc. Rapid visco analyzer and Mixolab data varied, and pulse flours showed variable cooking, pasting and gel formation properties. This study highlights the engineering properties of pulse flours which can help processors understand the impact of processing on variable pulse classes.

Extrusion of texturized vegetable protein using pulse flours

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As the global population grows, there is an increasing need for food, especially for products which are protein dense. Texturized vegetable protein (TVP) has become a staple for many, especially in meat-deficient settings. TVP is typically manufactured using high-protein soy materials. Although lower in protein, pulse crops are highly nutritious as well, and may be suitable for this purpose. The objective of this study was to 1) manufacture TVP using various pulse flours, including yellow field pea, green field pea, navy bean, pinto bean, black bean, lentil, and chickpea; and 2) examine the effects of extrusion processing conditions on final TVP properties. The blends were processed in a pilot-scale twin-screw extruder, with a screw configuration appropriate for TVP production, at speeds between 300 and 500 rpm, using a 3-mm circular die. Extruder parameters, including moisture content after the conditioner and at the die, as well as mass flow rate, were measured to quantify the extruder behavior during processing. The resulting extrudates were subjected to extensive property analysis, which included moisture content, water activity, color (Hunter L, a, and b), unit density, bulk density, pellet durability index (PDI), water stability, and floatability. All process settings produced highly-expanded, viable extrudates. Extrudate properties varied, depending upon the type of flour used. Hunter L ranged from 47.61 to 62.41; unit density ranged from 0.08 to 0.17 g/cm^3; bulk density ranged from 0.07 to 0.15 g/cm^3; PDI ranged from 12.95 to 37.58%; all extrudates were stable in water and floated for more than 30 min. This study highlights the importance of experimentally quantifying the effects of both ingredients and process variables when developing extruded products using novel materials.

Production of arabinoxylooligosaccharides from corn alkali-extractable arabinoxylan

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Arabinoxylans are the main non-starch polysaccharides in cereal grains, which can provide health benefits to humans due to their fermentation properties. Previous work showed that corn alkali-extractable arabinoxylans (CAX) were utilized by human fecal microbiota and provided a desirable slow fermentation profile. The smaller molecular mass and lower average degree of polymerization of hydrolyzed wheat arabinoxylans (arabinoxylooligosaccharides, AXOS) has been reported to increase the production of intestinal acetate and butyrate and promote the bifidogenic effect. Due to the complicated structure of corn arabinoxylan, corn-derived arabinoxylooligosaccharides (CAXOS) with complex branch chains might provide a different mechanism of slow rate of fermentation and improved prebiotic properties. The objective of the present study was to investigate a method to prepare CAXOS with different molecular masses from CAX and fractionate those compounds. Hydrolytic degradation of CAX by microwave, enzyme treatment with endoxylanase and acid hydrolysis with 0.05 M oxalic acid under pressure for 30 min were investigated. To isolate the hydrolysates, graded ethanol precipitation was used to obtain compounds with different molecular masses. Microwave treatment at 180°C for 10–20 min lowered the molecular weight of CAX slightly from 600 kDa to 400 kDa. The molecular mass of treated CAX (60 kDa) with endoxylanase was similar to that of CAX treated with microwave at 200°C. The hydrolysates obtained from acid treatment and precipitation with an ethanol concentration of 60–90% contained a heterogeneous molecular mass with molecular mass peaks at 31, 16, 6 and 1 kDa. Therefore, acid hydrolysis was the most effective method of those used to degrade the CAX molecule to produce CAXOS. Composition of monosaccharides was investigated.

Production of xylo-oligosaccharides from corn fiber (separated from DDGS) by autohydrolysis

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Xylo-oligosaccharides (XOS) are reported to have beneficial health properties, and so can be used as functional food ingredients. XOS was produced from corn fiber obtained from distillers dried grains with solubles (DDGS) which is a low value coproduct of corn milling for ethanol production. Corn fiber was treated with deionized water in a Parr-reactor at temperatures ranging from 140 to 220°C to produce XOS by autohydrolysis and determine the effect of temperature during its production. The reaction was conducted with 10 grams of corn fiber in 90 mL of deionized water. The holding time after desired temperature attained was 15 min. The reaction mixture was filtered and the liquor obtained was analyzed for individual XOS, acids and monosaccharides by high-pressure liquid chromatography (HPLC). The maximum total yield of XOS obtained from 10 g corn fiber was 1790 to 1865 mg at 170–180°C. There were no traces of formic acid and levulinic acid. The acetic acid, hydroxymethyl furfural (HMF) and furfural contents, which are toxic compounds, increased at temperatures above 200°C. This study clearly showed that XOS of low molecular weight can be produced from corn fiber in high yield which may provide health benefits, including prebiotic and antioxidant activities. The evaluation of these benefits will be the subject of our future research.

A new -physiologically more relevant- *in vitro* starch digestibility method for slow carbohydrates screening

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Numerous *in vitro* methods are in use for assessing speed and completeness of starch digestion in the human body. A method mimicking all the steps of food conversion as well as the dynamics of food digestion (e.g. stomach transit) would be the method of choice. Such methods are available but are very time consuming and expensive and therefore not practical for screening purposes. All the available one-tube methods differ greatly in the way of mimicking chewing, stomach passage and small intestinal transit. We adapted the widely used digestibility method of Englyst in such a way that it better reflects the conditions regarding stomach transit and small intestinal transit. The pepsin dosage in the stomach transit was tenfold reduced. The pH in the small intestinal transit was changed to 6.9 instead of 5. The amount of pancreatin was reduced 30 times, no microbial amyloglucosidase (AMG) was used and intestinal movement was reduced. The total amount of glucose that can be released by intensive incubation with AMG from the oligosaccharide mixture was assayed at different time points of pancreatin digestion. It was found that these much milder digestion conditions also lead to a rapid and complete degradation of rapidly digestible starch (starch solutions and white bread), which is one of the prerequisites of a reliable method. Compared to the Englyst method, the method is more discriminative for starch samples or starchy foods with a moderate decrease in starch digestibility. Attempts to improve the method even further (e.g. use of bile acids) are ongoing.

Comparison between potassium bromate and ozone gas as oxidants in breadmaking

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Potassium bromate is slow acting oxidant that improves the gluten strength when the dough is at its weakest point (at high temperatures in oven). Potassium bromate improves gas retention properties of dough and generally results in increased specific loaf volume. Research has shown that potassium bromate is a carcinogen and is not considered good for health. Ozone gas due to its high oxidation-reduction potential could be used as an alternative to potassium bromate. The objective of this research was to compare the efficacy of potassium bromate with that of ozone treatment in wheat flour oxidation for

breadmaking. In the first experiment, flour was treated with ozone at 1,500 ppm for 2, 4.5, 9, and 18 min. In the second experiment, flour was fully treated with ozone at 1,500 ppm for 45 min and then blended with control flour at concentrations from 10 to 30% (w/w). Flour became whiter and less yellow as ozonation time increased when compared to control flour. Size exclusion HPLC detected an increase in sodium dodecyl sulfate buffer insoluble polymeric proteins in flour exposed to ozone. Bread made from flour treated with ozone for 2 to 4.5 min significantly increased specific loaf volume and bread made from flour blended with fully ozonated flour at 5 and 10% (w/w) was not significantly different for specific volume when compared with bread made with flour containing potassium bromate. Bread made from flour treated with ozone for 2, 4.5 and 9 min had greater number of cells in crumb with larger loaf volumes than control flour. Results indicate that ozone treatment of flour could eliminate the need for potassium bromate in bread making.

Effect of pea fibre in breaded fish coatings as determined by functional, nutritional, and sensory properties

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Food coatings are an ideal system for addition of pea fibre due to its fat limiting and water binding properties. Pea hull fibre from both wet and dry fractionation processes was incorporated into a 3-step coating system (pre-dust, batter, and Japanese bread crumb) on a fish nugget test model by replacing traditional ingredients. Target fibre content was 4 g/125 g of fish nugget; thus based on preliminary studies, pea fibre was incorporated at 23.3% pre-dust, 25% batter mix, and 15% breading in combination with 100% replacement of wheat flour and corn starch with pea flour and pea starch. Yellow pea fibre from 3 sources was incorporated into coatings and fish nuggets were compared against each other and to a control containing no pea ingredients. Functional properties (batter viscosity, coating pick-up, cook yield) and nutritional composition of par-fried fish nuggets, as well as sensory attributes (adhesion, moistness, crispiness, overall quality) of oven baked fish nuggets were assessed. Significantly higher viscosity was observed in test samples compared to the control which led to higher coating pick-up and cook yield. Pea fibre from dry fractionation processes increased batter pickup significantly more than wet processed pea fibre; however, no significant differences in coating pickup were observed. Addition of pea fibre increased total dietary fibre, calcium, and iron levels in test samples compared to the control. Fish nuggets with pea coating contained 3 times the total dietary fibre of the control which allowed a "high in fibre" nutrient claim to be made. Sensory quality of test samples was not significantly altered by the addition of pea fibre. Potential exists for utilization of pea fibre in coatings as it is economical, gluten-free and increases fibre content without altering product quality.

Dent and flint corn particle size influence on the technological characteristics for expanded extrudates

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Corn grits used in extrusion show different behavior in the process due to the presence of vitreous and farinaceous endosperm. The corn milling streams hardness results in technological differences for the expanded extrudates. The aim of this study was to evaluate dent and flint corn particle size reduction on the expansion index (EI), compression force (CF), water solubility index (WSI) and water absorption index (WAI). The particle size for dent and flint corn grits showed 90.07 and 99.73% greater than 0.500 mm, respectively, and the sample with particle size reduction by hammer mill milling showed 78.92 and 85.34% of particle size under 0.500 mm for dent and flint corn, respectively. The samples were extruded in single-screw Brabender extruder with 80, 120 and 150°C for 1st and 2nd zones, and die temperatures, respectively. The feed ratio were 130 g/minute, screw speed of 120 rpm, compression ratio of 1:3 and die diameter of 2.7 mm. The results obtained were (3.84 ± 0.10 and 4.44 ± 0.06) for EI, (16.61 ± 1.55 and 16.86 ± 2.27 N) for CF, (23.67 ± 0.19 and 22.25 ± 0.14%) for WSI, and (8.37 ± 0.02 and 8.53 ± 0.03) for WAI for dent corn grits and dent corn grits with particle size reduction, respectively. The data found for flint corn grits and flint corn grits with particle size reduction were (3.96 ± 0.09 and 4.26 ± 0.09) for EI, (18.83 ± 2.38 e 19.16 ± 2.46 N) for CF, (26.70 ± 0.31 e 29.67 ± 0.23%) for WSI, and (8.73 ± 0.01 and 9.44 ± 0.03) for WAI, respectively. The data obtained for EI, WSI and WAI showed statistical difference between them ($p < 0.05$). The high data obtained for the samples with particle size reduction is due to the greater dextrinization and higher degree of cooking, resulting in better expansion of the end product. In general, it was found that the separation of varieties of corn could result in very significant benefits for extrusion process to obtain end product with high and good technological quality.

Production of bread and pasta from flour blends of wheat and millet (*Panicum miliaceum* L.)

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Millet (*Panicum miliaceum* L.) is a staple food in many countries (mainly Africa), but its use in typical Western diet products like bread and pasta is still scarce. In the present study millet from Hungarian and Austrian origin were investigated in flour blends of wheat and millet in different ratios for the production of bread and pasta. The effects of additional recipe parameters like the addition of emulsifiers, enzymes or proteins on bread and pasta quality were studied in a second step. The results demonstrated that millet addition has less detrimental effects on bread quality like other non-wheat cereals, e.g. maize or pseudocereals. Compared to a 100% wheat bread, in the breads without emulsifier volume was decreased by about 20–25% after 20% millet addition, which was not further decreased with higher (up to 50%) millet addition. In breads containing emulsifier volume was decreased by only 15% after 40–50% millet addition. Addition of enzymes (xylanase, transglutaminase) could further increase bread quality. Cooking quality of pasta produced from millet decreased with increased amount of millet. With millet addition of 20% and more the produced noodles showed statistically significant lower bite resistance than the 100% wheat noodles. For high millet addition the content of protein (dried egg white) should be increased to around 5% (about 4–5 times as much as needed for pure wheat noodles) in order to improve cooking quality, in particular bite resistance, to values comparable to wheat noodles.

Taking the hands and eyes out of grain inspection

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Grain quality assessment and grading by visual inspection is a highly subjective and time consuming exercise. (Statistics and results will be included) The end result is to a very large extent depending on the subjectivity of the different inspectors and even to the day-to-day variations for a given inspector. In grain receival operations the visual inspections are often part of a payment scheme in e.g. the transaction from farmer to grain company. For a delivery of several tons of grain these result variations can have a large financial impact on both the farmers and the grain elevators. New developments in Image technology now pave the way for a new generation automatic grain inspection instrumentations. Combining high-resolution spectral imaging with advanced chemometrics enables fast, accurate and reliable visual inspection to be carried out by even non-trained grain inspectors. Detection and quantification of multiple quality grading parameters plus measurement of individual kernel volume is made possible with the capturing of 2-D and 3-D images. By removing the hand and eye and thus the subjectivity of the analysis a fair, objective and consistent grading system can easily be achieved across multiple locations. Presentation shows calibration performance statistics, time saving studies and other relevant findings from a recent study in Australia where a system for automatic grading and segregation of wheat and barley is currently being implemented. Included is also a description of the internet-based network monitoring system used for remote instrument and calibration surveillance, image data transfer and simultaneous up/down-load communication with the entire instrument population.

Modelling wheat breakage during First Break roller milling based on single kernel characteristics

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The particle size distribution resulting from First Break roller milling of wheat determines the flows through the rest of the flour milling process. In this work the breakage equation for First Break milling was enhanced with a new breakage function, in order to allow prediction of the output particle size distribution based on the roll gap and disposition and the distributions of input wheat characteristics (kernel hardness, size and mass distributions) as measured by the Perten Single Kernel Characterisation System (SKCS). In this way the breakage of an unknown mixture of wheats milled at any roll gap can be predicted solely based on SKCS measurements.

Study of different mixing conditions with their possible effects on fermentation and dough rheology

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The objective of this study was to determine the influence of mixing conditions on dough expansion during fermentation in order to establish relationships between mixing, fermentation and dough rheology. In this purpose, different conditions were applied during mixing and dough expansion was observed by digital image acquisition, analyzed in terms of porosity and stabilization. The evolution of the porosity reflected the fermentation kinetics, governed by yeast action and, in a less extent, the difference of dough rheological properties. Stabilization was more influenced by rheological properties, as shown by the influence of mixing conditions at different energy levels (20-60 kJ/kg). For each condition, the thermo-viscoelastic behaviour of non fermented doughs was determined by DMA (Dynamic Mechanical Analyser), for two rest times (t_0 and t_1), and bi-extensional properties (viscosity, Strain Hardening Index as SHI) were measured by Lubricated Squeezing Flow (LSF). The thermograms showed an increase of the storage modulus between 55 and 70°C, characteristic of the cross linking of gluten, and swelling of starch granules. This increase was a decreasing function of specific energy during mixing (20-60 kJ/kg). The changes in elongationnal viscosity can be taken into account by a power law for large elongationnal deformations. Mixing duration has a significant influence on the consistency index, K = 9400-5400 $Pa.s^{0,35}$ for biaxial deformation e = 0.75 and SHI (1.4-2.1). These results suggest that the dough expansion is governed by gas production during fermentation; conversely, the structure of gluten network, modified both by energy level and intensity of mixing, contributes to the rheological properties and hence, to dough stability.

Amylopectin fine structure: Mechanism of the long chain function

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The impact of amylopectin long chains and internal structure on its functional properties was investigated. Greater and broader enthalpic transitions, greater increase in storage modulus and a denser and tighter gel microstructure after retrogradation were found in waxy rice starches with slightly higher proportion of internal long chains, particularly the chains of DP > 40, indicating that more extensive intermolecular interactions were formed. Therefore, the internal long chains of amylopectin were suspected to contribute to these intermolecular interactions through independent association. As a prerequisite to this hypothesis, the ability of internal chains to accommodate iodine as a turned or helical structure is regarded as an indication that internal chains either naturally exist in a helical form or have the flexibility to move around and form helices. Waxy and ae waxy corn starches were hydrolyzed by β-amylase for varied periods of time. The resulting β-dextrins, and the native structure, were exposed to iodine solution. Maximum wavelength and the corresponding absorbance of these mixtures were recorded. Results showed that the internal chains have the ability to bind iodine either because they are naturally synthesized in a turned helical form or they assume a helical structure under certain conditions, i.e. the removal of the external chains of amylopectin. Two scenarios were proposed for the iodine internal chain complexation: 1) only external chains of native amylopectin bind iodine and hydrolyzed external chains allow internal iodine binding and 2) both external and internal chains of native amylopectin bind iodine. Gain in a mechanistic understanding of amylopectin structure related to its functional properties provides further information on structures that would fit desired textural and nutritional starch functions.

Unique composition of flour from sweet wheat lacking GBSSI and SSIIa enzymes

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It has previously been reported that sweet wheat (SW), which lacks functional granule-bound starch synthase I (GBSSI) and starch synthase IIa (SSIIa), accumulates sugars at a high concentration in immature seed. However, when evaluating SW as an ingredient in flour products, it is more important to know the composition of mature SW seeds. In this study, we conducted detailed analyses of SW flour composition, including sugar, starch, protein, dietary fiber and amino acid contents. A higher accumulation of sugars such as glucose, fructose, sucrose, and maltose was observed in mature SW grain compared to the wild type wheat cultivar Chinese Spring (CS) or the SW parental lines waxy wheat (Wx) and high-amylose wheat (HA). Among these four lines, the starch content was lowest in SW by a considerable margin. Lipid content was two to three-fold higher in SW than in CS, Wx or HA. The content of total dietary fiber including insoluble dietary fiber (IDF), high-molecular-weight soluble dietary fiber (HMW-SDF), and low-molecular-weight resistant maltodextrin (LMW-RMD) was twice as high in SW as in other lines. The LMW-RMD fraction was particularly high in SW, and was found to be composed mainly of fructan. In addition, the levels of 18 out of 20 free amino acids were increased in SW, with proline being especially high. Our results showed that distinctive compositional changes occurred in SW grain, and we will discuss potential uses of SW flour.

Digestibility of cross-linked maize starches with different amylose contents

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Cereal Foods World 55:A69

The objectives of this study were to determine the digestibility of cross-linked maize starches with different amylose contents and compare the extent of digestion assayed by different methods. Waxy, normal, and high-amylose maize starches were cross-linked by using 99:1 (w/w) mixture of sodium trimetaphosphate (STMP) and sodium tripolyphosphate (STPP) in sodium sulfate aqueous slurry at 45°C. After 3 hours, the alkaline (pH 11.5) starch slurry was adjusted to pH 6.5, filtered, washed and dried at 40°C overnight. Cross-linked (CL) waxy maize starch had significantly higher phosphorous content (0.36%) than CL normal (0.32%) and high-amylose (0.32%) starches. Total dietary fiber (TDF) was determined using AOAC 2009.01 and AOAC 991.43 methods that were assayed with similar procedures except for the buffers and the α-amylase incubation temperature. AOAC 2009.01 method uses α-amylase incubation temperature at 80°C whereas AOAC 991.43 method at 95–100°C. TDF content obtained by AOAC 991.43 was lower for CL waxy (29.09%), normal (63.74%), and high-amylose (70.01%) starches as compared to the TDF content by AOAC 2009.01 which gave 37.87%, 65.23% and 72.44%, respectively. CL waxy maize starch showed a significant difference of TDF values by the two methods. A relatively high settling volume (19.25 mL) and amylograph viscosity curve of CL waxy maize starch indicated high swelling properties of the starch granules at higher temperature explaining the low TDF of CL waxy maize. Nevertheless, the swelling property of CL waxy maize was restricted at lower temperature, resulting in high resistant starch (RS) of 81.64% as determined by Englyst method with incubation temperature of 37°C.

A new twist on low-glycemic index snack foods

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Americans spend $23 billion annually on snack foods. However, even "healthier" snack foods including crackers, popcorn, and many granola bars all have high glycemic indexes (GIs), making it hard for diabetics and other GI-conscious consumers to control glycemia and insulinemia. The addition of soy is promising since it provides high quality protein and dietary fiber that are known to decrease the glycemic response and increase satiety. Our objective was to determine if soy has the ability to significantly increase satiety while simultaneously decreasing glycemic and insulinemic indexes and maintaining acceptability of a soft pretzel. In this study, the acceptability as well as the glycemic, insulinemic, and satiety indexes were assessed for 24.4% soy soft pretzels (dry weight) and compared to a conventional wheat-based soft pretzel. 49 subjects indicated that the soy pretzel is a consumer-acceptable substitute for the wheat pretzel, the wheat pretzel scored 6.7 ± 1.2 and the soy pretzel scored 6.6 ± 1.1 on a 9-point hedonic scale. By consuming one pretzel after an overnight fast, subjects reported that the soy pretzel was more satiating, likely due to higher protein and dietary fiber contents, but the average satiety indexes were not statistically different. With 11 participants consuming a pretzel totaling 50 g of carbohydrate, the average glycemic index (area under the glycemia vs. time curve) for the soy pretzel was found to be 39.1 ± 20.4, "low-GI" (<55), while that for the wheat pretzel was statistically significantly higher (66.4 ± 15.3, p = 0.002). The insulinemic indexes did not differ significantly likely due to counterbalancing actions of reduced food digestion rate by protein and fiber and increased insulin secretion from protein. In conclusion, a soy-based soft pretzel is a low GI alternative to a popular snack food.

Insoluble Distillers' Dried Grain (DDG) fraction in chemically leavened bread

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Cereal Foods World 55:A70

The objective of this study was to evaluate the addition of thermo-mechanically treated corn Distillers' Dried Grain DDG on batter and bread quality characteristics. DDG was processed by jet-cooking homogenized slurry of DDG and water followed by centrifugation and drum drying the insoluble fraction. The dried insoluble fraction was used as partial replacement (0, 5, 10, 15, 20, 25, and 30%) of cornmeal in chemically leavened bread. The effect of replacement on the batter rheology and bread characteristics was evaluated. Batters with DDG replacing 0–30% of cornmeal had a greater storage modulus than loss modulus, displaying solid like behavior under the testing conditions. Addition of DDG fraction in the formulation resulted in higher protein content in breads. The ash and fat content was not affected by the addition of processed DDG in cornbread. DDG caused an increase in loaf volume. The texture of the breads was softer with 25 and 30% DDG fraction. The shelf life was not affected by the addition of DDG fraction as indicated by no change in the water activity of the breads. The insoluble fraction of DDG has potential for use in baking.

Production and properties of pregelatinized rice flours from coloured rice varieties

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Coloured rice varieties are characterised by colour pigments (anthocyans, melanoidines) present in the outer layers of the kernel, which show high antioxidative potential. In many rice producing countries, these special rice varieties (red or black rice) are used for the production of very specific, traditional foods. Only little research has been done that deals with non-traditional food processing from such rice varieties. In the present study the production of pregelatinised flours of red rice (Sung Yod Phatthalung Rice Research Centre, TH; 18% amylose content) and black rice (Chia Meng Co., Ltd, TH; 5% amylose content) by drum drying and extrusion cooking was investigated. Drum drying was performed using a pilot scale steam heated drum dryer with one drum (drum diameter 50 cm, drum width 50 cm, drum temperature 145°C) and four spreading drums. Concentration of the slurry was 35% w/w. Extrusion cooking was carried out using a conical, counter-rotating twin screw extruder (mass temperature at die 135°C, feed moisture 12%). The pasting properties, water absorption index (WAI), water solubility index (WSI), total anthocyanin content (TAC), total phenolic content (TPC) and antioxidant activities of the pregelatinized flours were determined. The results indicated that extrusion cooking and drum drying affected the pasting properties, WAI, WSI, TAC, TPC and antioxidant activities of the pregelatinized flours in a significantly ($P < 0.05$) different manner. Extrusion cooking degraded the starch molecules to a much higher degree than drum drying, which only caused slight modifications. None of the extruded flours developed a characteristic peak viscosity. Drum dried flours showed low WAI and high WSI. Retention of TAC and TPC was higher in the drum dried flours than in the extruded flours, while antioxidative activity was less reduced by extrusion cooking than drum drying.

Fiber variation in whole-grain soft wheat flour within the United States

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The Dietary Guidelines for Americans recommends consumption of three or more ounce-equivalents of whole-grain products per day, with the rest of the recommended grains coming from enriched or whole-grain products. Yet, in 2009, whole grains as a percent of total grains consumed in the American diet was only 11%. Of the soft wheat snack food products, wheat crackers comprised 2.9% of whole grain intake. Increasing consumption of whole grains in the American diet will require increasing whole grain content across the spectrum of food products. Yet, limited information is available on the actual amounts of fiber present in soft wheat flour. The USDA National Nutrient Database for Standard Reference is used as a standard reference for labeling and dietary formulation. The profile is largely based on hard wheat flour samples and differs from the expected profile for soft wheat whole grain flour samples for important nutrients, most notably total grain protein concentration. Also, the fiber content of the flour in the database is imputed, that is derived but not measured directly. We use the new AOAC fiber analysis method 2009.01 (Mc Cleary All-in-one method) to measure samples in commercial and experimentally milled whole-grain soft wheat flour. For commercial flours, the average fiber concentration was 13.0% (14% moisture basis) compared with the previous imputed value of 11.7%. The commercial whole-grain soft wheat flours differed from the USDA database for protein concentration (9.2% for the study and 13.1% for database value) and selenium concentration (7.6 mcg/100 g for the study and 67.8 mcg/100 g for the database). Information from the experimental milled whole grain soft wheat flour also will be presented.

The development of low glycemic response rice noodles

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Cereal Foods World 55:A70

Rice noodles are usually classified as a high glycemic index (GI) food. This study aims to develop low GI dried rice noodles by fortifying different high fiber starches. Three high fiber starches from natural sources (banana, edible canna and taro) and two commercial high-fiber modified starches (brand A made from corn starches and brand B made from tapioca starches) were investigated for their functional properties and the potential to be used in the noodles. All starches showed single endothermic peak located broadly around gelatinization temperature range when assessed by DSC. Total starch and resistant starch contents of banana, edible canna and taro were 30.44/12.51, 33.99/18.58 and 28.32/11.96% w/w (dry basis), respectively. Commercial modified starches, brand A and B, contained 74.20/26.24 and 43.71/0.84% w/w (dry basis), respectively. Results from sensory evaluation suggested that maximum 20% w/w of all studied starches could be added to normal rice noodle formula without significant effects on taste and textures of the noodles. Rice noodles fortified with modified starches (brand A) provided the lowest GI. The higher resistant starch content the starches contain, the lower GI the noodles achieve. Among all starches from natural sources, banana and edible canna proved to be the potential ingredients for reducing GI in the noodles. The GI values of rice noodles fortified with banana and/or edible canna starches are lower than those fortified with commercial modified-tapioca starches (brand B). These natural starches are much cheaper than commercial modified starches in most Asian countries in where rice noodles are popular.

Rheological characterization of four Kansas hard red winter wheat cultivars in relation to end product quality

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Cereal Foods World 55:A70

Wheat flour dough exhibits complex rheological properties. Understanding the factors affecting the distinct structural and textural characteristics that consumers desire in baked products is of critical importance. The objective of this study was to characterize mixing, pasting and small deformation behavior, and end-product quality of four Kansas grown hard red winter wheat (Karl 92, Overley, Santa Fe and 2137) of different protein contents. SE-HPLC was used to characterize gluten proteins. Dough mixing characteristics were studied by Farinograph and Mixograph. Fundamental rheological properties were studied through strain, frequency and temperature sweeps, creep and stress relaxation tests. Bread quality was assessed through loaf volume, texture profile analysis, C-cell, and x-ray microtomography (XMT). Cultivars with higher protein and unextractable polymeric proteins (Overley and Karl 92) resulted in larger loaves (912-943 cc), expanded air cells, thinner cell walls, and greater void fractions (88.5-89.4%). 2137 displayed more closed cell structure, low void fraction (85.5%), larger cell wall thickness, and a significantly firmer crumb texture. In linear viscoelastic region, storage and loss moduli of Santa Fe and 2137 (2.6-3.8x104 Pa) were higher than that of Karl 92 and Overley (1.2-1.7x104 Pa) indicating stiffer dough texture. Stress relaxation gave the most useful information about flour quality. Flours with high total polymeric proteins could be identified through their higher relaxation spectra. Collectively, the protein quality and empirical and fundamental measures of rheology gave good characterizations of wheat flours. Although all four wheat cultivars were observed to have good breadmaking qualities, Karl 92 and Overley displayed relatively superior end-product properties mostly due to their high unextractable protein contents.

Rheological studies of Kansas wheat varieties

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Cereal Foods World 55:A70

Mixolab is a relatively new technique which measures mixing behavior of dough samples subjected to a dual mixing and temperature constraint. It has the capability to measure physical dough properties like dough strength and stability and also measures starch pasting properties, which make it an alternative for Farinograph, Mixograph and Rapid Visco Analyzer (RVA). The objective of this study was to establish relationships between these techniques using four hard red winter wheat varieties (Karl 92, Overley, Santa

Fe and 213). Water absorption rate, development time, stability, peak mixing time, peak viscosity and pasting temperature were studied using Farinograph, Mixograph and RVA and compared with Mixolab water absorption (C1), mixing stability, protein weakening (C2), starch gelatinization (C3), amylasic activity (C4) and starch gelling (C5). Farinograph water absorption values ranged between 58.4–61.1% and could be ordered as follows: Karl 92>Overley=Santa Fe>2137. Mixolab water absorption values determined on dry basis ranged between 88.4–92.1% and did not follow the same order. Farinograph development time and Mixograph peak mixing time were in accordance with Mixolab dough formation time. Karl 92 has higher stability (16.7 min) as compared to other flour doughs from farinograph and it is correlated with Mixolab data with higher stability (9.3 min) for Karl 92 flour dough compared to other dough systems. Gelatinization of starch is an essential step in the transformation of dough into bread. RVA final viscosity and peak viscosity values for the flours tested followed similar trends with C3 and C3 points on Mixolab profiles. Mixolab dough resistance observed at high temperature has advantage over RVA as the test conditions are more similar to baking due to higher solid concentrations used.

Electro-kinetic dewatering as a potential new low cost technique for drying food processing waste

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Cereal Foods World 55:A71

Recent work at Manchester Metropolitan University has found that a major barrier to the valorisation of food by-products was the need to reduce its high water content before extrusion processing. Energy cost calculations for the entire LCA of processing of the waste showed that the drying stage made up approximately 90% of cost. Dewatering techniques such as mechanical and thermal have limitations of efficacy or cost. Alternative methods that remove water in the liquid state without a phase change are more energy efficient, and offer the advantage that the water can be subsequently used for further processing. There is a need for low cost, energy efficient dewatering throughout the whole of the food manufacturing chain. Electro-kinetic (EK) dewatering involves the application of a low electric potential across the material to be dewatered. The electric field causes electro-osmotic flow which transports the water out of the materials towards the electrodes. The objective of this study was to investigate the combined electro-kinetic and mechanical techniques in dewatering brewer's spent grain (BSG). Measurements were conducted in the purpose built laboratory-scale EK dewatering cell using different voltages. The results indicated that a combined mechanical and electro-kinetic process can significantly ($P < 0.001$) reduce the moisture content. The energy consumption was evaluated and found to be up to twelve times more economical compared to thermal processing. This study showed that EKG has great potential to be a simple and efficient dewatering system in food industry. With further research, the exploitability of this system could extend to various applications.

Effects of the order of addition of reagent and catalyst on modification of starch with rapidly-reacting reagents

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Cereal Foods World 55:A71

The objective of this research was to determine if impregnating starch granules with rapidly reacting reagents before adjusting the pH by addition of alkali would produce different products than obtained with the usual procedure (adding alkali before addition of reagent). Commercial (C), laboratory-isolated (LI), and thermolysin-treated commercial (TC) normal (NMS) and waxy maize (WMS) starches were used. From previous work, it is known that the amount of external surface and channel protein present on the granules was LI>C>TC. Also examined were reactions of commercial and laboratory-isolated normal wheat starch (NWS) and laboratory-isolated waxy wheat starch (WWS). The 12 starch preparations were each reacted with 3 cross-linking reagents (acetic-adipic mixed anhydride [AAMA]), phosphorus oxychloride [$POCl_3$], STMP) and 3 stabilizing reagents (acetic anhydride [AA], succinic anhydride [SA], octenylsuccinic anhydride [OSA]), all of which are believed to be quite reactive. Data for NMS, for example, show that properties of the products of reaction with cross-linking reagents indicate a greater degree of cross-linking for the reaction with AAMA and little difference for reactions with $POCl_3$ and STMP (except for final viscosity in which the $POCl_3$ product also indicated an increase [AAMA > $POCl_3$]) for products of the reaction in which granules were impregnated with reagent before initiating the reaction as compared to products made in the usual way. Properties of the products of reaction with stabilizing reagents indicated a greater degree of substitution for SA and AA and little difference in the product of reaction with OSA (except for peak viscosity in which the OSA product also indicated an increase [SA>AA>OSA]) for products made by first impregnating the granules with reagent. Data from reaction of the other 11 starches and their analysis will also be given.

Characterization and discrimination of popcorn flake polymorphology

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Cereal Foods World 55:A71

The objective of this study was to identify and characterize popped popcorn flake polymorphologies from a single, commercial U.S. yellow butterfly popcorn hybrid (YP-213). Kernels were popped using a microwave oven, and visually sorted into three different polymorphisms depending on whether the appendages were expanded unilaterally, bilaterally, or multilaterally. The sorted popcorn flake shapes were then subsequently characterized by determining expansion volume and compositional attributes. When popped, 71.2% (CV=8.3%) of the kernels were of the bilaterally-expanded polymorph, 12.3% (CV=30.9%) were multilateral, and 9.0% (CV=34.3%) were unilateral shaped. The percentage of unpopped kernels averaged 7.6% (CV=18.8%) per bag. The observed expansion volumes were 29.2 (CV=13.2%) cm^3/g for unilaterally-expanded, 43.0 (CV=2.0%) cm^3/g for bilaterally-expanded, and 53.5 (CV=4.7%) cm^3/g for multilaterally-expanded popcorn flakes. In addition, significant compositional differences ($p \leq 0.05$) were observed between the different polymorphisms with unilateral popcorn flakes having the highest levels of fat, saturated fat, and sodium, while multilaterally-expanded flakes had the highest levels of protein, total carbohydrate, and popcorn-like aromatic pyrazines.

Structure and properties of poly (vinyl alcohol)/starch/laponite RD nanocomposite films

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Cereal Foods World 55:A71

Research on bio-based packaging materials has received an impetus due to environment concerns and unreliability of petroleum resources. In this study, a series of poly (vinyl alcohol)(PVOH)/starch/ laponite RD nanocomposites were prepared by solution mixing and cast into films. Laponite RD, a synthetic layered silicate, was used as a nanofiller. The structure of the nanocomposites and interactions between various components were studied using X-ray diffraction (XRD), transmission electron microscopy (TEM) and differential scanning calorimetry (DSC), which indicated good exfoliation of the clay layers. The addition of laponite RD improved both gas barrier and mechanical properties of the composite films, with surprisingly significant increase of elongation at break. With increasing concentration of laponite RD (0–20%), water vapor permeability of the nanocomposite films decreased from 0.306 to 0.226 g·mm/kPa·h·m2 at a RH differential of 0–50% and from 1.706 to 1.238 g·mm/kPa·h·m2 at RH differential of 0–75%; tensile strength increased from 8.53 to 13.32 MPa and from 4.83 to 10.02 at RH of 50% and 75%, respectively; and elongation at break increased from 155.5 to 229.2% and from 113.5 to 312.0% at RH of 50% and 75%, respectively. The films with 10% laponite RD presented best mechanical and barrier properties compared to other treatments. The results indicated that laponite RD not only functioned as a reinforcing agent, but also a binding agent and compatilizer, which helped improve the homogeneity of PVOH and starch polymer matrix. To summarize, nanocomposites based on combinations of PVOH, starch and laponite RD can potentially be used for low cost, commercial-grade biodegradable packaging films because of their good mechanical properties.

Unusual weather pattern impacts on wheat quality in Northern Paraná state, Brazil

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Cereal Foods World 55:A71

Climate pattern in the Northern region of Paraná state is typically warm and moderately dry. However, 2009 season was especially unusual, presenting high frequency of rainfall, particularly during wheat flowering (252 mm in July) and harvesting (228 mm in September) stages, resulting in the occurrence of *Fusarium graminearum* with possible mycotoxin development. The aim of this study was to characterize wheat technological quality and mycotoxin content, comparing their relationship from 2009 samples. The study was performed in Londrina, Paraná state, on hard wheat, with high gluten strength, mostly used for bakery and pasta production. Wheat samples were taken from each silo corresponding to each segregated batch (18 silos). Samples presented: test weight (TW) = 74-81 kg/hL; gluten content (GC) =

28-30%; grain falling number (GFN) = 144-379 s; gluten strength (W) = 228-381 × 10^{-4}J and elasticity index (Ie) = 49-63% (alveography); water absorption (WA) = 60-63% and stability (ST) = 3-12 min (farinography). As expected, high frequency of rainfall resulted in Fusarium Head Blight (FHB) infection and consequently production of mycotoxins. Mean mycotoxins values were: deoxynivalenol (DON) 1,027.16 micrograms kg^{-1}, nivalenol (NIV) 126.00 micrograms kg^{-1} and zearalenone (ZON) 499.86 micrograms kg^{-1} (high levels were 2,522.10 micrograms kg^{-1}, 134.00 micrograms kg^{-1} and 1,613.00 micrograms kg^{-1}, respectively). Significant correlations were: DON with TW (r = –0.64), GFN (r = –0.54), Ie (r = –0.51), GC (r = –0.55), and WA (r = –0.49); NIV with WA (r = –0.58); and ZON with GC (r = –0.47). The results showed that wheat quality was influenced by FHB infection during 2009 crop season.

Wheat traceability: A tool for segregation and quality management

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Cereal Foods World 55:A72

To preserve integrity and to ensure homogeneity of shipments, the grain industry is increasingly being oriented towards product differentiation rather than being characterized more traditionally by commodities. In this presentation, we will describe a traceability system that was developed to identify and differentiate classes in wheat production. The wheat traceability system was tested and implemented on western Canadian spring wheat, recording information on the management practices adopted in production, transportation and post-harvest. In addition, the analyses of technological and functional properties, such as protein, gluten strength and color were made with small-scale rapid methods, allowing the segregation of the wheat based on quality. Analyses of contaminants, especially mycotoxins, were also performed to ensure food safety. These data were combined with the production and storage information in the program, to produce a computerized tool that can be used for wheat differentiation and segregation according to the production system and the technological quality, thus helping to improve the competitiveness of the wheat production chain.

Development of a real-time PCR assay for *Fusarium thapsinum* in grain sorghum

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Cereal Foods World 55:A72

Grain mold is a yield-limiting disease that impacts caryopsis viability and quality of sorghum grain. The objective of the study was to develop an assay that will allow investigators to identify the presence and amount of disease observed in field trials to *Fusarium thapsinum* levels without laborious culture work and DNA sequencing. Field grown samples from four sorghum lines, Sureno, Tx2911, SC170, and Tx430, that vary in grain mold resistance were scored visually and given a grain mold rating. Samples were milled and *Fusarium* colony forming units were determined by plating flour dilutions onto potato dextrose agar. After subculturing, colonies representing different species were evaluated by PCR amplification of a region of the fungal translation elongation factor 1-alpha (TEF-1a) gene and DNA sequence comparisons were made. *Fusarium* spp. present in the field included *F. thapsinum*, *F. verticillioides*, *F. proliferatum* and *F. equiseti*. Purified genomic DNA from the major pathogen, *F. thapsinum*, was used to develop specific real time PCR methods based upon variable regions within the TEF-1a gene. Results confirmed specific detection of *F. thapsinum* and lack of cross reactivity between other *Fusarium* species. Based on genomic DNA, the limit of detection was 0.1 pg fungal DNA. Standard curves were developed using dilutions of genomic DNA, and DNA extracted from experimentally inoculated and field samples were analyzed. Analysis of sorghum flour from field grown samples demonstrated that the assay provides a highly specific method for identification and quantification of *F. thapsinum.*

Using the latest technology to measure gastrointestinal transit time after dietary fiber intervention

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Cereal Foods World 55:A72

Although it is generally accepted that one of the beneficial health effects of dietary fiber is decreasing gastrointestinal transit time, few recent studies have measured transit time with diet intervention. Historically, measurement of gastrointestinal transit time has required collection of fecal samples for up to 7 days after swallowing radio-opaque markers (ROM) and x-raying collected fecal samples; a tedious, labor-intensive technique for both subjects and investigators. Recently a wireless motility capsule (SmartPill®) capable of measuring gut pH, pressure and temperature in real time was developed. The SmartPill® device is able to measure gastric emptying time by pH change and whole gut transit time by temperature change. Intestinal transit time is the difference between whole gut transit time and gastric emptying time. this device was recently validated with a dietary intervention. In a crossover trial with 10 subjects, it was evaluated if the SmartPill® device could detect a significant difference in gastric emptying, intestinal and whole gut transit time after subjects consumed 22 grams of wheat bran (WB) or equal volume, fiber-free control. This dose of WB has previously been shown to decrease whole gut transit time using traditional methods. Results of this trial found that the SmartPill® was able to detect changes in whole gut transit time and found a decrease of 9.5 ± 2.9 hours (p = 0.0092) after consumption of the WB compared to the fiber-free control. These findings demostrate, with minimal participant burden, the SmartPill® technology is a useful tool for assessing transit time after dietary intervention.

A new method to determine the carbohydrate profile in soy fiber or cereal grains

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Cereal Foods World 55:A72

Soy fiber and cereal grains are a rich source of complex carbohydrates. However, much research is still required to provide a complete characterization of these carbohydrates at the molecular level. In order to address these needs, a new approach to effectively and reproducibly determine the sugar profile of Soy Fiber was developed. For the analysis of the carbohydrates in fiber, techniques known in the literature rarely deal with Soy Fiber and are typically constrained by their inability to either hydrolyze the Soy Fiber in a complete and reliable fashion or to detect and separate the resulting sugars adequately. The novel sugar profile analysis described in this paper comprised an improved acid hydrolysis of the Soy Fiber with sulfuric acid at high temperature and high pressure and a subsequent quantitative identification of the resulting sugars using HPAE-PAD (High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection). The modified acid hydrolysis assay included a pretreatment of Soy Fiber with 12 M sulfuric acid at 30°C for 1 hour, and after dilution, a subsequent autoclave treatment at 121°C and 18 psi for 1 hour. This autoclave-based method provided a more complete hydrolysis of the Soy Fiber as compared with the previously used reflux method under normal atmospheric conditions. The HPAE-PAD sugar analysis showed excellent reproducibility and was able to differentiate and quantify several mono- and oligosaccharides, including those of isomeric structures like galactose and glucose. As demonstrated with several examples, this combination provides a more complete picture of the hydrolyzed carbohydrate profile of Soy Fiber. This analytical method can be modified and applied not only to other soy-based materials, but also to other carbohydrate-containing seed and cereal materials.

Polyphenol-rich sorghum brans promote fecal water retention and alter short chain fatty acids in Sprague Dawley rats

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Cereal Foods World 55:A72

We have previously demonstrated that bran from Sumac and Black sorghum grain suppresses early preneoplastic lesions of colon cancer (ACF), and had lowered the concentration of butyrate on a fecal wet weight basis. We next determined whether the effects were due to changes in the fecal environment, specifically moisture content, and if these changes would further alter short chain fatty acid (SCFA) concentrations (dry mass basis). Rats (n = 10/diet) consumed diets containing 6% fiber from Cellulose or bran from White, Sumac (contains tannins), or Black (contains anthocyanins) sorghum. Diets were fed for 10 wk, with two azoxymethane (colon-specific carcinogen) injections (15 mg/kg BW) given in weeks 3 and 4 to initiate colon cancer. Fecal samples were collected at termination and used to determine the moisture content and concentrations of total and specific SCFA. Fecal moisture content was 28 and 32% greater in rats consuming Black or Sumac bran, as compared to the Cellulose diet ($P < 0.01$). On a dry matter basis, total SCFA concentrations were 41.7, 66.7, 34.8, and 31.8 μM/g feces for the rats consuming diets containing Cellulose, or bran from White, Black or Sumac sorghum grain. The concentrations of butyrate were 6.9, 15.9, 6.1 and 2.3 μM/g of dry feces for the same groups. For both total SCFA and butyrate concentrations, the concentrations were lowest ($P < 0.0001$) for Sumac bran and highest for White sorghum bran diets. We found a strong ($P < 0.01$) inhibitory effect of fecal moisture on ACF formation. These data suggest that polyphenol-rich sorghum brans are modifying the luminal environment,

including both moisture content and SCFA concentrations, to reduce colon carcinogenesis. Funded by United Sorghum Checkoff Program.

Antioxidant activity-guided fractionation of Blue wheat

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Cereal Foods World 55:A73

The aim of this study is to use activity guided chromatographic fractionation to find out which phytochemicals in blue wheat are the key compounds exhibiting antioxidant activities. Blue wheat was ground and consecutively extracted with 80% ethanol, acetone and ethyl acetate. This was followed by an alkaline hydrolysis of cell-wall bound phytochemicals from the extraction residue. Three in vitro antioxidant assays (Folin Ciocalteu, TEAC and leucomethylene blue test) were used to evaluate the extracts' reducing and radical scavenging properties. Only extracts showing the most pronounced effects in these tests were selected for fractionation by different chromatographic procedures. The highest antioxidant activities were exhibited by the alkaline hydrolyzate and 80% ethanol extract. The latter was further divided into a water-soluble (WS) and water-insoluble part (WI). Both the WI part and the alkaline hydrolyzate were subjected to size-exclusion chromatography. The WS part was fractionated by using Amberlite XAD-2, a polymeric adsorbent suitable for the separation of phenolic compounds, and these fractions were tested again. The most active Amberlite fraction in all three assays was obtained by eluting with 50% methanol. This fraction was of purple color, suggesting the presence of anthocyanins. It was further separated by semi-preparative RP-HPLC on a phenyl-hexyl stationary phase, and the new subfractions were tested again. Each of the three antioxidant assays indicated a different subfraction to be most active. These subfractions were subsequently purified by RP-HPLC. Two of them contained only one dominant peak which was isolated and characterized by NMR and MS.

Effect of the outer bran layers from germinated wheat grists on bread making properties

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Cereal Foods World 55:A73

The objective for this study was to know how to maintain breadmaking properties when bran is added. Wheat grists were germinated in the dark at room temperature (24°C) for 1, 2, 3, 5, and 8 days, and the outer bran layers were separated. Bread making was performed with wheat flour and 10% of the outer bran layer. The bread making properties (bread height (mm) and specific volume (cm3/g)) gradually enhanced when blending with the germinated outer bran layers, and optimal bread making properties were obtained at 5 days' germination. RVA (Rapid Visco Analysis) and Brabender Farinograph-profiles of wheat flour with outer bran layers (10%) indicated that the maximum decrease of peak viscosity and increase of angle of tail were obtained at 3 and 5 days-germination, respectively. Activities of α- and β-amylase, lipase, protease, and xylanase in the outer bran layers were measured, and correlation coefficients (r) between bread making properties and peak viscosity (RVA), angle of tail (farinograph), and enzyme activities were calculated. From these data it was suggested that xylanase activity in the outer bran layers was highly related to the enhancement of the bread making properties. Enzymes in the outer bran layers from germinated wheat grists can help maintaining good bread making properties.

The impact of structural changes on heat-moisture treatment on the susceptibility of normal and waxy potato starches towards α-amylase

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Cereal Foods World 55:A73

Heat-moisture treatment (HMT) modifies starch structure and properties without destroying its granular structure. HMT has been shown to cause starch chain interactions and crystallite disruption/reorientation within the amorphous and crystalline domains. However, a systematic study has not been carried out to examine how variations in HMT temperatures influence starch structure in normal and waxy starches. It is hypothesized that since starch structure influence α-amylolysis, any structural changes within the amorphous and crystalline domains on HMT could either increase or decrease α-amylolysis depending on the extent of starch chain mobility and crystallite disruption/reorientation at the HMT temperature. Thus, the objective of this study was to determine changes to the structure of normal and waxy potato starches on HMT at different temperatures (80°C, 100°C, 120°C, 130°C) for 16 h at 27% moisture, and to study the impact of these structural changes on the rate and extent of α-amylolysis. HPAEC, FTIR, DSC, WAXS and confocal laser scanning microscopy were used to determine the structure of native and HMT starches before and after α-amylolysis. The kinetics of α-amylolysis at the different HMT temperatures was also determined. The results showed that the susceptibility of normal and waxy starches towards α-amylase after HMT was significantly influenced by changes to molecular order, crystalline order and polymorphic composition. The extent of these changes were influenced by the difference in AMP content and HMT temperature. This suggests that similar trends in digestibility may also occur on HMT of cereal starches (maize, wheat, barley) of varying amylose content. The mechanism behind the variations in starch digestibility between the two potato starches on HMT, and the implication of this study to cereal starches will be discussed.

Functional properties of wheat gluten obtained by well defined shear flow

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Cereal Foods World 55:A73

A new separation process for wheat flour is developed to obtain a starch-enriched and gluten-enriched fraction, which is based on the application of well-defined shear flow to dough inside a conically shaped shearing device. Potential advantages of the new separation method are large water and energy savings and an increased protein recovery. In this research, we studied the functional properties of the gluten-enriched fraction and compared it with properties of commercial vital wheat gluten. A batch of gluten produced in the shearing device is analysed using kneading and baking tests. The results of both tests look promising, because they indicate that the gluten are able to enhance the functional properties of the dough. The consistency of the dough increased, leading to a higher resistance upon the mixing blades, when additional gluten was added. But, addition of 2w% commercial gluten increased the consistency with approximately 10%, while gluten obtained through shearing increased this with almost 25% at comparable water content. Baking tests gave comparable results. The loaf volume increased approximately 8% for commercial gluten and 16% for sheared gluten when 4w% protein was added on top. Concluding, the new separation process offers also a gluten product with interesting properties and therefore, the application of sheared gluten can not be dismissed as a promising product for future applications.

Endogenous β-glucanase activity in selected Ontario wheats

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Cereal Foods World 55:A73

The health benefits of β-glucan are well documented. The bioactivity of β-glucan is thought to be dependent on its molecular weight and the consequent viscosity in the gut. Several studies reported degradation of β-glucan in baked products. One of the main sources of β-glucan degradation could be endogenous β-glucanase in wheat. The objective of this study was to investigate the effect of genotype and location on β-glucanase activity in selected soft winter wheat varieties/lines grown in Ontario. Ten soft wheat varieties/lines (red/white) grown in two different locations, were used in this study. Endogenous β-glucanase activity of each sample was determined using the Megazyme kit (malt and bacterial β-glucan procedure) with some modifications. Results indicated that for both red and white soft wheats, location had significant effect on β-glucanase activity for some varieties/lines while it did not affect the β-glucanase activity in others. For example Superior, E0028w and Tw319-094 (soft white wheat); Beacher and Branson (soft red wheat) were affected by location, while Ava and 25w36 (soft white wheat); Emmit, 25R47 and Tw271*099 (soft red wheat) were not affected by location. Among the varieties/lines tested, wheat color (red or white) had significant effect on β-glucanase activity in some varieties/lines while in others wheat color did not affect the β-glucanase activity. This study highlights that endogenous β-glucanase activity varied between varieties/lines based on location and sometimes pigment color. Further studies are underway to understand the contribution of the genetics, environment and their interaction on β-glucanase activity.

Physical-chemical and rheological property of wheat flour with addition of three different sources of resistant starch

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Cereal Foods World 55:A73

Addition of different ingredients to wheat flour (WF) can change its characteristics. In products development, it is important to analyze and understand how these ingredients can affect dough properties. The objective of this study was to analyze the physical-chemical properties of raw materials and to characterize rheological properties of WF dough with addition of 10%

of three different sources of resistant starch (RS). Raw materials such as WF, Hi Maize 260 (HM), Promitor (Prom), and Green Banana Flour (GBF) were analyzed to its physical-chemical characterization (proximate composition, RS content and polarized microscopy) and 10% of each different RS were added on WF to evaluate dough rheological properties (farinograph, extensograph and pasta properties). The chemical composition showed that WF presented around 10% protein and low fat and ash content. In the other hand, GBF presented low protein content but high ash content. Prom presented the highest RS content (62.3%), while HM and GBF presented 44.3 and 45.7% RS, respectively. On polarized microscopy, it was clearly observed Maltese cross from ungelatinized starch granules of WF, HM and GBF. On pasta property, GBF presented the highest viscosity peak and breakdown value. In the other hand, HM and Prom didn't show any parameter, because the gelatization temperature appears above 100°C. Water absorption of WF dough was 61.5%. When 10% of HM, Prom and GBF were added, water absorption changed to 62.6, 60.8 and 62.0%, respectively. When 10% of GBF was added, dough stability and tolerance mixture index were significantly affected, weakening dough strength. The extensibility was reduced with 10% GBF, while it was maintained when 10% of HM and Prom was added. When HM and Prom are added to WF, dough properties are not altered indicating that these RS can be used in new products development without changing dough properties.

Improve bakery properties of Peruvian Wheat Centenario flour and a blend with Quinoa and Kañiwa using an enzyme complex

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The objectives are to determine the characteristics of Centenario peruvian wheat flour through physical and chemical analysis and its bakery properties. The second objective was to determine the bakery properties of the blend of Centenario wheat flour with quinoa and kañiwa in the respective proportion of 70:21:9 and to evaluate the volume of this bread. The effect of the addition of enzyme complex Granozyme (fungal alpha amylase, fungal xylanase, bacterial xylanase, glucose oxidase, galactolipase and lipase) was evaluated in a dossage of 100 ppm in the elaboration of white bread, using Centenario flour bread and the blend of Centenario wheat flour, quinoa and kañiwa. The characteristics of centenario flour are humidity 13.47%, ashes 0.67%, falling number 450 seg and dried substance protein 13.47%. Results of Alveograph are P = 88 mm, L = 66 mm, W = 221.82 10 E-4J and P/L = 1.34,el % gluten was 11.28%, gluten index was 96 and bread volume was of 3812 cc. These result of bread volume (3815 cc) are similar the result obtained in the proofs with imported wheat as a control. The proof of bakery made of the blend of different flours has shown as a result a piece of bread has a volume average of 1550cc. The flour from Centenario had good qualities for the use in the bakery industry. It was not possible to made a replacement of Centenario wheat flour by quinoa flour and kañiwa flour, because the volume of bread had a significative decreased. The addition of enzyme Granozyme improve the performance of Centenario wheat flour in the bread; the volume obtained (3975 cc) was 4% increased versus the control without enzyme complex. The enzyme was added to the blend of Centenario, quinoa and kañiwa, the improvement of volume (2250 cc) was 45% more than when we don't use the enzyme. The Granozyme, used in a quantity of a 100 ppm respect to flour has effect in the improvement of bread pieces when is use the blend of Centenario, quinua and kañiwa.

Polymorphic structure, crystallinity, and double helical component of developing wheat starch granules

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Cereal Foods World 55:A74

Organization of glucan polymers within the starch granule plays a significant role in starch functionality. However, the relationship between starch structure and the functionality requires further studies. The objective of this study was to explore the development of the organization of glucan polymers within starch granules during maturity. Starches were isolated from wheat grains sampled at 7 different maturities (7, 14, 21, 28, 35, 42, and 49 days after anthesis; DAA). Isolated starches were equilibrated to 0.97 water activity and examined for the polymorphic structure and relative crystallinity by using wide angle x-ray diffraction, and double helical component was measured by using Fourier transform infrared spectroscopy. Starches isolated from 7 and 14 DAA starches demonstrated B-crystallinity mixed with the A-crystallinity, whereas the mature starches demonstrated only A-crystallinity. Disappearance of the 5° peak and the shoulder in 23° peak, and the appearance of the 18° peak with the maturity of starch granules are indicative of possible transformation of B-crystallites into A-crystallites during maturity. Percentage relative crystallinity of individual A- and B-crystallites decreased with the maturity of starch, while that of V-type crystallites increased with maturity. Peak width at half height (PW) of peaks at ~5°, 18°, and 23° 2-theta decreased during maturity; however, the difference in the peak at ~23° is small. Furthermore, PW of the peak at ~17° 2-theta was not significantly affected, whereas PW of the peak at ~20° 2-theta increased during maturity. Double helical component of the starch did not change during maturity. These observations demonstrate possible rearrangements of glucan polymers during granule development.

Effect of iodine on the organization of glucan polymers of developing wheat starch granules

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Cereal Foods World 55:A74

The goal of this study was to use the iodine binding ability of glucan polymers to elucidate differences in the organization of glucan polymers during starch granule development. Starches were isolated from wheat grains sampled at 7 maturities (7, 14, 21, 28, 35, 42, and 49 days after anthesis; DAA). Isolated starches were equilibrated to 0.97 water activity (aw) and exposed to iodine vapor for 24 hr at the same aw. Then the starches were examined for iodine absorption by using K/S spectra (the ratio of absorption and scattering coefficients), polymorphic pattern and relative crystallinity by using wide angle X-ray diffraction, and double helical component (DHC) by using Fourier transform infrared spectroscopy. Developing starch granules exhibited an increase in color and K/S value following exposure to iodine. K/S maxima was observed at ~540 nm for starches from all maturities. Iodine did not change the polymorphic pattern of any of these starches. Iodine decreased the A-crystallinity of 21 and 28 DAA starches slightly, whereas it increased that of other maturities. V-crystallinity increased in starches of all maturities. Iodine increased the peak width at half height (PW) of 17°, 20°, and 23° 2-theta peaks at all maturities; whereas it decreased the PW of 15° and 18° 2-theta peaks in most maturities. The DHC of 7 and 14 DAA starches were decreased by iodine while that of starches from other maturities were increased by iodine. These results indicate that iodine affected mainly the A-type crystallites which were in the boundary of order/disorder; it formed more ordered structures in some maturities, while it disrupted them into completely disorder/amorphous state in some maturities. These results are further indicative of different levels of molecular organizations from the hilum to the periphery of a starch granule.

Dough mixing and expansion characteristics of flour millstreams

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Cereal Foods World 55:A74

The micro-DoughLab is an instrument for quantifying the mixing characteristics of small dough samples based on 4 g of flour. The dynamic dough density system allows the expansion capacity of small dough samples, which relates to breadmaking quality, to be quantified. This study brought these two innovations together, using the micro-DoughLab to prepare small yeasted dough samples under well-defined mixing conditions, and using the dynamic dough density system to quantify the expansion capacity of these samples. Wheats were laboratory-milled to produce six flour streams (three from the Break System, three from the Reduction System), which were used to demonstrate the differences in flour quality as shown by this combination of new techniques.

Investigating on the replacement of modified potato starch with phosphate salts in instant ramen noodles

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Cereal Foods World 55:A74

Starches from different sources and their derivatives have been utilized to improve the cooking and eating quality of instant noodles. Up to 15% (flour weight) of modified potato starch (MPS) is often added in Korean instant noodles because MPS increases flour pasting viscosity and improves the eating quality of noodles. However, the addition of MPS leads to higher raw material costs. Our previous study has shown that some phosphate salts and their blends could increase instant noodle dough pasting viscosities and improve cooked noodle texture. The objective of this research is to reduce raw material costs and enhance instant noodle quality attributes by replacing MPS with small amount of phosphate blends (PBs). The pasting properties of standard instant noodle formulation (containing 15% of MPS) and modified noodle formulations (containing 10% MPS and different amounts of PBs) were measured by the RVA. Instant noodles were made from these formulas, and the color and the texture profile analysis were performed on cooked noodles. The results showed that modified instant noodle formulations containing 10% MPS and each of the selected PBs had higher peak and final

viscosities, and lower breakdown values than the standard noodle formulation. Compared to the standard instant noodles, the color of modified instant noodles was similar; however, the hardness of the cooked noodles increased significantly, while other textural parameters were little affected. Sensory evaluation by expert panelists confirmed that the modified instant noodles had firmer noodle bite, while other textural characteristics were similar to the standard noodles. In summary, with less than 0.4% of selected PBs, the amount of MPS in the standard instant noodle formulation could be reduced by at least 30%.

Physicochemical and pasting properties of starches from field pea, lentil and chickpea

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Cereal Foods World 55:A75

This study was aimed to compare physicochemical and pasting properties of starches from field pea (*Pisum sativum*), lentil (*Lens culinaris*) and chickpea (*Cicer arietinum* L.), and to determine the relationship between those properties. Starches from several varieties of field pea, lentil and chickpea were prepared using a laboratory wet milling procedure. Physicochemical and pasting properties of those starches were determined according to published methods. Particle size distribution of starch granules was measured using a Mastersizer laser diffraction analyzer. Mean granule diameter of lentil starch (21.6 μm) was larger than that of chickpea starch (17.5 μm) but smaller than that of pea starch (27.0 μm). Pea starch contained significantly higher amylose content when compared to lentil and chickpea starch. Starch from lentil displayed significant higher solubility and swelling power than that from chickpea. Lentil starch also exhibited significant higher peak and breakdown viscosity, but lower setback and final viscosity than pea and chickpea starch. Results from this study indicated that starch granule size, swelling power, solubility and pasting properties were dependent on the source of the starch. Several significant correlations between physicochemical and pasting properties were revealed by Pearson correlation. Thermal properties of those starches will be investigated in future study.

Effect of Fusarium head blight on hard red spring wheat quality and correlation with accumulation deoxynivalenol in grain after fungicide treatment

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Cereal Foods World 55:A75

Fusarium head blight (FHB) is a fungal disease that negatively affects small grains. In wheat this is caused by the pathogen *F. graminearum*. An important effect of FHB infection is the production of several toxins including deoxynivalenol (DON) also referred to as vomitoxin. The Food and Drug Administration (FDA) has set an advisory level for wheat and wheat products for human consumption of less than 1 ppm of DON. This study focused on the correlation between DON levels and spring wheat quality parameters. One spring wheat variety (Freyr) was grown in one environment to eliminate the genetic and environmental differences. A grain infected with *F. graminearum* was hand-broadcast two weeks before anthesis growth stage to encourage the development of FHB and managed with different fungicide treatments to encourage the accumulation of various levels of DON in the wheat grain. Wheat kernels and flour were evaluated to determine the correlation between different levels of DON accumulation and quality parameters. DON levels in the flour ranged from 0.9 to 5.6 ppm. Wheat quality tests showed that a significant correlation was present between DON and many of the wheat quality parameters. A significant negative correlation between test weight and DON levels was also present. DON levels also had significant correlation with several flour quality characteristics. The L* value, which represents flour whiteness, had a significant negative correlation with DON. Gluten index also had a significant negative correlation with high DON indicating reduced protein quality in samples with high DON levels. Significant correlations were also found with alveograph and extensograph parameters including a negative correlation to strength and a positive correlation to extensibility. All of these results show that the level of DON in wheat and flour may affect the quality and end use properties.

Twin screw extrusion of low moisture soy protein meat analog

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Cereal Foods World 55:A75

Soy protein isolate (SPI), defatted soy flour, and wheat flour were mixed and extruded at 38% feed moisture content using a twin-screw extruder to make soy protein meat analog. The effects of SPI percentage (40, 50, and 60%), screw speed (160, 180, and 200 rpm), and barrel temperatures (115.6, 121.1, and 126.7°C) on the physical properties of the extrudate were investigated. The extrudate was dried to 6.1% final moisture content at 70°C. Properties of soy protein extrudate were investigated and compared to chicken breast after deep-fat frying. Data analysis show that fibrous soy protein meat analog with texture attributes similar to chicken breast meat could be made by low moisture twin screw extrusion. The moisture of rehydrated and then fried soy protein extrudate was 68.6 ± 1.1% (wb), and it was 72.3 ± 1.5% (wb) for fried chicken breast. The WB-shear force and tensile strength of rehydrated and fried soy protein extrudate were 2.15 ± 0.19 kg and 0.445 ± 0.038 MPa while they were 1.74 ± 0.20 kg and 0.128 ± 0.03 MPa, respectively, for fried chicken breast. Results show that all extrusion operation parameters including the SPI content, barrel temperature and screw speed had significant effects on the final product properties: as the SPI or screw speed increased, the specific volume, water holding capacity, and W-B shear force of extrudate increased. Increasing barrel temperature also increased product specific volume and water holding capacity.

Removal of the 3-O-substituent from 2, 3-disubstituent increases the enzymatic degradability of alkali-extractable arabinoxylans from corn bran

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Cereal Foods World 55:A75

Alkali-extractable arabinoxylan (AE-AX) from corn bran was recently reported by our group to have a desirable slowly-fermenting property. We hypothesize here that the branch profile and composition of AE-AX determines its enzymic degradability and consequently its potential fermentation property. In this study, AE-AX (Ara/Xyl = 0.51) was isolated and hydrolyzed using β-D-endoxylanase. After hydrolysis and removal of the precipitate, the hydrolyzed soluble polymer (HSP, Ara/Xyl = 0.44) was obtained by ethanol precipitation. HSP showed a single narrow HPSEC peak and could not be hydrolyzed further by increasing enzyme concentration nor by extending the incubation time. Hydrolyzed soluble oligomers (average DP of 5) remained in solution and had a high Ara/Xyl ratio of 0.73 indicating that comparably high arabinose-containing oligomers are released. A majority (67%) of the released arabinose residues were in the monomeric form and the remaining in sugar oligomers. To investigate what structural features impede further hydrolysis of HSP by endoxylanase, α-L-arabinofuranosidase with activity specifically to remove the 3-O-substituent from 2, 3-disubstituted xylopyranosyl residues was used to debranch HSP before a second hydrolysis. Endoxylanase hydrolysis of the debranched product produced a DP 32 precipitated polymer fraction versus DP 58 for HSP demonstrating that the removal of the 3-O-substituent increased HSP enzymatic degradability. The released soluble oligomers had an average DP of 10. Soluble arabinoxylooligosaccharides from this study may be good prebiotic candidates.

Locust bean germ flour as a replacement for gluten in pan bread

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Cereal Foods World 55:A75

The objective of this study was to find and characterize a substitute for gluten in yeast-leavened bread. Locust bean germ flour (LBGF) contains high protein and high dietary fiber without gluten. Pan bread made from LBGF and starch showed good loaf characteristics associated with pan bread. Rheological properties of doughs made with LBGF and starch were measured by the Mixograph and the Mixolab. When doughs were made from LBGF and starch, they showed gluten-like (viscoelastic) properties. Mixograms were similar to those of wheat flour. Mixolab curves show similar rheological characteristics to those of bread wheat flour but slower protein breakdown, delayed starch gelatinization and lower starch gelling final torque. When protein (caroubin) was isolated from LBGF, the protein content of the isolate was a minimum of 80%, similar to that of commercial vital wheat gluten (VWG). Mixograms of LBGF isolate showed gluten-like properties but slower hydration in the beginning of the mixing, weaker dough strength and slower increase strength during mixing. Mixolab-curves of LBGF isolate resembled those of VWG. SE-HPLC analysis showed differences in protein molecular distribution between LBGF isolate and VWG. Differential scanning calorimetry showed a glass transition temperature at 50°C for LBGF at 5.5% m.c. and 60°C for LBGF isolate at 6.6% m.c. When reduced proteins were isolated from LBGF, the protein content was a minimum of 90%, glass transition temperature increased to 110°C at 2.4% m.c. This dough had good extensibility but lower resistance to extension, similar to gliadin behavior. Proteins in LBGF may contribute desirable characteristics to pan bread making and may serve to substitute for gluten in gluten-free, yeast-leavened breads.

Properties of ozonated high-tannin grain sorghum flour and its ethanol production

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Cereal Foods World 55:A76

Kansas is the No.1 sorghum producer and has the No.8 largest ethanol production capacity in the United States. High-tannin grain sorghum is reputed for its resistance to drought, bird, mold, preharvest germination, and has higher yield than low/non-tannin grain sorghum. However, tannin has been considered undesirable because of its protein complexing for the food and feed applications of sorghum even as a feedstock for bio-ethanol production. Ozone is a strong oxidant and capable to degrade macromolecules. The objective of the present research was to study effects of ozonation on physicochemical properties and fermentation performance in ethanol production of whole high-tannin sorghum flour. High-tannin grain sorghum flour was treated with different dosage of ozone. Tannin content in the ozone treated sorghum flour was significantly lower than that of the control ($P \leq 0.05$). Results of the gel permeation chromatography on isolated starches indicated starches in ozone-treated flour had been degraded to certain extent. Rapid visco analyzer data show that the setback viscosity of ozone-treated flour was lower than that of the untreated flour by 43-104 RVU's. The results showed that the ethanol yields from ozone-treated high-tannin sorghums were significantly higher than that from the untreated control flour. The fermentation efficiency of ozone-treated high-tannin grain sorghum was 8–14% higher than that of the untreated sample at the 36th hr of fermentation. At the end of 72 hr fermentation, the efficiencies of ozone-treated sorghum were above 90%, which was 2–5% higher than that of the untreated sample. Therefore, ozonation could be a novel method to improve fermentation performance of high-tannin grain sorghum in ethanol production.

Ways of improving quality of dough during the dough mixing process

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Cereal Foods World 55:A76

Objective: This research focused on improving the quality of dough through improving the technological process, and dough quality parameters while shortening the duration of dough preparation. For this experiment we designed and tested a new spiral mixing unit to use in dough mixing equipment. We tested it in a lab and compared results with those of a widely-known dough-mixing machine in Ukraine – the L4-XTB. Results/discussion: The experiment took place at several sites in Ukraine. We worked using basic techniques and technological parameters, and followed the standard approved technology for mixing dough. The data we obtained using the new mixing unit was recorded in the column "new". We compared the results with those of the old model, which is recorded in the tables as "base". We used three criteria to prove the effectiveness of the new mixing unit: elevating force, acidity and dough volume. The benefits of using the new spiral mixing unit were: lower energy expenditure, increased reliability of the mixing unit actuator, and decreased baking time of final bread product and of dough ripening. The photos obtained during the research show the final baked product as a result of using the new spiral mixing unit. The final baked product was smooth in appearance and had soft pulp with even, thin porosity, glossy light brown crust, and pleasant aroma and taste. Conclusion: Using the new model allows for greater acidity increases compared to the "base"; The new mixing unit allows a time reduction to 86% of that when the "base" mixing unit was used; An obvious increase in dough volume when the new design of the mixing unit is used; The maximum volume was reached within 2.2. hours, which is 10% quicker than when the base mixing unit is used; The best results are achieved 0.5 hours quicker than with the base unit; The new mixing unit produces a dough product with improved final characteristics.

Phytoestrogenic potential of sorghum phenolic extracts

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Cereal Foods World 55:A76

Evidence indicates sorghum may be protective against gastrointestinal cancer; however, the mechanisms are largely unknown. Estrogen is believed to protect against colon cancer by preventing colonocytes from growing out of control. The goal of this study was to evaluate if sorghum phenolic extracts have estrogenic properties. Estrogen dependent human breast cancer cell line (MCF-7) and noncancerous mouse colon epithelial cell line (young adult mouse colonocytes, YAMC) were used to evaluate estrogenic properties of crude extracts of three sorghum varieties (black, red, and white) with different phenolic compositions. Estrogenic compounds should promote MCF-7 but retard YAMC cell growth. Sample concentrations used were from 1-150 µg/mL. Estradiol (E_2, 1 nM) was used as a positive control in all the assays. Crude extracts from both black and white sorghum dose-responsively promoted proliferation of MCF-7 cells, which suggests an estrogenic effect; while red sorghum extract did not. Black and white sorghum extracts significantly increased MCF-7 proliferation at 5 µg/mL and 100 µg/mL, respectively. Black (5 µg/mL) and white (10 µg/mL) sorghum extracts activated the estrogen receptor reporter in MCF-7 cells, which confirmed the increased cell growth observed was estrogenic. Both black and white sorghum extracts inhibited YAMC cell proliferation in a dose-dependent manner. Black and white sorghum extract significantly inhibited YAMC growth at 1 and 5 µg/mL, respectively. The results indicated that black and white sorghum may be estrogenic at physiologically relevant levels. Future research will focus on confirming estrogenic effect of sorghum phenolic extracts through various estrogen receptor assays and identifying specific phytoestrogens in sorghum extracts.

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 55:A76

Michigan has experienced two years (2008 and 2009) of severe Pre-Harvest Sprouting (PHS). α-amylase is an important component of PHS and the falling number test is used by industry to identify sprouted wheat that is unacceptable for various food products. Red wheat is considered, in general, to be more resistant to PHS than white wheat. The objective of this study was to evaluate wheat cultivars adapted to Michigan for the quantity of α-amylase and the corresponding falling numbers at three maturity time-points (before physiological maturity (PM), at PM and post PM) in the absence of PHS inducing conditions. Twenty soft winter wheat genotypes (10 red and 10 white) with varying levels of susceptibility to PHS were planted in two locations (East Lansing and Clarksville, MI) in a three-replication alpha lattice design. Spikes were collected three days before PM, at PM, and three days post PM. Immediately following collection, samples were frozen (–20°C), after which they were freeze-dried and threshed. Threshed samples were milled and evaluated for α-amylase content and Falling Number (FN) values. The data showed clear trends in the reduction of α-amylase and the increase in FN during the progression of maturation. In addition, α-amylase and FN data were significantly correlated. There were significant differences among cultivars for α-amylase levels and falling number at the three time points, most noticeably at 3 days before PM, while α-amylase activity levels converged towards similar values at 3 days post PM. In addition, separate evaluation of the red and white wheats showed significant differences within each wheat class. The identified genetical variability could be a prediction factor for variety selection and subsequent research. It is convincible that the time to induce PHS should be taken at PM and three days post PHS.

Correlation between rheological behavior of corn dough and the quality parameters of tortilla making

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Cereal Foods World 55:A76

The aim of this work was to develop a method to study the rheological behavior of nixtamal corn flour and determinate its relation with the quality parameters of tortilla making. 75 g of dough were subject to a mechanical force (mixing speed = 160 rpm) and a temperature ramp (1st Step 50°C, 1 min; 1st Temperature Gradient 5°C/min; 2nd Step 90°C, 5 min; 2nd Temperature Gradient –5°C/min; 3rd Step 50°C, 1 min) The effect was measured as torque. All the samples were hydrated at 125%. Torque changes were observed along the first eight minutes of the kneading because of the different Water Absorption Capacities (WAC) of each sample. When the dough was heated, a fall of its consistency was observed due to the starch gelatinization. The gelatinization rate and the highest point of torque during the hot phase were compared with the results of the tortilla's characterization (softness, resistance and shelf life). There was no significant correlation between the consistency changes during heating and the quality parameters of the tortilla. Once the ramp reaches its highest temperature the starch gel starts to be cooked. Due to the fact that the starch is pre-gelatinizated during the "nixtamalizacion" process, the retrogradation effect couldn't be measured successfully with this method. The presence of some additives like gums could be identified, improving the WAC and increasing the viscosity along the gelatinization phase. The analysis of the data showed a significant correlation between torque values and WAC, obtaining an R2 value of 0,98; thus the method was proved to be useful on the determination of the WAC of corn flour to reduce significantly the error caused by the analyst during Quality Control of this product.

Starch structure-property relations for digestion of cooked rice

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Cereal Foods World 55:A77

Seven Malaysian rice varieties (amylose content ranging from 0.2 to 27%) were subjected to in-vitro digestion with a multi-step process that mimics digestion in humans. The rice was cooked, ground and digested and digestate collected at various times. The kinetics of starch hydrolysis during the digestion fitted the Michaelis-Menten mechanism. As expected, higher V_{max} values were obtained for two waxy samples compared with the rice samples with higher amylose contents; however, the K_m values did not show any correlation to amylose content. These results are consistent with the assumption that amylose chains tending to leach from the granules during cooking, forming a viscous network that encapsulates the starch granules, making them less accessible to pancreatic alpha-amylase and slowing the enzymic process, resulting in the lower V_{max} values. The time evolutions of the size distributions of the whole and debranched starch in the undigested fractions were obtained using multiple detection size-exclusion chromatography (SEC). The starch was extracted using an improved extraction/dissolution technique for complete starch extraction and dissolution without degradation. This gave the size dependences of the weight distribution, number distribution, weight average molecular weight and radius of gyration. Trimodal chromatograms were observed for all digested samples, which consisted of amylose, amylopectin and intermediate materials (size range 10–20 nm). The three peaks persisted until the end of digestion analysis (6 h), only with decreased amounts over time. This showed that the starch molecules in the cooked rice grains were hydrolyzed in a controlled fashion without much molecular size selection. This may be caused by the large size of entities in the sample, which limited the action of digestion enzymes to the sample surfaces.

Cyanophycin biosynthesis from sorghum-derived sugars and recombinant *Escherichia coli*

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Cereal Foods World 55:A77

Cyanophycin (muti-L-arginyl-poly-L-aspartate) is a non-ribosomally synthesized reserve polypeptide, which consists of equimolar amounts of arginine and aspartic acid arranged as a polyaspartate backbone and arginine as the side chain. Biosynthesis of cyanophycin is catalyzed by cyanophycin synthetase (CphA). Cyanophycin synthesis requires aspartic acid, arginine, ATP, Mg2+, and a primer (low-molecular mass cyanophycin). *Anabaena Variabilis* ATCC 29413 contains the structural gene (cphA) for cyanophycin synthetase, which was cloned and sequenced successfully in this study. The cphA gene was amplified by PCR, ligated to the vector pET45b+ and introduced into E. coli BL21 (DE3) pLysS and E. coli BL21 (DE3). Experiments by design for high cyanophycin synthesis was performed at shake flask level using the recombinant BL21 (DE3)pLysS, LB broth as carbon and nutrient source, and casamino acid as primer. Characterization of cyanophycin was done by SDS-PAGE, and protein differentiation. Molecular weight of cyanophcyin from recombinant BL21 (DE3)pLysS is between 21 kDa to 31 kDa. Protein differentiation results showed that protein with molecular weight of 21 to 31 kDa did not match E. coli protein when compared with E. coli protein data base, thereby confirming cyanophycin biosynthesis. Transmission electron microscopy to depict cyanophycin inclusions in the cytoplasm of IPTG will be discussed in our presentation. Experiments are ongoing using recombinant BL21 (DE3) pLysS and grain sorghum-derived sugars for cyanophycin production at 2 to 5 L fermentor level. Successful outcome of this study will enable a low-cost production method for cyanophycin synthesis from cereal grains-derived sugars, such as from grain sorghum, and the process can be effectively integrated with other operations in a biorefinery.

Effects of octenylsuccinylation on the structure and digestibility of high-amylose maize starch

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The octenyl succinate (OS) starches are widely used as emulsifiers in food, pharmaceutical, and cosmetic industry for more than 30 years. Recently, OS-starch was reported also to have special nutritional value. Structural changes and digestibility have therefore become an interesting area of research for food scientists. In this study, structural changes from high-amylose maize starch (Hylon Ⅴ) to OS-starch were investigated by Fourier transform infrared spectroscopy and differential scanning calorimetry (DSC), and finding was obtained on the distribution of OS groups from confocal laser scanning microscopy (CLSM). Effects of octenylsuccinylation on rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS) of high-amylose maize starch (uncooked and cooked) were determined. DSC data revealed a broad gelatinizition endothermic peak ranged from 72.5°C to 96.4°C for native starch, and a downward trend for products of increasing degree of substitution (DS). The distribution of OS groups in the starch granules was investigated under CLSM imaging with Methylene Blue dye. OS groups appear to be distributed throughout the OS-starch granules, especially in the surface region. Octenylsuccinylation increased SDS and RS levels in cooked starches, while only increased RS level in granular starches. Even though uncooked OS-starch (DS ≈ 0.04) has more than 85% RS content (native high-amylose maize starch is about 70%), its RS content reduces to 7.4% after boiling.

Damaged starch in whole grain flour by Amperometric method: Affecting factors

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Damaged starch content is an important indication of the milling quality and flour functionality. AACCI has multiple standard methods that measures the damaged starch content of flour based on different principles. Among these methods, the Amperometric method is simple and quick, and is suitable for industry to do frequent spot check during milling for quality control purpose. The method, like many other tests for flour, is relatively new when applying to whole grain flour. The non-starch components of whole grain flour (bran, pentosan, etc.) as well as the particle size (which tend to vary in whole grain flour) may affect the accuracy of the test. The objective of this study is to understand the effect of bran and particle size on damaged starch measured by Amperometric method. Pure bran sample was produced by washing off starchy endosperm, and then freeze dried. The pure bran was ground into different particle size. These bran samples with various particle sizes were blended with standard flour samples with known content of damaged starch (2.6%), at different levels (10, 15, and 20%). The combined samples were tested for damaged starch. The results showed that for samples blended with fine particle bran (60%<212 micron), the measured damaged starch content were 2.34, 2.22, and 2.10% respectively for samples contain 10, 15, and 20% bran, comparing to standard value (by calculation) of 2.32, 2.19, and 2.05%, indicated that the quantity of bran do not change the measurement, other than simple dilution. However, for the samples with coarser particle bran (70% >212 micron), the measured value was 7 – 10% lower than the calculated standard value, indicating bran particle size has an impact on the measurement, it underestimates damaged starch content. Therefore, when testing the whole grain flour, the instrument would need specific calibration, using standards made with whole grain flour containing similar size of bran particles.

Effect of temperature cycling on in vitro digestibility of retrograded waxy and normal maize starch gels

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Starch retrogradation is considered to reduce the digestibility of starchy food. It is still controversial as to whether retrograded amylopectin contribute to the resistant starch (RS). In this study, gelatinized waxy and normal maize starch gels of 40% concentration were subjected to 4/30°C temperature cycling to induce extensive amylopectin retrogradation. Gels stored under constant 4°C were used as comparison. Modified Englyst method was carried out directly on the retrograded waxy and normal maize starch gels without reheating. The effect of temperature cycling on the digestibility of retrograded waxy and normal maize starches was evaluated. For both waxy and normal maize starch gels, although high amount of RS could be obtained by temperature cycling according to the original definition given by Englyst, the hydrolysis almost reached to 100% after a longer time of digestion regardless of storage conditions and the type of starch, indicating the RS measured by the Englyst method is not truly resistant to the digestive enzymes. SEM results showed that the use of pancreatic amylase and amyloglucosidase together as the digestive enzymes may lead to extreme hydrolysis of the retrograded starches high in amylopectin. The kinetic constant (k) could more accurately reflect the rate of hydrolysis in the early stage. Both waxy and normal maize starch retrograded under 4/30°C temperature cycles show lower k values than those stored under constant 4°C. The higher thermal stability of the crystallines (showed by DSC) and more densely packed gel network (showed by SEM) formed under 4/30 temperature cycles, which are less accessible to enzyme hydrolysis, may reduce the digestibility of the starch gels than that stored under constant 4°C. It was concluded that temperature cycling is an effective way to reduce the digestibility of starch high in amylopectin and possibly increase the level of RS.

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