Table of Contents

2009 Program Planning Team

Program Chair

Jodi A. Engleson, *Grains for Health Foundation, Minnesota, U.S.A.*

Program Vice-Chair

Christophe Courtin, *Katholieke Universiteit Leuven, Belgium*

Team Members by Scientific Initiative Track

Biotechnology and Sustainability

Chair: Ann E. Blechl, *USDA ARS WRRC, California, U.S.A.*
Vice-Chair: Peter Shewry, *Rothamsted Research, United Kingdom*

Cereal and Polymer Chemistry

Chair: Mirko Bunzel, *University of Minnesota, U.S.A.*
Vice-Chair: Peter Koehler, *Hans-Dieter-Belitz-Institute, Germany*

Engineering and Processing

Chair: Sajid Alavi, *Kansas State University, U.S.A.*
Vice-Chair: Vijay Singh, *University of Illinois at Urbana-Champaign, U.S.A.*

Food Safety and Regulatory

Chair: Jack C. Cappozzo, *National Center for Food Safety & Technology, Illinois, U.S.A.*
Vice-Chair: Lauren Jackson, *U.S. Food and Drug Administration, Illinois, U.S.A.*

Health and Nutrition

Chair: Jan Devries, CSM, *The Netherlands*
Vice-Chair: Bruce Hamaker, *Purdue University, Indiana, U.S.A.*

Ingredients and Cost of Goods Sold

Chair: D'Anne M. Hayman, *Kellogg Company, Michigan, U.S.A.*
Vice-Chair: Greet Vandeputte, *Nestle PTC Orbe, Switzerland*

Quality and Analytical Methods

Chair: Nancy Ames, *Agric & Agri-Food Canada, Winnipeg, Canada*
Vice-Chair: Art Bettge, *USDA ARS WWQL, Washington. U.S.A.*

2009 Annual Meeting
Abstracts of Pre-Meeting Workshops

Abstracts submitted for presentation at the 2009 annual meeting in Baltimore, Maryland, September 13–16. 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.

An Emerging Scholarship of Cross-Cultural Engagement

Fundamentals of Chinese medical theory
C. Hafner
Crocus Hill Oriental Medicine
Cereal Foods World 54:A1

Chinese Medicine is one of several ancient systems of medical care based upon a different world view than the prevailing biomedical model; it employs its own language, systems of logic, and criteria for understanding health and diagnosing illness. The fundamental ideas upon which Chinese medical theory rest do not fit well within a biomedical model, and are often discounted or ignored. Chinese Medicine does not rely upon the chemical composition of food or herbs as a basis for understanding medicinal efficacy, safety or quality. In Chinese dietary and herbal therapies the yin / yang qualities that are inherent in foods and medicinal herbs are identified and classified through the sensory attributes that naturally occur in these substances. Over-attachment to a pharmaceutical approach, combined with under-appreciation for the coherence of CM as a knowledge base for determining appropriate use of food and medicinal herbs threatens the underlying integrity of the CM perspective as a resource in solving today's complex diet-related health issues.

Culture and healing for all people
P. Schultz
White Earth Tribal College, Mahnomen, MN
Cereal Foods World 54:A1

Paul will speak about the importance of us allowing alternative ways of knowing and practicing to integrate the way it was always meant to do in human health care. In his tradition, individualization of care has gone on for thousands of years. When the Indian Health Services came into the reservations to provide medical care, they treated the native people like children and devalued their practices. So the challenge now —"How to impact the clinics and physicians working there to create change?" On White Earth Reservation, change began when the local physician reached out to ask to join Paul in healing. That one gesture has led to new definitions of mutual respect. The indigenious healer is recognized as just as important and effective as the medical doctor. This kind of respectful relationship can be built anywhere, and these inroads to integration can be replicated!

An emerging scholarship of cross-cultural engagement
C. Hassel
University of Minnesota
Cereal Foods World 54:A1

Every human society has developed its own ways of knowing food and health relationships as matters of survival and sustainability. Yet training in food and nutrition sciences can lead members to hold so tightly to western/scientific models for producing knowledge that little room seems available for open-minded consideration of the epistemologies found in culturally diverse communities. The assumptions and presuppositions underlying our scientific methods are ideas we tend to think with, not about. As a result, we tend to impose such ideas as universal truths, without learning the skills of how to navigate the deeper dimensions of cultural difference. An emerging scholarship asks professional scientists to develop skills in "cross-cultural engagement" (CCE) as a prerequisite to work with culturally diverse communities. CCE prepares scientists to respectfully access foreign ways of producing knowledge of food and health that lie outside the orthodoxy of their professional training. This practice allows for knowledge otherwise incomprehensible to become more empathetically understood; it allows the presuppositions and paradigms of scientific disciplines becomes more visible; it can lead to broader and more appropriate forms of scientific inquiry.

Cellulosic Ethanol: Critical Constraints to Success

Cellulosic ethanol issues overview
R. Madl
Bioprocessing & Industrial Value Added Program/KSU Center for Sustainable Energy, Manhattan, KS
Cereal Foods World 54:A1

Commercial ethanol production is based on biochemical conversion of sugar or starch. To achieve higher production capacities, technology must economically convert lignocellulosic feedstock to advanced biofuels. There are several critical issues which must be solved before this is accomplished. Logistics and transportation has been under recognized as a major constraint. The low density cellulosic materials must be harvested and transported to the conversion facility consistently throughout the year. The pretreatment and enzymatic conversion of biomass to sugars has been an expensive and

constraining step in the process. New advances in enzyme technology will be described in the workshop. The biorefinery concept is important because it utilizes all process streams to produce multiple products. One approach will be described. An alternative to biochemical conversion that has received increasing attention is the thermochemical platform. It solves some of the initial deconstruction constraints, but creates new issues for separation of multiple products. Can it contribute to ethanol production? Finally, the regulatory standards are a key driver for all biofuels. New complications, such as calculations for reductions in greenhouse gas emissions and changes in land use will be discussed to wrap up the workshop.

Feedstock logistics
R. Hegg
USDA-CSREES, Washington, DC
Cereal Foods World 54:A2

Achieving the cellulosic biofuel targets set forth in the Energy Independence and Security Act (EISA) of 2007 will require a very large increase of cellulosic biomass feedstocks from agricultural, forest, and other resources. By 2022, it is estimated that 180 million dry tons of biomass will be needed annually to produce the 16 billion gallons of cellulosic biofuels called for by EISA. Supplying this volume of material will require developing an industry comparable to current agricultural supply chains for commodity crops and hay. Machines and systems capable of performing each biomass supply chain operation (harvest and collection, storage, preprocessing, and transportation) are not designed with the scale and efficiency required in the biofuel industry. Logistics issues are those that affect the assembly of a biomass supply system and impact its ability to deliver needed quantities of biomass in a cost-effective and sustainable manner. Technology issues are those that must be addressed in the design of new machines and systems in order to develop and sustain biomass feedstock supply chains. The three major categories of biomass feedstock resources: agricultural resources, forest resources, and other resources, including municipal solid wastes, livestock manure, and algae.

Breakthroughs in the conversion and integration of biomass technologies
C. Veit
Novozymes NA Inc., Franklinton, NC
Cereal Foods World 54:A2

Novozymes has focused its Biomass (lignocellulose to ethanol) R&D and business efforts on developing new enzymes that enable cost effective hydrolysis of lignocellulose to simple sugars. Work to date includes the introduction of new enzymes characterized by higher specific activities, increased expression levels, and lower overall production costs. Building upon these past efforts and a belief that the conversion of Biomass to Biofuels is almost upon us, Biomass has become the single largest R&D effort in Novozymes' history. Novozymes continues this unprecedented effort to develop the products and continue to lower the costs to hydrolyze cellulose to simple sugars. Novozymes also realizes that a market enabling process will require the integration of technologies both upstream and downstream of enzymatic hydrolysis. This integration of pretreatment, hydrolysis, and fermentation technologies is an absolute must for any commercially viable process to emerge. There is no single company which holds the key to all parts of the value chain and therefore, technological and business driven alliances and partnerships have emerged that will allow for the needed breakthroughs to occur. Alliances between private and public companies, universities and academia often facilitated by governmental support are paving the way for needed breakthroughs in these key technologies. This presentation will provide an update of current biomass developmental and commercial efforts within Novozymes with news on product and process developmental efforts. It will also outline the approach Novozymes is taking towards overall process integration; an approach driven by the collaborations Novozymes has established with Biofuel industry leaders.

Improvements in enzymes for cellulosic ethanol
M. Li
Genencor, a Danisco Division, Palo Alto, CA
Cereal Foods World 54:A2

Utilization of lignocellulosic materials as a renewable carbon source for biofuels and chemicals depends on the advances in pretreatment, enzyme production, enzyme hydrolysis, as well as conversion of those sugars to usable fuels and chemicals. This presentation will provide an overview of Genencor's recent efforts on biomass enzymes including whole cellulases, xylanases, as well as beta-glucosidase. The enzyme complex, including Accellerase® 1500, Accellerase® XY, Accellerase® XC, and Accellerase® BG, can be used from laboratory evaluation to pilot plant/demonstration design that is representative of what process developers will see at full scale. The synergistic effect of enzyme systems on the lignocellulosic biomass hydrolysis and fermentation will be discussed. It will also present Genencor's view of how the market is developing, and the ongoing challenges being addressed as this emerging industry progresses toward commercialization.

An integrated approach to biorefining
P. Vadlani
Bioprocessing & Industrial Value Added Program, Kansas State University, Manhattan, KS
Cereal Foods World 54:A2

Production of biofuels from cereal grains and renewable biomass is important to attain self sufficiency in transportation fuel needs of the nation. Considerable research and development efforts are underway to attain biofuels production targets specified by federal mandates. While the efficiencies and economics are mainly related to logistics and production methods used for biofuels, it is imperative to integrate processes that will consider all the constituents of the feedstocks and the byproduct streams for production of high value products. This integrated approach to biorefining will provide additional revenue streams and also alleviates environmental problems associated with the disposal of byproduct and waste streams. In this presentation, the biorefinery concept will be discussed, particularly pertaining to the utilization of non-starch components in cereal grains, and protein and lignin residues from cellulosic ethanol process. Bioconversion of pentose sugar stream to other platform chemicals, such as succinic acid and 2,3 butanediol will also be discussed.

The thermochemical platform
P. Grabowski
US-Department of Energy, Washington, DC
Cereal Foods World 54:A2

Most of the biofuel discussion has been focused on the biochemical platform which has major constraints with the pretreatment step and efficient conversion of pentose sugars and lignin. These issues are overcome with the thermochemical platform which converts biomass to a range of organic compounds, some gases, and char in less than 10 seconds at 500-700 degrees F in "fast pyrolysis" reactions. At higher temperatures, termed "gasification", biomass is converted to mostly hydrogen, carbon monoxide and methane under proper reaction conditions. Research on the former process is focused on finding optimum conversion temperatures, subsequent separation techniques, and catalysts for conversion to biofuels, other high value chemicals and solvents. In the latter process, focus is on minimization of carbon dioxide formation and catalysts to convert the gases to target biofuels. The biochemical platform constraints have been exchanged for technical issues with separation technologies and catalytic chemistry.

Renewable fuels 2009 and beyond – The Federal horizon
P. Argyropoulos
US EPA Office of Transportation and Air Quality, Washington, DC
Cereal Foods World 54:A2

The Energy Independence and Security Act (EISA) of 2007 significantly revised the National Renewable Fuels Standard Program (RFS2). Several key changes were included in EISA. The Act significantly increased the total volume of renewable fuel required for use in the transportation sector. The Act also established specific standards for the type and specific volumes of certain types of renewable fuels including conventional, advanced, biomass based diesel and cellulosic. Further, EISA applied specific restrictions on the land feedstocks can come from and applied specific definitional requirements for feedstock type and use. Another key provision and of significant interest and controversy is requirement that renewable fuels meet minimum greenhouse gas reduction standards as compared to the petroleum based fuels they are replacing. These revisions seta challenging and aggressive path forward in the US, but also provided the opportunity for a more certain path forward for the introduction and use of advanced and cellulosic based renewable fuels. This presentation will provide deeper insight into EPA's proposed rule and what else may be on the horizon at the federal level for renewable fuels in the coming years.

2009 Annual Meeting
Abstracts of Symposia Presentations

Abstracts submitted for presentation at the 2009 annual meeting in Baltimore, Maryland, September 13–16. The abstracts are listed in alphabetical order by title of symposium and time order of presentation within each symposium. Abstracts are published as submitted. They were formatted but not edited at the AACC International headquarters office.

Advances in Delivery of Food Nutrients - Tailoring Process Operations for Health and Wellness

Health impact of nanotechnology in food ingredients and processing – applications and implications
H. Chen
USDA/CSREES, Washington, DC
Cereal Foods World 54:A3

Recent advances in nanoscale science, engineering and nanotechnology have revealed great potential for designing and testing novel vehicles for better delivery of bioactives and drugs. New delivery systems aim at improving and expanding functionality including higher bioavailability, controlled releases on triggers, easier processing and integration into food matrixes, more acceptable sensory attributes, and better stability under environmental challenges. New food materials have been investigated for delivery applications. New functionalities such as targeted delivery, integrating sensing capabilities, and nanoscale tagging for product identify preservation and traceability are under exploration. This presentation intends to give a brief overview of relevant new research and development concepts and activities in using nanotechnology for better delivery of nutraceuticals for enhancing individual health management. Challenges in developing and marketing nanotechnology enhanced nutraceutical delivery and functional foods, including safety considerations, will be also highlighted.

High incorporation of cereal bran fibers into foods
B. R. HAMAKER, D. Pai, O. H. Campanella
Whistler Center for Carbohydrate Research and Department of Food Science, Purdue University, West Lafayette, IN, USA
Cereal Foods World 54:A3

Cereal bran fibers show good potential for high incorporation into processed foods (e.g., extruded foods), but first must be modified to improve functionality. Additionally, these fibers show good fermentation profiles for colon health. In general, it is necessary to facilitate interaction of insoluble fibers with the amorphous phase (e.g. starch) in processes such as extrusion that favors expansion. The potential functionality of corn bran arabinoxylans was examined. Relationship between the extrudate properties and the rheology of composite formed by corn mean and different fractions of corn bran were established. Alkali-soluble corn arabinoxylan, as well as alkali-treated bran, provide different shear and extensional-based rheologies and have different behaviors during the extrusion operation. Results show that it is possible to incorporate arabinoxylans at levels up to 30% in extrudates with little effect on quality parameters.

Phytonutrients and challenges of delivery
S. Lamikanra
Frito-Lay R&D, Plano, TX
Cereal Foods World 54:A3

Phytonutients are widely believed to be key compounds responsible for the health promoting properties of some plants. While there are several reports suggesting association of these compounds with specific benefits, direct evidence of their roles when consumed from food sources appear to be limited. In this presentation, a comparison will be made between functional benefits commonly associated with Phytonutrients, particularly Flavonoids, and results from studies that have determined their specific effects from food on human health. Some research needs that could help bridge gaps between perceived and authenticated benefits will also be discussed.

Novel thermal processing based on microwave and radio frequency energy for packaged foods
J. Tang
Washington State University, Pullman, WA
Cereal Foods World 54:A3

Thermal processing is a preservation method commonly used to control food pathogens and spoilage microorganism in production of refrigerated or shelf-stable foods. In conventional thermal processing, slow heat transfer to and within prepackaged solid or semi-solid foods lead to long process times and often severe thermal degradation. Volumetric heating techniques using microwave and radio frequency energy offers possibilities for developing novel thermal processes. In microwave and radio frequency heating, direct interaction between electromagnetic energy and foods that are hermetically sealed in microwave transparent pouches or trays significantly reduces the time needed for products to reach the desired temperatures to control the targeted bacteria, and can potentially improve texture, appearance, and nutritional values. This talk will provide a brief overview on status of microwave and radio frequency technology research and developments for packaged foods, and shows examples of improved quality for several ready-to-eat foods, including pastas.

Impact of processing on functional ingredients
K. L. McCarthy
University of California, Davis, Davis, CA
Cereal Foods World 54:A3

With the growing awareness of the beneficial effects of a healthy diet on the quality of life as well as on cost-effectiveness of health care, the food industry is facing the challenge of developing new products with special health

enhancing characteristics. To meet this challenge, research in my laboratory has addressed the use of an existing processing technology, e.g., extrusion, to boost the nutritional and functional characteristics of snack-type products. In particular, barley and fruit pomace products were evaluated for their potential to add fiber, antioxidants and B-vitamins to the diet. Fiber content was successfully increased using barley, as compared to other grains. The addition of fruit pomace (e.g., tomato, grape, pomegranate) increased the antioxidant activity and phenolic content of feed material. However, both antioxidant activity and phenolic content of the extrudate were significantly decreased due to the heat and shear treatment. This work has led to the investigation of ways to incorporate components into the food matrix that can withstand processing and be released at the appropriate point during digestion.

Challenges to utilizing physically or chemically structured lipids in baked product systems
K. Seetharaman
Department of Food Science, University of Guelph, Guelph, ON, Canada
Cereal Foods World 54:A4

Solid shortenings are a preferred mode of lipid addition in baked product systems for a number of reasons, many of which relate to improvements in sensory, textural and/or shelf life of products. However, traditional structuring of oils to semi-solid plastic pastes results in either increased saturated fats or increased trans-fat levels, both of which have adverse impact on the cardiovascular and metabolic health of consumers. Much focus has been targeted to developing alternative processing or formulation strategies to structure semi-solid plastic lipids, devoid of saturated or trans fats. One such alternative shortening is the novel monoglyceride gel (MAG) that encapsulates high volume fractions of oil in a water matrix. Positive health benefits have been reported that are associated with the structure of MAG gels; however, fundamental questions remain in terms of its use and functionality in baked products, including; does the structure interact differently with the dough matrix compared to the individual structural components during processing; how does the water in the structural matrix influence dough processing and baking; does the structure of the MAG gel confer additional health benefits beyond any benefits derived from the reduced lipid content? Answers to these and other questions are critical to realizing the potential of using structured and self-assembled alternative shortenings in the marketplace to provide consumers with baked products that address nutrition, diet and healthy lifestyle needs.

Biofuel from Maize: Current Economics and Future Sustainability

Biotechnology and its potential impacts on corn ethanol
N. Kalaitzandonakes
University of Missouri-Columbia
Cereal Foods World 54:A4

Biotechnology offers the potential to increase yields and lower input use in the production of feedstocks as well as aid in the conversion of corn to ethanol. These could have meaningful impacts on the energy balance and greenhouse gas emissions of ethanol production as well as on its economics. The realization of such benefits, however, is conditioned by prevailing market and policy conditions. The potential economic and energy balance impacts of the biotechnology pipeline will be discussed. The ways various policies, most notably the Renewable Fuel Standard, condition the potential impacts of biotechnologies will also be discussed.

Genomics-assisted improvement of biomass production among Andropogoneae fuelstock grasses
S. Moose
University of Illinois at Urbana-Champaign, Urbana, IL
Cereal Foods World 54:A4

Among the wide variety of plant species proposed as potential biofuel feedstocks, four closely related grass species within the Andropogoneae tribe emerge as leading candidates because of their superior efficiencies in photosynthesis, nitrogen economy, and water use. Maize (*Zea mays* L.), sugarcane (*Saccharum* spp.), and Sorghum are established and highly productive biomass crops that collectively are cultivated across the global spectrum of agricultural production environments. Miscanthus also shows promise as a leading feedstock crop, based on its exceptional biomass yields with minimal production inputs in recent European and U.S. field trials. Each of these grasses also offers complementary advantages in their forms of harvestable carbon, growth cycle and adaptation to diverse climates. A comparative genomics approach to understanding genes that condition phenotypic differences among the closely related Andropogoneae genomes is likely to reveal strategies for improving biomass yield and quality in these species. This presentation will present plans and progress to improving biomass production towards this goal, with an emphasis on genetic control of biomass and N utilization in maize and the development of functional genomics resources for Miscanthus.

Review of biotechnology as a tool for starch modification and novel starch applications
S. Patil
S.K. Patil & Associates
Cereal Foods World 54:A4

Starch is a primary feedstock for ethanol and other products in biofuels, food and feed industry; 2nd only to cellulose as a carbohydrate feedstock and the carbohydrate economies. Biotechnologies as tool via discovery of genetic control and biosynthetic pathways of starch synthesizing enzymes have enhanced our knowledge of how we can create novel starches and the derivatives for multitude of food and industrial applications. Improvement in the extraction of starch from corn kernel and the efficiency of processing this into food and fuel area that has been overlooked by the industry. Great possibilities also exist in providing additional functional benefits to food, feed and industrial processing. Starch modification via biotechnology is poised to make major functional improvements above and beyond available today by chemical modifications for food & industrial applications. Chemical modifications are costly; replacing this via biotechnology can create sustainable solutions to satisfy growing global needs in the areas described. Over all the market needs must drive the development efforts. Food markets are highly fragmented and starches and their derivatives, modified and unmodified have very diverse applications in many food segments. Starch and their various derivatives are utilized in 100's of processed foods and non food products. Modifications that can be achieved through transgenic means by which genes for new enzymes are introduced into corn from other plants or novel mutations for enhanced carbohydrates will be presented. The pace of technological change seems to continually accelerate and the opportunities for novel starches and the derivatives remain attractive going forward. This presentation will provide insights into current developments and provide examples of what may lie ahead to capture new opportunities with novel functionalities in food, industrial fuel and feed markets.

Life Cycle Assessment as a tool for industry to optimise the environmental performance of biofuel
T. Forman
Novozymes North America Inc., Franklinton, NC
Cereal Foods World 54:A4

Sustainability focused industries have traditionally used Life Cycle Assessment to support the decision-making related to the development of new processes and products – as a tool to choose the environmentally most favourable among more alternatives processes or products. With the general increase in environmental awareness the use of LCA is expanding. Today LCA is on top of the agenda of policy-makers as a means to ensure a sustainable development of society. The life cycle concept is crucial to both types of considerations, however the goal and the scope and thus the modelling and data requirements are very different and there is a need to distinguish clearly between these alternative uses of LCA. Biofuel provides a very good example to illustrate this point. LCA is currently considered the basic methodology for establishing a regulatory framework that will ensure a sustainable use of biofuel by society. However, LCA is also used by the biofuel industry and the agricultural sector to further decrease the environmental footprint of producing biofuel. The presentation will address this need of industry for a generally acceptable and operational LCA framework, which supports the efforts to improve the environmental performance of biofuel technology, short term as well as long term. More specifically the presentation will present the views of a provider of biotechnology – and thus bring the production of biofuel into the broader perspective of the biobased society.

Ethanol: Industry, policy and environmental impact
J. Caupert
National Corn-to-Ethanol Research Center, Edwardsville, IL
Cereal Foods World 54:A4

The revitalization of the ethanol industry, in the early part of this decade, is the result of the dedication of this nations farmers and their desire to develop a value added market for corn. The corn (starch) based ethanol industry remains

strong, despite recent media sound-bites. Today, there are more than 160 dry grind ethanol plants in the United States with total production capacity in excess of 10 billion gallons. The ethanol industries impact on the United States is demonstrated by the following: • The ethanol industry is a biofuel that our Nation's farmers are growing here at home in the United States. • The ethanol industry enhances rural development and job creation. • The ethanol industry lessens the carbon emissions of our automobiles. • The ethanol industry contributes directly to our National security by reducing our dependence on imported foreign oil. When thinking of environmental impact, water utilization and usage, is at the forefront of everyone's mind. The ethanol industry "uses" significantly less water than one might expect. In fact, it requires less water to produce one gallon of ethanol than it takes to produce any of the following: • One gallon of gasoline; • One pound of plastic; • One average size Sunday newspaper.

Examining the product stream and costs of corn fractionation systems
C. Hart
Iowa State University, Ames, IA
Cereal Foods World 54:A5

As the ethanol industry continues to work through tight economic margins, companies are searching for processes to either reduce costs and/or increase revenues. One process that offers potential is corn fractionation. Fractionation is not a new process. Wet millers have been fractionating corn for decades, as have dry millers for corn meal and flour. But dry mill fractionation is power intensive and works best at a fairly large scale, above that needed for most ethanol plants. However, fractionation offers several potential benefits to ethanol plants, so several companies have devised fractionation processes specifically targeted for ethanol plants. At one time, Ethanol Producer magazine reported roughly 50 patents on processes to fractionate corn. Ethanol companies are sorting through these processes to find approaches that are cost effective and provide ethanol and co-product benefits. Fractionation can benefit ethanol production because it increases the relative starch content of the mash, it can reduce the work load for the enzymes, it reduces the amount of oil that moves through the ethanol process, and it can reduce the drying requirement for the distillers grains. Fractionation also opens up new product areas. Higher grade corn oil can be captured. The fiber could be used in a variety of ways, including new products for human or animal use or as an energy source. This presentation will outline several corn fractionation processes being installed across the ethanol industry. The outline will cover the product streams that each process offers, the potential markets for those products, and the costs associated with each process. From the outline, an examination of the various product streams possible from the fractionation processes will be presented, along with an exploration of the potential for additional revenue streams to the ethanol plants that add fractionation technology.

Cereal Grain Components: Analysis and Bioavailability

Fiber and/or phenolics: Preventive compounds in cereal grains?
L. R. Ferguson
The University of Auckland, Auckland, New Zealand
Cereal Foods World 54:A5

An inverse association between high cereal intake and low cancer incidence has been found in many epidemiologic studies. The cancers most associated with these effects are breast, colorectal and gastric cancers, but not prostate or lung cancers. There has been an assumption that this protection is associated with the non-cellulosic polysaccharides present in cereals, i.e. arabinoxylans, (1→3), (1→4)-beta-glucans, pectins and arabinogalactans. However, purified preparations of these polysaccharides have not generally shown cancer protection effects in animal studies, although there are some data showing effects on immune response. In the gastrointestinal tract, digestion and fermentation of dietary fibres lead to the generation of short chain fatty acids, among which butyrate has been shown to have cancer preventive properties. However, it seems likely that it may be the phenolic components of the cereals, rather than the polysaccharides, that are the most beneficial. Recent discussions on the definition of dietary fibre may confuse the picture still further. A range of human, animal and in vitro data will be reviewed, in order to address the question as to which really are the protective cancer preventive compounds in cereal grains.

Challenges in the analysis of bioactive compounds in grains
E. M. ABDEL-AAL, J. C. Young
Agriculture and Agri-Food Canada, Guelph Food Research Centre, Guelph, Ontario, Canada
Cereal Foods World 54:A5

Bioactive components found in grains play significant roles in human health. Such components are essential for human well-being and a productive and healthy lifestyle. They impart their physiological properties as antioxidants, pro-vitamins, anticancer, anti-inflammatory, co-enzymes, hormone-like substances, etc. Grains have been found to contain a variety of bioactive compounds that their size and chemistries vary from small phenolic acids through intermediate anthocyanins, phytosterols, tocols, alkyresorcinols and carotenoids to very large dietary fiber and beta-glucan. The large number and diversity of these compounds require collaborative efforts from industry, governments and academia to establish internationally-harmonized standard analytical protocols that provide accurate, precise and reliable methods for extraction, separation, quantification and identification of these compounds. Such protocols are required by regulatory agencies to monitor the quality of products, i.e. to protect consumers from adulteration and fraud. The protocols are also needed in R & D to develop new grains that are rich in bioactive compounds, to investigate effects of processing on bioactive components and to accurately determine bioactive compounds in biological fluids in order to understand their bioavailability and functionality in human health. Challenges that face the development of such protocols include chemical and structural complexity of bioactive compounds, lack of efficient extraction procedures, lack of authentic and pure standards, and lack of collaborative lab studies that lead to development of validated methods. This presentation will address these challenges with a particular interest to the analyses of carotenoids and anthocyanins.

In-vitro tests for antioxidant activity: Effective tools to evaluate health benefits of cereal grains?
V. Fogliano
Universita degli Studi di Napoli Federico II, PORTICI-NAPOLI, Italy
Cereal Foods World 54:A5

The determination of total antioxidant capacity (TAC) has gained much interest as a tool to explore the role of antioxidant-rich products in preventing degenerative diseases and for selecting cereal varieties with potential health benefits. However, the TAC determination of cereals is complicated due to wide ranges in polarity of extraction solvents, and covalently bound antioxidants in cell walls. Despite the use of different extraction procedures, the TAC of cereals/cereal products may be underestimated due to difficulties in rendering bound phenolic compounds soluble prior to measurement. This raises several basic questions: What are the most appropriate chemical mechanisms (e.g. hydrogen atom transfer, electron transfer, etc) for measurement of antioxidant activity? What is the physiological relevance (e.g. LDL oxidation, ferric reducing capacity, etc) of the functions measured? What are the sensitivity, reproducibility, laboriousness and costs of the method? The direct procedure is a new approach for measurement of TAC of foods. Extraction and hydrolysis are not required prior to measurement of antioxidant capacity. The working hypothesis is to place in direct contact the solid food and the radical reagent solution while skipping all extraction steps. The soluble moiety of the sample exerts its antioxidant capacity by quenching radicals present in the solvent according to the usual liquid-liquid type reaction. At the same time the insoluble part exert its antioxidant capacity by means of the surface reaction occurring at solid-liquid interface, where the solid phase is represented by antioxidant groups bound to the insoluble polysaccharide fraction and the liquid phase is represented by free radicals present in the solvent. Data obtained with the direct procedure are directly related to the antioxidant action in food or in the human gastrointestinal tract.

Bioavailability and metabolism of ferulates and other grain phenolics
Z. Zhao, M. H. MOGHADASIAN
Department of Human Nutritional Sciences and the Canadian Centre for Agri-food Research in Health and Medicine, St. Boniface Hospital Research Centre and the University of Manitoba, Winnipeg, MB, Canada
Cereal Foods World 54:A5

Ferulic acid and other phenolic compounds commonly found in grains may offer benefits against chronic diseases such as diabetes, cancer, and cardiovascular disease. The impact of grain phenolics on health depends on their absorption, metabolism and bioavailability. Factors such as chemical structure, dietary dose (intake) and/or source determine the metabolic fate and bioavailability of phenolic compounds. Limited studies suggest that the relative bioavailability of free phenolic acids may be increased in the order of caffeic acid < ferulic acid < p-coumaric acid. Experimental and

clinical evidence suggests that free phenolic acids in low doses are quickly absorbed in the stomach and foregut, while most of bound pnenolics reach the hindgut, where free phenolics are released for absorption and metabolism. Some phenolics are degraded into smaller molecules like m-hydroxyphenylpropionic acid by gut microflora before absorption. Absorbed phenolics are conjugated mainly by the liver with glucuronic acid, sulfate, and/or glycine. Phenolics which are highly bound with insoluble fibers -like heteroxylans in maize- are hardly digested and thus excreted intact through feces. In this session, recent studies establishing the bioavailability and metabolism of grain phenolics will be discussed. Future studies will determine the impact of dietary source and the form of phenolics on improving human health.

Enzymatic liberation of ferulate derivatives in the human GI-tract
C. B. Faulds
Centro de Investigaciones Biológicas (CIB), Consejo Superior de Investigaciones Científicas (CSIC), E-28040 Madrid, Spain
Cereal Foods World 54:A6

The in vivo physiological importance of ferulic acid has been determined from studies on its availability for absorption. However, ferulic acid does not enter enterohepatic circulation and oral or intravenous ferulate does not easily reach the colon. Ferulic and diferulic acids esterified to cereal-derived arabinoxylans must therefore be cleaved by esterases located possibly on the brush border membrane of epithelial cells or by the indigenous colonic microbiota and released as free acids where they can then be absorbed into the circulatory system and exert putative health-beneficial effects. Most of the ferulate and diferulates enter the colon still esterified to the polysaccharide matrix, with approximately 95% of the total release of feruloyl groups taking place during fermentation. Arabinoxylan and large feruloylated oligosaccharides do not appear to be absorbed, and so must be broken down by inducible enzymes. The specificity of gut esterases as well as differences in uptake across the epithelial membrane influences the bioeffectiveness of phenolic acids. Diferulates are also released from cereals in the colon, but at a slower rate and release is structure specific. Both epithelial and microbial feruloyl esterase activity can be cytoplasmic or internally membrane-associated, and a feruloyl esterase has recently been purified from Lactobacillus acidophilus. Enzymatic pretreatments can increase the amount of phenolic acids released by faecal bacteria. The actual amount of ferulic acid released by the gut microorganisms, however, is below the threshold required to exert a chemopreventative effect. Methods to improve the delivery of dietary ferulates and subsequent location of cleavage will be discussed.

Conversion of grain phenolics by human intestinal microbiota
A. Braune
Department of Gastrointestinal Microbiology, German Institute of Human Nutrition Potsdam-Rehbruecke, Arthur-Scheunert-Allee 114-116, D-14558 Nuthetal, Germany
Cereal Foods World 54:A6

The consumption of whole grains and whole-grain products has been implicated in the prevention of cancer and other chronic diseases. Beside dietary fiber, protection could also be attributed to phenolic compounds contained in grains. Major grain phenolics include benzoic acids, cinnamic acids, flavonoids, and lignans. Most of the phenolic compounds in the grains are present in the bound form and may reach the colon. Human gut bacteria catalyze not only de-esterification and deconjugation but also further conversion of phenolics. The bacterial metabolites formed may have biological activities that differ from those of the original compounds. Thus, intestinal bacteria may play a key role in activation and inactivation of phenolic compounds. We therefore strive to evaluate the impact of human gut microbiota on the bioavailability of dietary polyphenols, which includes the identification of microbial metabolites, elucidation of the degradation pathways, and isolation of involved bacterial species. Based on the in vitro studies, we test the activity of identified bacteria in vivo using gnotobiotic animal models. To assess the importance of active bacterial species in human subjects, their prevalence is determined in fecal samples. Our studies have been mainly focused on flavonoids and lignans. Recently, we investigated the ability of human intestinal microbiota to cleave dehydrodiferulic acids (DFA). DFA form cross-links between cell wall polysaccharides and are abundant components of cereal insoluble dietary fiber ingested by humans. The cleavage of DFA by intestinal microbiota, which depended on their coupling type, may affect not only the bioavailability of free DFA but also the degradability of DFA-coupled fiber in the gut by host and microbial enzymes.

Characterizing the Size and Molecular Weight Distributions of Starch

Starch: Problems, solvents and mysterious molecular masses
S. Hill
University of Nottingham, Loughborough, UK
Cereal Foods World 54:A6

While our understanding of the fine structure of starches and an appreciation of the architecture of the starch granules continues to develop, due to better technologies in the areas of genetics, microscopies and spectroscopies, we seem to have made poor progress in agreeing the molecular weights for amylose and amylopectin. It may be a misdirected use of effort to try and consider the size of materials by solution techniques when clearly starches will normally exert their influence as complex aggregates of material. However, while we continue to think it is reasonable to put a value on the molecular mass for amylopectin and amylose we should at least be able to justify this quantity. Therefore, like any other assessment, measurement of starch molecular weights should be validated. With no standard methods for starch dissolution, separation, detection or data handling it is not surprising that there is no consensus on the size of these important macromolecules. With no suitable standards or reference samples, it is hard to even know if reporting of comparative molecular weights of starches is valid. For example, does processing a sample reduce its molecular weight one hundred fold, or does it change its solubility and this then impacts on a perceived change in molecular weight? Solutions for this problem, like the formation of a starch solution, may be difficult, but we must at least start to define acceptable procedures and hence the new IUPAC working group. One area that needs agreement is the dissolution of the samples and retaining the material in solution throughout the assessment.

Current dilemmas and paths forward: The needs in food science
M. J. Gidley
University of Queensland, Brisbane, Australia
Cereal Foods World 54:A6

Much progress has been made in relating quantifiable structural features of starch, such as amylose content and, amylopectin branch length distributions, with properties such as aggregation, crystallisation and amylase sensitivity. These physical properties underlie important end-use application properties, such as stability, texture, and digestibility/ biodegradability. Because amylose content and amylopectin branch length distributions can be determined routinely, the genes/enzymes responsible for variation in these structural features have also been well characterised. In contrast, there is little knowledge of the biosynthesis factors responsible for determining starch polymer size, and limited understanding of how molecular size (distribution) affects end-use properties. This is due largely to the lack of standardized reproducible methods for quantifying molecular size. This presentation will highlight the scientific opportunities that would be made available if starch molecular size distributions could be measured routinely.

Field-flow fractionation as a means to find true molecular weights and sizes of undegraded starch
P. COLONNA, A. Sabate
INRA, Nantes, France
Cereal Foods World 54:A6

Starch consists of a mixture of two alpha-glucans built mainly upon alpha-(1,4) linkages: amylose an essentially linear polymer, and amylopectin a branched polymer by the presence of 5-6% alpha-(1,6) linkages. Functional properties of starches are determined by their macromolecular characteristics and the conformation in solution of both constitutive polymers. The need to investigate the biological variability is reinforced by the recent opportunity to create easily new genotypes using results from genomic studies. To characterize starch polysaccharides, the method usually used is high-performance size-exclusion chromatography (HPSEC) combined with multi-angle laser light scattering (MALLS). The limitation of HPSEC columns is their low exclusion limit regarding amylopectin size. Further technical improvements are necessary to gain fractionation systems effective on the entire distribution of amylopectin to achieve its complete structural characterization. The present work analysed the structural properties of starches with different amylose content and from different cereal sources using a combination of AFFFF (Asymmetrical Flow FFF) and HPSEC with MALLS, on-line quasi- elastic light scattering (QELS) -which provides the RH distributions- and DRI (differential refractometric index) techniques. The

procedure, involving a dimethylsulfoxide (DMSO) pretreatment and then a solubilisation in water, provides a representative injected sample without alteration of the degree of polymerisation. Amylopectin Mw and RG were around respectively 1.05-3.78 × 1E8 and 163-255 nm. HPSEC and AFFFF data are matchable but AFFFF allows a better separation of amylopectins and thus an enhanced structural characterisation of starches. One advantage of this experimental approach is to get both distributions as function of molar masses and hydrodynamic radii as well.

Chemistry and Structure of Non-Wheat Proteins

Comparative properties of cereal seed proteins
P. Shewry
Rothamsted Research, Herts, United Kingdom
Cereal Foods World 54:A7

Cereals are the most important crops in the world in terms of yield and total area, being used for food, feed and industrial raw material. The grain proteins are particularly important in determining the end use quality, particularly for nutrition of humans and livestock and for food processing. The major protein fractions in all cereals except oats and rice are prolamin storage proteins, which can be classified into two families. The major prolamins of the Triticeae (wheat, barley and rye) and minor prolamins of maize and related cereals form part of a large protein "superfamily" which also includes a number of other protein groups, notably puroindolines, amylase inhibitors, lipid transfer proteins and 2S albumin storage proteins. In contrast, the major prolamins of maize, sorghum and related species appear to form a discrete protein family with no known relatives. Prolamins are only minor components in oats and rice but also belong to the prolamin superfamily. I will therefore discuss our current knowledge of the molecular and genetic relationships of cereal grain prolamins in relation to the phylogenetic relationships of the species and to the utilisation of the grain.

Novel methods for seaparation and characterization of proteins from non-wheat cereals
M. Tilley
USDA-ARS, Manhattan, KS
Cereal Foods World 54:A7

Although once only regarded as useful in traditional foods, so-called "ancient grains" are becoming popular in mainstream diets. Grains such as sorghum, millet and teff are of particular interest for use in special bakery products, health and organic foods including the expanding gluten-free market. However, knowledge of the functionality of the storage proteins of these grains is necessary. Previous reports analyzed storage proteins of teff using multiple sodium dodecyl sulphate polyacrylamide electrophoresis (SDS-PAGE) techniques and isoelectric focusing (IEF) and showed substantial polymorphism within the prolamin fraction. Additional research examined teff prolamins by reverse-phase HPLC and N-terminal amino acid sequencing revealed homology with the alpha type prolamins of maize. Free-zone capillary electrophoresis (FZCE) is a separation technique that has been useful in classification of cereals. A method for separation and characterizing teff storage proteins by free-zone capillary electrophoresis (FZCE) was developed and refined. This data and the use of methods such as HPLC, capillary electrophoresis and lab-on-a-chip electrophoresis will be discussed with emphasis on sorghum and teff.

Biochemistry, structure and function of non-wheat proteins: Case study of barley beta-amylase
C. Henson
USDA-ARS, Madison, WI
Cereal Foods World 54:A7

The importance of a protein is not always evident and may be due to its multifunctional nature. beta-Amylase in seeds of barley (*Hordeum vulgare* L.) constitutes approximately 2% of the total protein in mature seeds and is assumed to be important when storage proteins are mobilized to support protein synthesis during seed germination. However, its commercial importance is primarily due to its enzymatic ability to participate in hydrolysis of starch during the industrial process of mashing for the production of fermentable sugars to produce alcoholic beverages. Unfortunately, its structural limitations preclude maximal participation in this process as the protein undergoes extensive thermal denaturation. This presentation will describe the results of both traditional breeding and in vitro genetic manipulation efforts being used to increase the utility of this protein. Additionally, the potential use of polymorphisms (SNPs and indels) in both coding and noncoding regions of the gene by barley breeding programs using marker assisted selection will be discussed.

The proteins of rye grain-classification, analysis, and functionality
P. Koehler
Deutsche Forschungsanstalt fuer, Garching, Germany
Cereal Foods World 54:A7

Although rye and wheat are comparable in their overall composition, there are specific differences in the functionality of the flours. This is especially valid for the rye proteins, which do not form a cohesive, viscoelastic matrix comparable to wheat gluten. With respect to the Osborne fractions rye contains a considerably higher proportion of albumins/globulins as well as a much lower content of glutelins than wheat. The storage proteins of rye have been termed secalins. Same as for wheat they can be classified into the alcohol-soluble prolamins and the alcohol-insoluble glutelins. Four types of proteins are present in rye, namely high-molecular-weight (HMW-), gamma-75k-, omega-, and gamma-40-k secalins. Except the gamma-75k-secalins these proteins are homologous to protein types present in wheat gluten. In contrast to wheat rye neither contains low-molecular-weight (LMW-) subunits, nor omega5- or alpha-gliadins. The amino acid sequences of gamma-75k-secalins are homologous to gamma-gliadins, however, the molecular mass is considerably higher and they are present as aggregates linked via intermolecular disulfide bonds. Rye protein types can be analyzed quantitatively by means of a combined extraction/HPLC method, in which the absorbance area of the peaks at 210 nm is used for quantitation. gamma-75k-Secalins are the most abundant (46%), followed by the gamma-40k- (25%), omega- (17%), and HMW- (7%) secalins. Specific structural features of rye proteins in comparison to wheat proteins are responsible for the poor breadmaking performance of rye flour. Bread baked from rye flour only gains 60% of the loaf volume a wheat flour bread achieves. HMW-subunits of rye have a different pattern and number of cysteine residues, and this obviously inhibits polymerization and in consequence high molecular mass aggregates. Furthermore, rye flour lacks LMW-subunits which also contribute to the formation of gel protein (GMP) in wheat. The importance of the structure of the HMW secalins can be demonstrated by genetic engineering. The incorporation of HMW subunits from wheat into rye considerably improves the GMP content and the breadmaking performance. The formation of high molecular mass aggregates by cross-linking rye proteins with transglutaminase leads to comparable results.

Kafirin and zein disulfide bonding: Its negative and positive effects on sorghum and maize nutritional and functional properties
J. Taylor
University of Pretoria, Pretoria, Republic of South Africa
Cereal Foods World 54:A7

Cysteine-rich Mr 27 k gamma and Mr 19 k beta species of the kafirin group of sorghum storage proteins crosslink through disulfide bonding with other kafirin polypeptides. This crosslinking is promoted by wet heat treatment and the actual extent of crosslinking is still to be clearly established. Some workers consider that only oligomers are formed, whereas others have presented evidence to indicate that polymers of Mr > 200 k are produced. The gamma homologue of zein, the maize storage protein, also crosslinks but for reasons unknown the degree of crosslinking is less. There is now compelling evidence that crosslinking of the kafirin polypeptides is the major cause of low protein digestibility of wet-cooked sorghum foods. This is probably due to steric hindrance limiting the access of digestive proteases. The kafirin crosslinking also seems to adversely affect starch granule expansion during cooking, which in turn reduces starch digestibility. These negative effects of kafirin crosslinking on sorghum nutritional quality are counterbalanced by African indigenous knowledge that sorghum foods provide more sustained energy than maize, and that sorghum is protective against Type II diabetes. As yet there is little if any hard scientific evidence to support these observations. Nevertheless, given what we know about kafirin crosslinking, they appear likely. Regarding kafirin and zein functional properties, bioplastic films produced from laboratory prepared whole kafirin are stronger than films from commercial zein, where the gamma-zein species is absent. Kafirin disulfide bonding is probably responsible for this difference. This is supported by the fact that the visco-elastic properties of commercial zein resin (dough) are superior to those of whole kafirin resin.

Industrial extraction and utilization of zein
G. Selling
USDA-ARS, Peoria, IL
Cereal Foods World 54:A7

Through improved isolation techniques and new chemical modifications of zein, a potentially major co-product bio-ethanol industry, the economics of wet and dry-mill ethanol plants will be improved. While traditionally ethanol has been used to extract zein from corn gluten meal, it has been found that

other low molecular weight alcohols have a significant impact on the ability to remove zein from corn-gluten meal. These alcohol methods will be compared with using acetic acid as the extracting solvent. Improved utilization of zein has been accomplished through cross-linking with glyoxal, glutaraldehyde and formaldehyde. Films and fibers have been produced using zein modified with these reagents. It has been found that not only are physical properties improved with this modification, but resistance to dissolution by standard zein solvents is also dramatically improved.

The Effects of Dietary Fiber from Cereals on Gut Health

Nutritional and microbial modulation of intestinal epithelial integrity: Role of dietary fibers

J. Dekker
Top Institute Food & Nutrition, Wageningen, the Netherlands
Cereal Foods World 54:A8

The intestinal epithelium is the only gateway by which food and fluid enter the body. The condition and integrity of this epithelium is key to health and survival. The intestinal epithelium maintains these absorptive capacities while providing equally important protection against intestinal luminal hazards such as microorganisms and antigens. The serious consequences of suboptimal functioning of the intestinal epithelium, in particular malnutrition and intestinal inflammation, are exemplified by e.g. celiac disease and inflammatory bowel disease. But also in (near) healthy persons, every day effects of diet, intestinal microorganisms, and lifestyle have their impact on intestinal epithelial functioning. Dietary fibers in their many forms are considered to have positive effects on human health, and in many cases this can be attributed to their direct or indirect effects on the intestinal epithelium. E.g. insoluble and indigestible fibers act as mechanical stimulants of the intestinal epithelium. Soluble and fermentable fibers, such as inulin, are often described as prebiotics, i.e. they are fermented by intestinal commensal microbes and some of the products, such as short chain fatty acids, provide essential nutrients to the intestinal epithelium. In our studies we use in vitro, animal and human models that represent or mimic common dietary stressors to the intestinal epithelium to study the mechanisms how diet affects the epithelium and these models report on essential epithelial functions such as permeability, nutrient uptake, and parameters of cellular damage. In our studies we take into account the effects of diet (including fibers) on the epithelium and the microbial community in the intestine. These models will also be used to evaluate effect of dietary fibers on intestinal epithelium, providing mechanistic insight in the actions of fibers on the epithelium.

Dietary fiber from cereals and gut health

J. Slavin
University of Minnesota, St. Paul, MN
Cereal Foods World 54:A8

Cereals are rich in fermentable carbohydrates that reach gut – dietary fiber, resistant starch, and oligosaccharides. Most research that supports the importance of cereals and gut health was conducted with isolated fiber fractions, rather than whole grains. Whole grains are an important source of dietary fiber and grain fibers such as wheat, oats, barley, and rye are known to increase stool weight, speed intestinal transit, get fermented to short chain fatty acids, and modify the gut microflora. Wheat bran is particularly effective in increasing stool weight with wheat bran increasing stool weight by a 5 to 1 ratio in contrast to many fibers that increase stool weight only on a 1:1 ratio. In vitro fermentation studies with whole grains find that carbohydrates in oat bran (rich in beta-glucan) were consumed by the bacteria faster than those of rye and wheat brans (rich in arabinoxylan). Grain fibers were fermented more slowly than inulin and there was less gas production. Wheat is particularly high in fructo-oligosaccharides while wheat germ is high in raffinose oligosaccharides. Whole grain breakfast cereal was more effective than wheat bran breakfast cereal as a probiotic, increasing fecal bifidobacteria and lactobacilli in human subjects. Wheat bran consumption increased stool frequency. Thus, the gut enhancing effects of cereals are known, but most data is from the fibers isolated from cereals.

Health Claims and Use of Dietary Fibers in Cereal Products

Scientific evaluation for health claims and qualified health claims

K. C. Ellwood
FDA, Center for Food Safety and Applied Nutrition, Washington, D.C., U.S.A.
Cereal Foods World 54:A8

The Nutrition labeling and Education Act (NLEA) passed in 1990 was to assist consumers in maintaining healthy dietary practices, provide a level playing field for claims and encourage innovations in food products. Health claims were first authorized through the NLEA. Health claims describe the relationship between a substance (food or component of food) and a disease or health-related condition. The standard that Congress set for scientific evidence for the claim was the significant scientific agreement standard. This strong standard was challenged by several manufacturers of dietary supplements. Several courts cases, known as the Pearson Court Decisions, favored "disclosure over suppression" for claims that did not meet the significant scientific agreement standard. FDA was to provide for the claim as long as it contained qualifying language as not to mislead the consumer. In December 2002, the agency announced a major new initiative, "The Consumer Health Information for Better Nutrition Initiative", which among other things, provided for the use of qualified health claims for both conventional foods and dietary supplements. The process for reviewing the scientific evidence for a claim reaching significant scientific agreement and for those that require qualifying language is the same. In January 2009, FDA issued a guidance document entitled "Evidence-Based Review System for the Scientific Evaluation of Health Claims". The elements contained in this guidance document are very similar to two prior guidance documents issued by FDA. The process for the review of the scientific evidence for both health claims and qualified health claims will be described in the talk.

Whole grain and dietary fiber health claims: An industry perspective

K. Wiemer
General Mills Bell Institute of Health & Nutrition, Minneapolis, MN
Cereal Foods World 54:A8

Since 1993, health claims have been approved for use on food products by the FDA in the United States. There are a variety of routes to get an approved health claim: Significant scientific agreement (SSA), Food & Drug Modernization Act (FDAMA) and more recently, Qualified (QHC). This talk will highlight the key differences among these types of claims and illustrate how the food industry uses approved whole grain and dietary fiber health claims, including key considerations, issues and opportunities when using these claims on food products.

Fiber enriched products – Challenges for product developers related to label claims guidelines

B. Govindarajan
Kellogg Company, Battle Creek, MI
Cereal Foods World 54:A8

Fiber is a nutrient that is deficient in the diets of the majority of people, particularly in developed countries. The food industry and consumers are faced with the challenge of bridging the gap between the current intake of fiber at 15-18 g per day to the recommended the dietary allowance of 25-38g per day. Fiber can occur in many forms: structurally, functionally and physiologically. However, approved health claims for fiber are very few. Product developers face many challenges as the food industry competes for shelf space with high fiber products. Product development challenges to incorporate fiber into foods include taste, color, appearance and texture. In addition, fiber also changes the processing of food systems and all these factors have to be taken into consideration while developing high fiber foods.

HEALTHGRAIN Project Symposium

Healthgrain: EU approach to use more of grains for health maintenance
K. Poutanen
VTT, Espoo, Finland
Cereal Foods World 54:A9

The European integrated project HEALTHGRAIN (www.healthgrain.org, 2005-2010) has the aim to increase the intake of health-protective grain components, and to increase understanding of cereal food factors and mechanisms contributing to health effects of cereal foods especially with respect to prevention of insulin resistance. HEALTHGRAIN is a forum of 43 research partners, over 50 companies in the industrial platform, and over twenty leading health professionals in the nutrition information network. The research deals with different aspects of the grain-to-consumer chain for development of healthy grain-based foods and ingredients, and has a technology transfer and communication program to bridge science with industry and other stakeholders. The research program includes studying of consumer expectations, developing a biotechnology toolbox for plant breeding & novel bioprocessing and milling technologies for grain processing, studying mechanisms behind the metabolic merits of foods in a series of in vitro, animal and human studies, and identifying health-relevant cereal food criteria. Emphasis is also put to enable production of tasteful cereal foods high in grain dietary fibre and outer grain layers, and demonstrating the feasibility of new technologies. The HEALTHGRAIN research programme has brought together a large group of scientists from very different disciplines, and also has made efforts in networking different industrial actors with each other and the scientists in order to cross the interphase between producing and using scientific knowledge. The expected impact in the long run is to facilitate better use of cereal grain as human food, so as to exploit its protective potential in maintenance of diet-associated well-being in the modern society. The study is financially supported by the European Commission in the Communities 6th Framework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008).

Strategies for improving the amounts and compositions of phyto-chemicals and dietary fibre components in wheat
P. Shewry
Rothamsted Research, Herts, UK
Cereal Foods World 54:A9

Improvement of the amount and composition of bioactive compounds in wheat requires sources of genetic variation that can be exploited by plant breeders and tools to allow their selection in plant breeding programmes. We have identified sources of variation by carrying out an extensive diversity screen, with initial analyses being carried out on 150 lines grown on a single site followed by more detailed analysis of 26 lines grown on four sites. In addition, further variation in the composition of dietary fibre and starch is being generated by the introgression of mutant genes (both naturally occurring and induced) and transgenesis. Genetic and molecular approaches are also being used to map QTLs and to identify novel genes that determine the amount and composition of bioactive components which will facilitate the development of molecular markers for use in breeding programmes. The direct determination of major components, particularly dietary fibre will also be facilitated by the development of NIR calibrations and kits based on antibodies and inactivated enzymes. *This study was carried out by partners in HEALTHGRAIN Module 2 including Li Li, Rebeca Fernandez-Orozco, Jane Ward (UK), Vieno Piironen, Anna-Maija Lampi, Tanja Nurmi, Laura Nyström (Finland), Per Åman, Annica Andersson (Sweden), Zoltán Bedö, Mariann Rakszegi, András Salgó, Szilveseter Gergely (Hungary), Ivelin Rizov (Bulgaria), Danuta Boros, Anna Fras, Wioletta Dynkowska (Poland), Kurt Gebruers, Jan Delcour, Christophe Courtin (Belgium), Quraishi Umar Masood, Jerome Salse, Catherine Ravel, Luc Saulnier and Gilles Charmet (France). The study is financially supported by the European Commission in the Communities 6th Framework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008).

Strategic options for processing of cereals aiming to fully exploit their health promoting potential
J. Delcour
Catholic University Leuven, Belgium
Cereal Foods World 54:A9

A large part of the Healthgrain programme deals with processing of cereal to fully exploit their health promoting potential. In general, technologies to that end can be classified into either dry or wet processing technologies. In this presentation, the emphasis will be on selected achievements of the Healthgrain Module “Processing of Cereals”. In the dry processing area, tools were developed for understanding and control of cereal fractionation processes, whole grain fractionation to produce functionally and nutritionally improved flours and bran fine fractionation using cryogenic and electrostatic technologies. Specifications have been proposed to quantify the relative proportions of wheat tissues in milling fractions. The anti-oxidant capacity of wheat fractions was highly correlated with their levels of aleurone, and ferulic acid was the major component behind this activity. In the area of wet processing, xylanase technology was developed for production of soluble arabinoxylan and arabinoxylan oligosaccharides, and it was shown to deliver improved properties of breads high in fibre. Fermentation also released phenolic acids from the bran matrix. Work of relevance for celiac patients showed that laccase improved the volume and bread crumb of 100% oat breads. The study is financially supported by the European Commission in the Communities 6th Framework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008).

On the metabolic benefits of whole grain; briefing of findings from in vitro and animal experimental models, and human intervention studies
I. Björck
University of Lund, Lund, Sweden
Cereal Foods World 54:A9

Epidemiological data suggest that whole grain intake is associated with a lower body mass index and reduced risk for type 2 diabetes and cardio-vascular disease. A variety of whole grain food factors have been implicated e.g. dietary fibre, trace minerals, phyto-chemicals and antioxidants including polyphenols, physiological methyl donors, and low glycaemic index properties. However, the mechanisms for the preventive benefits remain to be elucidated. The over-all objective of the nutrition research within HEALTHGRAIN is to evaluate possible mechanisms for health benefits with whole grain diets, and to utilize this knowledge in the tailoring of novel cereal products with magnified effects. Data indicate that potentially bioactive components in whole grain cereals vary in bioavailability. Ferulic acid contributed considerably to the antioxidative capacity of wheat aleurone. The in vitro bioavailability of ferulic acid in wheat products was low, but increased importantly following cereal processes e.g. fermentation or enzyme treatment. Colonic metabolism of whole grain components, as estimated in vitro and in vivo, led to formation of potentially metabolically active compounds such as e.g. SCFA, or phenyl-propionic acid derivatives. Semi-acute meal studies in healthy humans showed that DF and RS present in barley products improved several parameters related to glucose metabolism and increased GLP-1, possibly mediated through colonic SCFA formation. A 12w intervention in over-weight women with hypo-caloric whole grain- or refined wheat diets, respectively, indicated body weight reductions with both diets. However, a significantly higher reduction in fat body mass (%) was seen with the whole grain diet. Compared with a refined diet, a diet rich in wheat aleurone, increased plasma betaine levels, and reduced CRP and LDL-cholesterol following 4w intervention in at risk subjects. The study is financially supported by the European Commission in the Communities 6th Framework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008).

Consumer responses to grain products and health claims
R. Shepherd
University of Surrey, Guildford, UK
Cereal Foods World 54:A9

In order to increase the consumption of both wholegrain and functional cereal products it is necessary to understand the views of consumers about such products. As part of the HEALTHGRAIN project (www.healthgrain.org) we have carried out a series of studies in the UK, Finland, Germany and Italy. Focus groups were followed up by quantitative surveys involving around 500 consumers in each of the countries. Although wholegrain products were rated more positively than refined cereal products in terms of healthiness, naturalness, being nutritionally balanced, filling and offering slow energy release, these effects were more pronounced for the Finnish sample but less so for consumers from the UK and Italy. Women were found to be more aware of benefits of cereal based foods than men, to be more health conscious and to expect less illness in later life caused by their eating habits. Women and older people were more willing to use cereal products produced to have specific health benefits (e.g. bread containing added fibre). Perceived healthiness and pleasantness were the best predictors of willingness to use functional cereal products. A second study investigated the impact of health claims on perceptions of healthiness and likelihood of buying cereal products. There were major differences between countries in the way in which health claims were perceived and also differences between consumers according to age and gender and whether the claims were directly relevant to them. The study is financially supported by the European Commission in the Communities 6th Framework Programme, Project HEALTHGRAIN (FOOD-CT-2005-514008).

Healthgrain - and what is next? Introduction and discussion
J. W. van der Kamp
TNO, Zeist, The Netherlands
Cereal Foods World 54:A10

HEALTHGRAIN is showing at the start of its 5th and last year the great benefits of a multi-centre, multi-disciplinary research project: - A large (70), and still growing amount of peer reviewed publications, many of them co-productions of 2 or more groups. - Recognition of the quality of the work by independent parties – e.g. by 'best paper' Awards and by Special Issues of scientific journals – e.g. J. Agr. Food Chemistry 56, with 11 publications of the HEALTHGRAIN cereal diversity screen of bio-active components in 200 cereal cultivars. - Involvement at an unprecedented scale of industry in the Industrial Platform, with 60 paying member companies, and of key nutritionists of all major EU countries. A start has been made with developing the HEALTHGRAIN Cereals and Health Research and Technology Platform – in short: the HEALTHGRAIN Network as a legal entity aiming at: - Developing a Strategic Research Agenda cereals & health research for 2010 – 2015 and annual Working Plans for publishable research. - Uniting participating research groups and industries participating in the execution of the Working Plans. - Acting as a focal point in Europe, a) for activities related to cereal and health R&D, such as regulatory issues – e.g. developments in food and health regulations, and the definition of whole grain and b) science based promotion campaigns for healthy eating related to grain based products. - Maintaining and extending a website with a highly functional database, with information about research results and other important areas, such as information about the issues as mentioned above. After a short outline of the state of affairs regarding the HEALTHGRAIN Network participants are invited to join the discussion on the best ways for continuing European and international cooperation and coordination of activities.

Opportunities to Enhance Cereal Products: Pulse Components as Nutritional and Functional Ingredients

Opportunities to improve cereal products using pulses
J. A. Wood
NSW Department of Primary Industries, Tamworth Agricultural Institute, Tamworth, NSW, Australia
Cereal Foods World 54:A10

Health is becoming a major issue for many western societies as diet-preventable diseases become more prevalent. Diet-preventable diseases account for approximately 60% of all deaths worldwide and include cardiovascular disease, obesity, diabetes, and cancer. This percentage is higher in western societies with increasingly sedentary lifestyles who consume more energy-dense foods. The age at which people are diagnosed with these diseases has been steadily decreasing. Whilst many people know they should be eating a healthy diet that is high in wholegrains, fruits and vegetables, they are reluctant to give up their convenience and snack foods which are often laden with sugar and fat. In contrast, pulses are almost the ideal health food. They are high in protein, carbohydrates, fibre, vitamins and minerals and contain many beneficial components such as antioxidants and phytoestrogens and are gluten-free. In addition, pulses have very low glycaemic indices (GI) and chickpeas have been shown to lower blood cholesterol levels. Whilst some developing countries have a high consumption of pulses (and a low incidence of diet-preventable diseases) they are seen as unfamiliar and inconvenient in fast-paced western societies, so consumption remains low. Cereals, however, are consumed world-wide and are commonly used in many convenience foods in western societies. For example, bread, pasta, rice, breakfast cereals, cakes, biscuits and many snack foods. Many of these products are highly refined and there has been a lot of recent interest in trying to improve the nutritional benefits of these foods by modifying/adding ingredients and processes. Pulses are the ideal partner to cereals due to their complimentary protein composition and GI-lowering ability and can achieve nutritional improvement and a functional food status. There are opportunities to improve cereal products using pulses and/or various fractions of pulses as ingredients to confer nutritional and even functional properties. The development of such products may help reduce the incidence of these diet-preventable diseases by offering healthier alternatives.

The factors influencing digestibility in vitro of pulse starch
Q. LIU, H.-J. Chung
Guelph Food Research Centre, Agriculture and Agri-Food Canada, Guelph, ON, Canada
Cereal Foods World 54:A10

Starch digestibility has been known to vary among different starchy foods, which have been ascribed to various factors, including botanical source, food processing, particle size, amylose/amylopectin ratio, the molecular characteristics of amylose and amylopectin such as chain length and its distribution, density of branch chain, type of crystalline polymorphic (A, B or C) form, interaction between starch and other components, and presence of amylose-lipid complexes. In this study, the digestibility in vitro and physicochemical and structural properties were investigated using various analytical techniques including Megazyme procedure for resistant starch content, Englyst method for slowly digestible starch, quickly digestible starch and resistant starch, differential scanning calorimetry for starch gelatinization and retrogradation, rapid viscoTM analyser for starch pasting, scanning electron microscopy and light microscopy for starch morphology, high performance anion exchange chromatography – pulsed amperometric detection for branch chain length and its distribution of starch, x-ray diffraction for starch crystallinity, and Fourier transform infrared spectroscopy with attenuated total reflectance for short-range order in starch. The factors influencing pulse starch digestibility in vitro will be further discussed in native and cooked starch in this presentation. In addition, what extent changes to crystalline structure, properties and digestibility in vitro of pea, lentil, navy bean and corn starches after hydrothermal modification with single and dual heat-moisture and annealing treatments are also presented and discussed. The results of this study may provide an alternative route for improving digestibility of starch by selecting different pulse sources and using different hydrothermal modifications.

Precooked pulse flour: Processing, quality and end product utilization
M. TULBEK, S. Simsek, C. Hall
Northern Crops Institute. North Dakota State University Department of Plant Sciences. North Dakota State University Department of Cereal Sciences
Cereal Foods World 54:A10

Pulses are good source of protein, dietary fiber, vitamins and minerals which can be utilized as staple as well as flour. Hydrothermal cooking can be applied to pulses in order to enhance shelf life and improve the chemical attributes. In this study process technology, physical, chemical, nutritional, microbiological, rheological attributes and end product quality utilization of pre cooked pulse products will be discussed. Whole pea, split pea and pre cooked lentils were used. Hydrothermal treatment and extrusion processes were applied as a tool for pre-cooked flour development process. Pea samples were soaked in water (60°C) for 30 min. Then soaked peas were roasted at 170°C for 12.5 min. Cooled peas were milled with Fitzmill- at 7200 RPM mill speed and 25 RPM feed screw speed. Moisture, total protein, total starch and ash were determined. RVA was used to determine pasting profile of the flours. Changes in molecular weight of starch were determined using High Performance Size Exclusion Chromatography (HP-SEC). Differential Scanning Calorimetry (DSC) and X-ray diffraction was used to determine physicochemical changes in starch. Changes in starch digestibility were determined using Englyst assay. Pre cooked lentil flour was processed by Wenger TX-52 twin screw extruder and further milled with Fitzmill at 4500 RPM. Roasting process significantly decreased moisture content and test weight scores of all samples. Precooking decreased peak viscosity, hot paste viscosity, final viscosity and setback scores. There were significant changes in physicochemical properties (HP-SEC, X-Ray diffraction and DSC profiles) of starches from peas, and they were correlated to the changes in starch digestibility. Pre cooked pulse flour samples had higher water absorption and stability compared to control pulse flours in dough systems. Baking studies indicated that precooked lentil flours processed with higher specific mechanical energy had higher loaf volume score.

Gluten-free expanded snacks made from lentil-fiber based formulations
J. DE J. BERRIOS, J. Pan, M. Tom
USDA, ARS, WRRC Albany, CA, U.S.A.
Cereal Foods World 54:A10

Pulses, such as lentils and dry peas, are a great fit for the healthy eating pattern. They are part of the high-protein food and the vitamin-rich vegetable groups in the USDA Food Pyramid-Dietary Guidelines. They are high in protein, dietary fiber, complex carbohydrates, B-vitamins and folate, and significantly low in fat and sodium. Additionally, they are gluten-free. Wheat bran and other fiber-rich cereal ingredients are generally used to increase the fiber content in snacks and breakfast cereal products. However, these

ingredients contain gluten, which represents a problem for a large number of the population who are allergic to gluten, a disease known as the celiac disease. Extrusion cooking is a high-temperature and pressure, and short-time, versatile, and modern food processing operation. This study aimed to develop unique, gluten-free expanded extruded snack-type foods from lentil-based formulations fortified with gluten-free fiber ingredients (GFFIs). Extrusion was performed using a Clextral EVOL HT32-H co-rotating, twin-screw extruder operated at a speed of 500 rpm, and die temperature of 160 oC. Formulations containing three GFFIs, alone and in combination, were evaluated. Fiber addition varied from 0 to 10% among the different formulations. High expansion ratio of extruded products is associated with the desirable crunchy texture of expanded snacks and breakfast cereal products. In general, the extrudates containing GFFIs were highly expanded and their expansion ratio was directly related to fiber fortification. Conversely, the bulk density of those extrudates was inversely related to fiber fortification. 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. Sensory evaluation, using a 10-point hedonic scale, demonstrated that the novel, value-added, and expanded extruded lentil-based snacks fortified with GFFIs had a desirable crunchy texture and were highly acceptable to the sensory panel. This research would bring new information to food scientists and the food industry on the processing and utilization of pulses in an attractive, safe, and convenient form, like snacks and Ready-to-Eat-type foods. Also, it would have great impact to more than 7,000 people who are diagnosed as allergic to gluten in the USA alone every year, improve the consumption of dietary fiber by consumers, and benefit growers of pulses worldwide.

Use of pulse flours in cereal based products: Pasta, tortillas, muffins and extruded snacks

A.-S. Bellido, L. MALCOLMSON, G. Boux, P. Frohlich
Canadian International Grains Institute, Winnipeg, MB, Canada
Cereal Foods World 54:A11

Consumer's awareness about the relationship between food and health has increased dramatically. Pulses such as peas, beans, lentils and chickpeas are high in protein and dietary fiber and are low in fat making them a healthy food choice. Their excellent nutritional profile along with their complementary protein composition to wheat makes them an ideal ingredient to enhance cereal based products such as pasta, tortillas, muffins and extruded snacks. Research undertaken in our pilot plant has shown that chickpea flour could be substituted for durum semolina in spaghetti up to a level of 30% without negatively affecting the quality of the pasta, while yellow pea flour and navy bean flour gave acceptable spaghetti when used at levels up to 20%. Addition of pulse flours in pasta formulations improved the protein content by 16-18%. The substitution of pulse flours for wheat flour in tortillas and muffins was also possible although modifications were necessary to the formulations to maintain quality. For both products, the total dietary fiber content significantly increased allowing for a high fiber claim. It was also possible to obtain a highly acceptable 100% non-wheat extruded snack using yellow pea flour making it suitable as a non-gluten and non-corn based product.

Perspective on pulse uses in India

P. BANUMATHI, M. Ilamaran
Department of Food Science and Nutrition, Home Science College and Research Institute, Tamil Nadu Agricultural University, Tamil Nadu, India
Cereal Foods World 54:A11

Pulses are important sources of protein in Indian Diets. India is the world's largest pulse producer and consumer accounting for 25 and 27% respectively. Pulses are grown in an area of 22-23 million hectares with an annual production of 13-15 million MT in 2007-08. In India, the state of Madhya Pradesh (24%) is the largest pulse producer followed by Uttar Pradesh (18%), Maharashtra and Rajasthan (14.0% each) and Karnataka, Tamil Nadu, Andhra Pradesh and Bihar (5.0% each). Productivity of some important pulses like bengal gram and horse gram are in the increasing trend by 10.4 and 22.5% respectively from the year 2004-05 to 2005-06 whereas, there is a decreasing trend in red gram (19.0%), green gram (15.8%) and black gram (10.6%). Increasing demand for pulses due to rise in population has resulted in imports rising to over 20 lakh tonnes during 2007-08 whereas, the same was only 4.6 lakh tonnes during 1998-99. There are too many uncertainties in the indigenous supply chain and costs are also higher. Since demand for pulses is price sensitive, the per capita consumption has gradually declined over the years. While total pulse availability in the country has increased by nearly 1.39% every year during the last two decades, the population increased at 1.8% level every year. The importance of pulses in Indian diet has long been recognized by nutrition workers. Commonly used pulses are: bengal gram, red gram, green gram, black gram and lentil. The protein content of these pulses varies between 22 and 25% and together with cereals; they are important sources of protein. The use of pulses as components of weaning foods in combination with cereals is a boon to malnourished children. Pulses can help to manage weight related health problems such as type 2 diabetes and heart diseases. Most pulses are consumed in shelled and split forms. Pulses are used to make dhal, a thick, gravy like dish. Pulses are also used in curries and snack foods, such as samosa, pakoda and pappad. Research on pulses has focused on developing various technologies to improve the nutrient content of cereal products by incorporating pulses. As part of Food Security Mission and Price Control Measures, the Tamil Nadu Government proposes to encourage the cultivation of pulses in the state by offering to procure pulses from farmers at Minimum Support Prices. With ever growing health consciousness, the Indian consumers are seeking pulse based foods that are not only tasty and convenient to use, but which also provide added nutritional and health benefits.

Replacing Gluten Functionality

Evaluation of risk of different dietary proteins for celiac disease patients

A. M. Calderon De La Barca
Centro de Investigacion en Alimentacion y Desarrollo, A. C., Hermosillo, Mexico
Cereal Foods World 54:A11

Reliable and sensitive methods to evaluate risks of dietary proteins in ingredients and processed foodstuffs are needed for celiac disease (CD) patients. A sensitive and reproducible ELISA protocol was developed to evaluate immuno-reactive dietary proteins using IgA antibodies in sera from CD patients. The immuno-reactivity to foodstuffs was estimated relative to 100% immuno-reactivity to gliadins. The evaluated ingredients were caseins, soy, amaranth, chia, millet, rice and maize as well as foodstuffs either transglutaminase (mTG)-treated or not, and labeled as "gluten-free" or not. Extraction was done with 0.9% NaCl for globulins and 70% ethanol or 40% 1-propanol plus 1% DTT for prolamins. Among assayed grains, just maize prolamins had high immuno-reactivity percentages. Extraction with 1-propanol and DTT was better that ethanol for detection of immuno-reactive proteins in processed foodstuffs. Some foodstuffs labeled as gluten-free and all the barley malt- or maize-containing foods, particularly those of mTG-treated bread, presented more than 20 ppm of reactive proteins, using crude gliadins as standard. Breakfast cereals containing rice or amaranth were lower than 20 ppm independently if they were labeled as gluten-free or not. The proposed assay may be a sensitive method for evaluation of immuno-reactive proteins in foodstuffs for CD patients.

Replacing gluten: Requirements to produce leavened products

B. S. SROAN (1), F. MacRitchie (2)
(1) Frito Lay Research and Development, Plano, TX; (2) Kansas State University, Dept. of Grain Science and Industry, Manhattan, KS
Cereal Foods World 54:A11

Aerated products, of which the various bread types are the main ones, comprise an industry worth billions of dollars. The soft spongy texture of wheat bread, due to its cellular structure (gas cells), is relished by consumers. The unique properties of wheat flour dough makes it ideally suitable for incorporating air in the form of bubbles and allowing their expansion without failure during proving and baking. Any flour system must meet three basic requirements to produce a good leavened product: (1). To produce a viscoelastic dough, capable of trapping and retaining air in the form of gas cells, a dough must be mixed at a temperature higher than the glass transition temperature (Tg) of its continuous phase; (2). The expansion of retained gas cells depends on the dough being strong enough to prevent rupture of expanding gas cells and extensible enough to allow the expansion. For this, the developed dough must have a high strain hardening index. Achievement of this, in turn, requires an optimum molecular weight distribution of its proteins. The protein component must have a sufficient proportion of large-size polymers (glutenins in the case of wheat) to provide resistance but not to compromise the extensibility at the strain rates used in processing; (3). The presence of compounds such as proteins and polar lipids capable of forming stable monolayers at gas liquid interfaces provides a secondary stabilizing mechanism for liquid lamellae that surround the gas cells. It may be possible to apply the understanding of these requirements obtained from studies of wheat dough systems to produce leavened products like breads from non-

wheat cereals, meeting requirements for gluten intolerance and bringing underutilized cereals into main stream food products.

Potential of prolamins from maize and sorghum to form gluten-like structures in wheat-free bread
T. SCHOBER, S. R. Bean
USDA ARS-GMPRC, Manhattan, KS
Cereal Foods World 54:A12

Prolamins from maize (zeins) are known to form viscoelastic, extensible, cohesive dough when mixed together with starch and water above their glass transition temperature (Tg, ~28°C). By adding hydroxypropyl methylcellulose (HPMC, a surface-active hydrocolloid) to this formulation, leavened bread can be produced that closely resembles wheat bread. Zein-starch dough can be shaped like wheat dough and made into hearth-type breads, rolls or pretzels without the use of bread pans, a major advantage over traditional batter-like gluten-free doughs. However, the ability of zein-starch dough to hold its shape upon proofing depends on the zein quality. Several quality factors were identified in commercial zein, including protein content, molecular weight distribution of the proteins and lipid content. With commercial zein of the appropriate quality, it was possible to make rolls that closely resembled wheat rolls, whereas inadequate zein quality led to flat rolls. However, commercial zein is a by-product from starch isolation and therefore not easily available in a standardized quality. Isolation of zein directly from maize flour requires sufficiently hydrophobic solvents (e.g. 92% i-propanol) to be functional for breadmaking. Although regarded as highly analogous to zein, sorghum prolamins (kafirin) could not be used for breadmaking. However, some progresses in kafirin isolation led to an improved ability to aggregate above kafirin's Tg into a gluten-like substance.

Rheological characterization of gluten-free systems
O. POLENGHI, V. Cerne
Schar R&D Centre, Trieste, Italy
Cereal Foods World 54:A12

The use and related difficulties of some rheological instruments, to characterize gluten-free raw materials/doughs, are presented. Conventional cereal quality instruments and methods are usually not suitable for gluten-free cereals or need to be arranged to analyse gluten-free systems. Information and results required different interpretations from data which come from gluten system. For these reasons some methods such as micro visco-amylo-graph® (Brabender) and Mixolab® (Chopin) are discussed and some illustrative data are given.

The gluten-free initiative: 3 friends, multiple disciplines, and a business
J. ENGLESON (1), W. (Bill) Attwell (2)
(1) Grains for Health Foundation; (2) Cargill Inc., Plymouth, MN
Cereal Foods World 54:A12

Our gluten-free initiative encompasses a gluten-replacer program to improve gluten-free foods and investment in the first pharmaceutical company exclusively dedicated to celiac disease, Alvine Pharmaceuticals, Inc., to address unintentional gluten exposure with pharmaceutical therapies. Our gluten-free and dairy-free breads have changed the breadmaking rules to some extent. They deliver mild taste and soft, chewy texture that is very close to conventional bread. The breads are made from a viscous batter that is high in water compared to conventional dough. Mixing hydrates hydrocolloids, modified starches and emulsifiers, which thicken and hold the batter together. The batter requires shorter proof times than normal because diffusion is faster in the batter and air cells are less stable compared to gluten-containing dough. Emulsifiers increase the stability of air cells. The batter matrix retains air cells, but lacks strength and collapses if it contacts a solid surface unlike gluten-containing dough, which is extensible and has strength to prevent collapse. Upon heating, yeast and chemical leavening and in turn expanding air cells yield ovenspring, which must occur quickly before the batter sets. This is faster than normal because there is no gluten competing for water in the batter system. Film forming ingredients promote oven spring by improving the strength and flexibility of the batter. The batter sets as starch gelatinizes and proteins denature; set-ability is highly dependent on plasticizer (sugar, water, etc.) content. Setting in the batter is more challenging than in conventional bread because the batter does not contain gluten, which can undergo strain hardening and thermoset. In the baked bread, hydrocolloids, starches (modified), and emulsifiers impart soft and chewy bread texture. This is traditionally the role of gluten in conventional bread. Gluten is not only inherently rubbery; it also minimizes the formation of a continuous starch network and in turn brittleness. Flavors are added to the batter to enhance final bread flavor and compensate for the flavor of gluten and the flavor that results from reactions between gluten and sugars. There is also minimal yeast fermentation in the batter, and therefore yeast flavors are added to the batter. Alvine Pharmaceuticals reported positive results with ALV003 in Phase 1 Trial of therapy in development for celiac disease. ALV003 is an orally administered combination of two proteases (glutamine specific cysteine protease and proline specific prolyl endopeptidase) engineered to degrade gluten into non-immunotoxic fragments. Doses at 300mg achieved up to a 96% reduction of gluten in the stomach, which supports use of ALV003 as a drug to be taken with meals to address unintentional gluten exposure and further clinical development of ALV003.

Texture and cereal protein functionality
B. R. HAMAKER, C. D. Mejia, M. A. Goodall, B. A. Bugusu
Department of Food Science, Purdue University, West Lafayette, IN
Cereal Foods World 54:A12

Corn and sorghum prolamin proteins, the zeins and kafirins, have been generally thought to be non-functional in food systems. Lack of functionality is partly due to their location in fairly rigid protein bodies that precludes protein-protein interaction during mixing. When outside the confines of the protein bodies, however, zein proteins are known to be viscoelastic when brought above their glass transition temperature. In this state, they can be made to function much like gluten protein in forming viscoelastic fibrils capable of trapping gas to make a leavened product. Increased viscoelasticity coincides with an increase in beta-sheet structure that is similar to what occurs in mixed wheat gluten. However zein protein shows a rapid loss of this protein secondary structure as well as rheological properties during relaxation. We found that small amounts of certain proteins can act to stabilize beta-sheet structure, thereby improving the functional properties of the protein. Recent results also show that sorghum kafirins can be made functional and can participate in dough and bread structure.

The Role of Grain-Based Foods in the Prevention of Childhood Obesity

The role of grain foods in childhood obesity
L. Marquart
Grains for Health Foundation, University of Minnesota, St. Paul, MN
Cereal Foods World 54:A12

Several adult epidemiology studies suggest there is an inverse association between whole grain intake and body weight. It is unclear if this relationship also exists with children. Further studies are needed to understand the role whole grains play in childhood obesity. The school food environment influences the food decisions and choices made by students. Increasing the availability of whole grain foods provides more nutrient dense food and can potentially positively affect student health. Success in incorporating whole grains may be enhanced by focusing on foods that are already typically consumed in the school environment.

Working together – Approaches to maximize consumption, nutrition and value of whole grain foods
L. MARQUART, R. Rosen
Grains for Health Foundation, University of Minnesota, St. Paul, MN
Cereal Foods World 54:A12

Data suggests children in the U.S. are not getting enough whole grains—less than the 3 servings recommended daily—and therefore may not receive all the health benefits whole grains offer. Acceptance of new foods, such as whole grains, may take repeated exposure plus presentation in a combination of familiar and unfamiliar attributes such as pizza with a whole grain crust. Studies strongly suggest that gradually introducing whole grain foods, such as rolls or snacks, with increasing levels of whole grain is a way to gain acceptance and inclusion of whole grains into the diets of school-age children. Educating parents, children, and foodservice staff can improve whole grain availability and intake. Efforts based on communication and partnerships between school foodservice, academia, food manufacturers, regulatory and policy-making entities, and scientific and trade groups may increase consumption of whole grain foods by increasing availability in schools. This may improve diets of children and contribute to long-term health.

Incorporating behavioral research approaches into the development of whole grain foods to maximize acceptance
E. ARNDT (1), R. Rosen (2)
(1) ConAgra Foods, Omaha, NE; (2) University of Minnesota, St. Paul, MN
Cereal Foods World 54:A12

Food manufactures and school foodservice directors have used various approaches to determine the acceptability of whole grain foods for school lunch. Taste tests and focus groups are helpful, but don't provide complete

information on the factors influencing the consumption of whole grain foods. Observation of children eating school lunch and analysis of their behaviors and intake has shown that the consumption of whole grain foods is influenced by many factors including the other foods served within a meal and the overall lunchroom environment. This type of research provides important insights that can help manufacturers make whole grain foods that children prefer to eat. Further collaboration between manufacturers and school foodservice directors is needed to effectively optimize consumption of whole grain foods in schools.

Regulations, labeling and communication for the National School Lunch Program
L. Lapeze
USDA-FNS, Baton Rouge, LA
Cereal Foods World 54:A13

The National School Lunch and School Breakfast Programs impact the nutrition of more than 30 million students each day. To obtain broad scientific input on recent changes in the science of children's nutrition, USDA requested the Institute of Medicine (IOM) to recommend updates and revisions to the national nutrition standards and meal requirements for school meals. The recommendations are to reflect new developments in nutrition science, increase the availability of key food groups in school meals, and increase the ability of the Programs to meet the nutritional needs of students, foster healthy eating habits, and safeguard children's health. This 24 month study, which began February 2008, anticipates recommendations for October 2009. The regulatory process by which USDA will update the nutrition standards and meal requirements after receiving the IOM recommendations will be reviewed. In the meantime, USDA-FNS encourages all schools to make changes to implement the 2005 Dietary Guidelines within their menu planning approaches, and has provided guidance to assist the schools. USDA-FNS has implemented the Healthier US School Challenge, a voluntary nutrition and wellness initiative, to recognize schools' efforts to provide healthier meals.

The role of grain components in school lunch - bran, germ and aleurone
J. Wellnitz
Cargill Incorporated, Plymouth, MN
Cereal Foods World 54:A13

As work continues to increase the nutritional value of foods provided to children in school food programs, barriers still exist. Economics and availability, sensory performance, among other challenges, can inhibit schools from incorporating better foods into menus. As we continue to learn about the health benefits of the 'WHOLE' grain, we cannot overlook the grain components that significantly contribute to these benefits. Bran, germ, and aleurone are examples of wheat components that can deliver concentrated nutritional benefits. This session will discuss the economic feasibility of using grain components to deliver nutrition versus whole grains as well as the benefits and challenges of whole grain components in school food programs.

Whole grains in the marketplace
C. Harriman
Whole Grains Council, Boston, MA
Cereal Foods World 54:A13

Although dietary guidelines recommend that all of us, including children, make at least half our grains whole, 2008 data show that kids' actual consumption is at only 9% – and that children eat a lower percentage of their grains as whole grains than any other age group. Understanding whole grains' benefits for weight control and for health in general, and formulating better whole grain products are only part of the battle; we also need to craft creative programs that entice parents to buy whole grains, and children to eat them. This session will detail several innovative programs that are successfully bringing more whole grains to kids, including the Whole Grain Stamp program, the annual Whole Grains Challenge for schools and foodservice operations, and the new Whole Grains Yardstick Awards.

Tools to Evaluate Health Benefits of Cereals

Clinical evaluation of cereal grains
P. Jones
Richardson Centre for Functional Foods and Nutraceuticals, Winnipeg, MB, Canada
Cereal Foods World 54:A13

Evaluation of efficacy and safety of bioactive ingredients in well controlled clinical trials represents the hallmark of evidence needed to establish health claims for functional foods. Clinical trials have been used to successfully study many different cereal grains, however, variations in study design and endpoint measures selected can influence the usefulness of the data that emerge from such trials. Optimal study designs for proof-of-concept studies examining cereal grains include randomized, crossover approaches with controlled feeding regimens to optimize volunteer compliance. The dosage of and duration of intervention with the cereal of interest must be given careful consideration, as well as the manner in which that material is matrixed into the food or capsule provided. The study subject group to be studied must be carefully selected. In addition, the primary and secondary endpoints must be chosen so as to ensure that the appropriate disease surrogate marker has been identified. For instance, measuring the lipid lowering capacity of a cereal bioactive component may be inappropriate if the health advantage of that bioactive has been shown to be more likely to affect glucose and or insulin metabolism. Also important in the clinical evaluation is maintaining the correct level of blinding through the investigation and ensuring that adequate samples have been collected to enable secondary "freezer study" analyses to be carried out subsequent to completion of the study trial itself. Such aspects of clinical evaluation of cereal grain foods and food-related bioactives are important in ensuring that data emerging from such human studies are of the highest quality and applicability to understanding potential health effects.

Use of cell culture techniques to link cereal grain components to reduction of disease risk in humans
D. Pascoe
Cargill Animal Nutrition, Elk River, MN
Cereal Foods World 54:A13

The use of in vitro models, specifically cell culture has been neglected in many applications of nutraceuticals and functional foods. Cell culture has several advantages over other models: simplicity, high through-put, increased turn-around time, and accessibility of cell lines. Today the options for obtaining an immortalized cell line for every major tissue in humans exists with the additional benefit of being able to create specialized cells through somatic, stem, and hybridoma cells. A particular cell line can become a screening tool under diverse designs to accommodate the question being asked. The creativity with which some in vitro models have been successfully applied and published provides opportunity. The opportunity to apply these models to the evaluation of whole grain components has never had more momentum. Carbohydrate characterization in cereal grains has been evaluated, but with new processing technologies and diverse grain genetics, similar polymers may have different functionalities and are often not found in related publications. Data from two different cell culture models (immune and endothelial cell lines) will be shared to demonstrate the opportunity to further investigate whole grain components.

Understanding the nutritional benefits of cereal foods through animal models
W. Yokoyama, H. Kim
USDA, ARS, Albany, CA
Cereal Foods World 54:A13

Ideally, individuals consume nutritious foods with the objective to optimize their health and longevity. However, often nutrition is a component of a program to restore health or prevent further deterioration of an unhealthy condition. For example, about 50% of the U.S. population have high blood cholesterol and hypercholesterolemia is a risk factor for cardiovascular disease. Blood cholesterol can be reduced by cereal beta-glucans. As a result of human studies and 39 animal studies FDA approved health claims for cereal beta-glucans. Cereals contain a diverse array of phytochemicals including tocols, plant sterols, dietary fibers, and proteins that have beneficial bioactive properties. Sterols reduce blood cholesterol, fiber prevents colon cancer, and protein hydrolysates can reduce hypertension. Soluble dietary fibers prevent many of the obesity related metabolic disease characteristics such as hypercholesterolemia, abdominal fat weight gain, fatty liver, elevated fasting glucose and insulin, elevated blood pressure in hamsters on high fat diets. The development of molecular methods such as microarrays, pcr and antibodies has increased the utilization of animal models in order to discover new benefits of bioactive food components and to understand the molecular mechanisms behind their observed physiological activities.

Assessing availability of grain components using rapid techniques
R. G. Fulcher
University of Manitoba, Department of Food Science, Winnipeg, MB, Canada
Cereal Foods World 54:A13

Cereal grains contain an extraordinary range of bioactive substances, from soluble and insoluble fiber, through low molecular weight antioxidants,

phenolic compounds and high levels of vitamins and minerals, to potential antibiotic and anti-inflammatory compounds. The complexities associated with these numerous compounds relative to bioavailability, potential activities in mammalian systems, and effects of processing on their activities are difficult to assess, and often demand major financial investment in time, personnel, equipment. In addition, much of the expenditure is targeted to feeding studies (in both small mammals and humans), which are themselves prohibitively expensive and time-consuming. Such studies often are limited in the breadth of experimentation (i.e. number and frequency of feeding trials) that can be used economically, and this in turn often limits the utility and applicability of the results. Perhaps more critical is the fact that many important grain constituents are esterified and/or otherwise bound in mature grains such that they resist digestion. In order to assess the potential of these many compounds to act as bioactives, we therefore must first ask whether they can, in fact, be made available by simple digestive processes. To this end, we have begun to develop simple procedures to determine the level(s) of their release during digestion, and of the effects of manufacturing on the process.

In vitro assays for cereal grain based nutraceutical/functional ingredients

L. (Lucy) Yu
University of Maryland, College Park, MD
Cereal Foods World 54:A14

In vitro assays play a role in researching and developing nutraceuticals and functional foods although animal and pilot human studies are important to confirm the efficacy of nutraceuticals and functional foods. In vitro assays could be used for screening large number of samples, evaluating effects of food formulation and processing conditions on selected health component(s) or optimizing food formulation and processing conditions, investigating the possible mechanisms behind the biological actions of food factors, and identifying possible marketing factors. Examples will be discussed with the emphases on assay selection, important health factors of cereal grains, and the interpretation of the results from in vitro assays. The examples will include improving functionality of psyllium and enhancing antioxidant availability of wheat-based food ingredients and food products.

Evaluating the structure function relationships of dietary fibre: Cereal beta-glucan, a special case

P. Wood
Agriculture and Agri-Food Canada, Guelph, ON, Canada
Cereal Foods World 54:A14

Consumption of oat and barley products leads to reduced levels of serum cholesterol, associated with a lower risk of heart disease. The US and other jurisdictions have allowed health claims on this basis, and identify oat soluble fiber as a bioactive ingredient on which to base the claim. The soluble fiber sub-division of dietary fiber was originally intended to distinguish those fibers which appeared to modify glycemic response by virtue of a capacity at low concentrations to greatly increase solution viscosity. These polysaccharides also lowered serum cholesterol levels. Viscosity is a property of polysaccharides controlled by molecular size and solubility. The soluble fibre naturally present in oats and barley, (1→3)(1→4)-beta-D-glucan (beta-glucan) is a linear high MW polysaccharide which at low concentrations in water generates shear sensitive high viscosity which above about 0.2-3% increases exponentially with concentration and MW. Health claims specify that an eligible food source must reasonably be able to supply a daily intake of 3 g beta-glucan. However, if physiological effect is related to development of viscosity in solution, and if there is variation between food sources in solubility and MW, total amount of beta-glucan may not fully describe bioactivity. Various studies indicate that there are indeed differences in solubility and MW distribution of beta-glucan amongst the different cereals and amongst varieties of each. In addition to differences based on cereal source, changes may arise during processing/cooking. The presence of beta-glucanases in wheat flour leads to depolymerization of beta-glucan incorporated into wheat based foods such as bread and pasta. Depolymerization may produce both an increase and decrease in solubility within food products, and freeze-thaw treatments may greatly modify solubility. Data showing strong correlation between attenuation of glycemic response and solubility, MW distribution and viscosity in different food matrices will be reported, and approaches to evaluating bioactivity of foods in terms of these properties will be suggested. The literature on the role that the physicochemical properties of beta-glucan play in the lowering of serum cholesterol levels is less clear and will be discussed.

A physicochemical method for evaluation of health effects of cereal fibre

T. Sontag-Strohm, R. Kivelä, L. Nyström, H. SALOVAARA
University of Helsinki, Helsinki, Finland
Cereal Foods World 54:A14

The paper describes a viscometric method for evaluation of the physiological potential of extractable and soluble dietary fibre, such as oat beta-glucan. Dietary fibre is a concept that includes nondigestable carbohydrates of various chemical structures, sizes and physicochemical characteristics. The mechanisms imparting the health benefits of dietary fibre are not fully understood. However, there is clear evidence that the physicochemical characteristics, such as increased lumen viscosity, as caused by viscous dietary fibre, contribute to the physiological health effects, for instance to blood glucose attenuation, and probably to cholesterol lowering. Surprisingly, little attention has been paid to development of analytical methods which describe the physicochemical properties of the various forms of dietary fibre. We have used an in vitro type method for the characterisation of the soluble fibre found in oat foods. The soluble fibre is extracted in a manner mimicking the procedure applied in the original Asp analysis for dietary fibre. The modified procedure includes a concentration step and measurement of the apparent viscosity of extracts containing increasing concentrations of the oat beta-glucan. Informative curves are finally obtained by plotting the viscosities against beta-glucan concentration. The method has been used as a complementary tool to dietary fibre analysis for predicting physiological health effects of foods and ingredients containing oat beta-glucan. Evidently such a method is of great value to those working in product development in industry and to those performing clinical studies for substantiation of health claim potential. The paper also discusses the role of various mechanisms which may possibly cause instability of beta-glucan and its physicochemical properties.

2009 Annual Meeting
Abstracts of Oral Presentations

Abstracts submitted for oral presentations at the 2009 annual meeting in Baltimore, Maryland, September 13–16. 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.

Fundamental studies on molecular interactions in starch/PVOH/clay nanocomposites used for making biodegradable packaging films

S. S. ALI (1), X. Tang (1), S. Alavi (1), J. Faubion (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A15

The use of petroleum-based packaging material is of great environmental concern and also a drain on limited non-renewable resources. This study focuses on replacing petroleum-based films with starch-based biodegradable films, which are comparable in cost and performance. In this study, nanocomposites of poly(vinyl alcohol) (PVOH), starch and clay were produced using solution and melt extrusion methods. X-ray diffraction (XRD), transmission electron microscopy (TEM) and differential scanning calorimetry (DSC) studies were carried out to determine the d-spacing between clay nano-layers, study the nano-structural conformation of starch and clay particles, and measure the glass transition (Tg) properties of the nanocomposites, respectively. This greatly facilitated an understanding of the molecular interaction in the multi-component starch/PVOH/clay nanocomposites. Results from XRD and TEM explained the phenomenon of intercalation and exfoliation in the nanocomposites made from both solution and melt extrusion methods. It was observed that nanocomposites made by solution method showed good intercalation but lesser exfoliation than films made from nanocomposites developed through melt extrusion. The higher shear and mechanical energy from extrusion system helped in better dispersion of clay layers which resulted in better exfoliation. DSC studies showed an increase the Tg when clay was added to the PVOH/ starch system. This increase in Tg was due to the phenomenon of intercalation in the nanocomposites. Study on mechanical and barrier properties showed that tensile strength and elongation at break of films ranged from 17.1 to 23.5 MPa and 63.4 to 130.5% respectively, while water vapor permeability ranged from 1.51 to 1.91 g.mm/kPa.h.m^2. This study helped in understanding the underlying phenomena that regulate these critical performance parameters.

Comparison of rheological properties of gluten modified with changes in surface tension and disulfide linkages

A. A. AMBARDEKAR (1), P. Kalyanaraman (1), S. Mulvaney (2), P. Rayas-Duarte (1)
(1) Robert M Kerr Food & Agricultural Products Center, Oklahoma State University, Stillwater, OK; (2) Department of Food Science, Cornell University, Ithaca, NY
Cereal Foods World 54:A15

A study involving changes in surface tension and the oxidation state of gluten and the effect of its rheological properties is reported. Surface tension and disulfide linkages in gluten were changed by using diacetyl tartaric acid ester of monoglycerides (DATEM) (0.3, 0.6 and 1.0% w/w) and ascorbic acid (AA) (50, 100, 150, and 200 ppm), respectively. These levels were applied to six commercial hard red winter wheat flours with different protein quantity (8 to 13.7% protein) and quality. Flours with no treatment were used as controls. Viscoelastic properties of gluten were analyzed with a creep-recovery method. Molecular weight distribution, monomeric to polymeric proteins ratios and allelic variation of high and low molecular weight glutenin subunits were also analyzed. Baking properties were evaluated using a straight dough method on pup loaves. The levels of surface tension modifications used decreased creep-recovery compliance in all flours by 31 to 50%, strengthening the gluten. The decrease in creep-recovery compliance of gluten with modifications in their oxidative state was lower (19 to 35%) than the surface tension changes and observed in a reduced number of samples. Changes in surface tension modifications showed significant increase in specific volume (density) of loaves in all levels of DATEM and flours by 12 to 23%. No significant differences were observed in specific volumes in loaves treated with AA. The results of this study suggest that changes in surface tension were more effective in increasing the elastic response of gluten (decreased compliance) compared to oxidative changes promoting disulfide bond formation.

Carotenoid production on whole stillage by mixed and monoculture fermentation of *Phaffia rhodozyma* and *Sporobolomyces roseus*

N. ANANDA KONAYAKANA HALLI (1), P. Vadlani (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A15

Whole stillage, a by-product of the corn-based ethanol industry, is used as animal feed in the form of Dried Distiller's grain with Solubles (DDGS). Carotenoids are added separately to animal feed to enhance meat color and quality, vitamin-A levels in milk and meat, and reproductive efficiency. This study explored the use of whole stillage as a substrate for carotenoid production by red yeasts, *Phaffia rhodozyma* and *Sporobolomyces roseus*, and compared their production in mono and mixed culture fermentations. Astaxanthin and β-carotene were produced by *P. rhodozyma*, while *S. roseus* produced only β-carotene. Submerged fermentation of whole stillage medium supplemented with glycerol and corn steep liquor was carried out in shake flasks at 20°C, 180 rpm for nine days. At the end of fermentation, samples were freeze dried and analyzed for astaxanthin and β-carotene using HPLC, with confirmation by MALDI/TOF-MS. Carotenoid concentration was expressed as µg/g of freeze-dried whole stillage. This study showed that mixed culture fermentation of whole stillage for astaxanthin and β-carotene production is feasible, wherein *P. rhodozyma* accounted for 6.5% astaxanthin, and *P. rhodozyma* and *S. roseus* accounted for 93.5% β-carotene prior to

optimization. *Phaffia rhodozyma* monoculture (90 µg/g) produced twice the astaxanthin yield as mixed culture (43 µg/g) fermentation. β-carotene yield in mixed culture was 623.5 µg/g, which was similar to that of *S. roseus* (696.5 µg/g) and significantly greater than that in *P. rhodozyma* (100 µg/g). This study showed that carotenoid-enriched whole stillage can be produced by secondary fermentation and has promising application in animal feed and feed blends.

Structural changes from native waxy maize starch granules to water soluble dextrin

Y. BAI (1), Y. Shi (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A16

Producing dextrin by heating a starch in the presence of acid has been known for a long time but the detailed structural changes during the dextrinization process is not well understood. In this study, structural changes from native waxy maize starch granules to water soluble dextrin were investigated by synchrotron based small angle X-ray scattering (WAXS) and wide angle X-ray diffraction (SAXD), and new insight was obtained regarding the structural changes during dextrinization. Waxy maize starch (40% solids, w/w) was slurried in water, adjusted to pH 3.0 by 0.5N HCl, filtered and air dried. The air dried starch was ground and heated at 170°C for 30 min and 4 h, resulting in dextrins with 21 and 100% solubility in water, respectively. Even though the dextrin heated for 4 h was 100% water soluble, it was still birefringent when viewed in glycerin under polarized light and shown granular structure. In addition, the two dextrins displayed A-type crystalline pattern as determined by WAXD. The dextrin of 21% solubility did not have any peak in pure glycerin in SAXS, but a peak at about 0.6 nm^{-1} appeared when a mixture of water and glycerin (2:8, w/w) was mixed with the dextrin. However, the peak size was reduced compared to the native starch. For the dextrin with 100% solubility, no peak was observed in SAXS when it was hydrated with the mixture of water and glycerin, indicating that the regularity between the amorphous and crystalline regions was destroyed during the dextrinization process.

Molecular markers for starch quality improvement in rice

J. BAO (1), H. Corke (2), M. Sun (2)
(1) Zhejiang Univ, Hangzhou, PEOPLES REP OF CHINA; (2) School of Biological Sciences, The University of Hong Kong, Hong Kong, P R China
Cereal Foods World 54:A16

Quantitative trait loci (QTLs) mapping and association mapping are currently used to dissect the natural occurring variations for traits of agronomical importance. We found that the major QTLs for starch quality co-locate at the starch-synthesizing gene loci, e.g. *Wx* locus controls the genetic basis of amylose content, pasting viscosity, gel texture and retrogradation properties, while *starch synthase IIa* (*SSIIa*) locus controls the gelatinization temperature (GT) and amylopectin structure. Some of other genes involved in starch biosynthesis and other minor QTLs were also detected. Gene tagged markers such as simple sequence repeat (SSR) and single nucleotide polymorphism (SNP) that were inside or close to those starch-synthesizing genes were designed. Among 499 nonwaxy rice accessions, polymorphisms of SSR in the *Wx* gene, soluble starch synthase I gene (*SS1*) and starch branching enzyme I gene (*SBE1*), SNPs in *Wx* and starch branching enzyme III gene (*SBE3*) and *SSIIa*, and a sequence tagged site (STS) in *SBE1* were surveyed. Ten SSR alleles were found at the *Wx* locus and four SSR alleles were found at the *SBE1* and *SS1*, respectively. Two continuous SNPs (GC/TT) alone can differentiate rice with high or intermediate GT (possessing GC SNPs) from those with low GT (possessing the TT SNPs). Association test was conducted using all starch gene markers. Results indicated that *Wx* SSR and SNPs were strongly associated with amylose content, pasting viscosities, gel hardness, and retrogradation properties, whereas the *SSIIa* GC/TT SNPs were strongly associated with the pasting temperature and retrogradation properties, which confirmed the findings from QTL mapping. These markers are useful in molecular breeding for improvement of rice eating and cooking qualities. This study was jointly supported by funds from NSFC (30771327), 863 project (2006AA10Z193), Science and Technology Department of Zhejiang Province (2007C32014) and IAEA (12847).

Dietary interventions with fibre ingredients – considerations, measurements and manipulations

E. J. BECK (1), L. C. Tapsell (1), S. M. Tosh (2), M. J. Batterham (1), X. Huang (1)
(1) University of Wollongong, New South Wales, AUSTRALIA; (2) Agriculture and Agri-Food Canada, Guelph, Ontario, Canada
Cereal Foods World 54:A16

Large bodies of epidemiological data show an inverse relationship between dietary fibre intake and body weight so the logic of including fibre in an energy-controlled diet remains tantalizing, but practicalities need to be confirmed. In this analysis we show the impact of fibre enriched foods on dietary intakes in a randomised-controlled dietary intervention trial. The trial was designed to measure the effects of increased levels of intake of the mixed linkage β-glucan in oat bran on weight reduction. Products were developed to provide significant levels of β-glucan at breakfast (3–5 g) and afternoon tea (3–4 g). Molecular weight, viscosity and solubility were determined to ensure the integrity of products. Dietary modelling for intervention advice considered usual dietary patterns and study dietary targets. Compliance was monitored using 3-day weighed food records. Despite a significant reduction in total energy intake (8725 kJ at baseline vs 6000 kJ at three months, $P < 0.001$), and a significant difference in fibre intake between groups (control 22 g vs high β-glucan 33 g, $P < 0.001$) the amount of bread and cereal products consumed by both groups was similar and maintained throughout the study. Analysis of food records indicated that >90% of the change in fibre intake was attributed to the supplied intervention products. This demonstrates that product development of high fibre foods enables high fibre intake with usual consumption levels in the context of an energy-restricted diet. Subjects, as a representative group of consumers, could significantly increase fibre intake with well-designed functional foods rather than consuming greater amounts of cereal-based products.

Rice sustainability will require enhanced grain nutrient profiles

C. BERGMAN (1), A. McClung (2), E. T. Champagne (3), C. C. Grimm (3), M. Chen (4)
(1) Department of Food and Beverage Management, University of Nevada, Las Vegas; (2) Dale Bumpers National Rice Research Center, Stuttgart, AR; (3) Food Processing and Sensory Quality Research, USDA, New Orleans, LA; (4) USDA, Beaumont, TX
Cereal Foods World 54:A16

The term sustainability when referring to rice production means different things to different groups of people. For rice farmers, the focus is generally on the use of production practices that preserve the growing environment's productivity. Those in the nutrition and food processing arenas include in the definition of rice sustainability that it be produced in sufficient quantity and quality to meet the cultural desires and health needs of the human population. Much of the globe's population today suffers from two forms of malnutrition: over- and under-nutrition. Thus rice needs to include nutrients and fractions that will meet the health needs of both of these groups. There are many research projects under way across the globe focused on enhancing the health benefits of rice. This presentation will address two of these. We are working to understand consumer preferences for milled versus brown rice. Both forms of malnutrition could be lessened by changing eaters' preferences from milled to unmilled rice. Those that are under-nourished would benefit from consuming more protein and essential vitamins and minerals. Those suffering from chronic diseases related to over-nutrition would also likely benefit due to the association between whole grain consumption and reduced risk of developing heart disease and some forms of cancer. We are also working to understand the potential for using a giant embryo mutant to increase kilocalorie intake of those that are under-nourished. This mutant is also being evaluated for its potential use as a cultivar designed to increase the levels of several cholesterol lowering fractions contained in rice bran oil. The health needs of rice consumers across the planet are many. Rice can no longer be looked at as only a source of kilocalories. For rice to be sustainable, cultivars must be developed that are specifically designed and processed to meet human health needs.

Molecular composition of acid-resistant crystals obtained from waxy maize starch granules

E. BERTOFT (1), S. Pérez (2), H. Angellier-Coussy (3), J. Putaux (2), S. Molina-Boisseau (2), A. Dufresne (4)
(1) Swedish Univ of Agricultural Sciences, Uppsala, SWEDEN; (2) CERMAV-CNRS, Grenoble, France; (3) Université Montpellier II, Montpellier, France; (4) Pagora Grenoble INP, Saint Martin d'Hères, France
Cereal Foods World 54:A16

Crystals of remarkable specific shapes of the nano-size scale were obtained by treatment of waxy maize starch granules in diluted sulfuric acid. In this work the molecular composition of the crystals was investigated. The crystals were composed of two main fractions also described by several other groups, namely a major group usually denoted "the linear fraction" with a degree of polymerization (DP) around 13, and a minor group known as "singly branched dextrins" at DP around 25. The two groups were isolated by gel-permeation chromatography into fractions named C and A, respectively, and their structures were further analysed using enzymatic treatments in combination

with high-performance anion-exchange chromatography (HPAEC). From the estimations of the molar amounts of the products obtained by debranching and β-amylolysis, it was possible to quantitatively describe the composition and the principal molecular structures of the dextrins in the two fractions. It was found that a substantial part (1/3) of the "linear" fraction C was in fact composed of branched dextrins, probably singly branched, and the "singly branched" fraction A was to a large extent composed of multiply branched dextrins. Overall, the quantitative data suggested a regular distribution of linear and branched molecular species, including the position of the branches at either the non-reducing or the reducing-end side of the molecules. As the nano-crystals were remnants of acid-resistant crystalline lamellae inside the starch granules, their composition reflected the molecular structure of the lamellae, of which probably the branches were remnants of the branched building blocks that build up the clusters of the amylopectin macromolecule.

Recent applications of small-angle scattering techniques in the structural characterisation of resistant starches

J. BLAZEK (1), A. R. Bird (2), M. K. Morell (3), Z. Zhou (2), M. J. Gidley (4), I. A. Appelqvist (5), E. P. Gilbert (1)
(1) Bragg Institute, Australian Nuclear Science and Technology Organisation, Menai, New South Wales, Australia; (2) Commonwealth Scientific and Industrial Research Organisation, Human Nutrition, Adelaide, South Australia, Australia; (3) Commonwealth Scientific and Industrial Research Organisation, Plant Industry, Canberra, Australian Capital Territory, Australia; (4) Centre for Nutrition and Food Sciences, University of Queensland, St Lucia, Queensland, AUSTRALIA; (5) Commonwealth Scientific and Industrial Research Organisation, Food Science Australia, North Ryde, NSW, Australia
Cereal Foods World 54:A17

A major challenge in cereal biotechnology is to achieve rational design of renewable polymers to meet specific requirements for improving human health, nutrition and food quality. Increasing awareness of the health benefits of resistant starch, and enhanced understanding of the role of amylose content on the wide range of industrially important properties of starches, can be exploited to create novel variability in carbohydrate polymers in cereal grains. Small angle neutron and X-ray scattering techniques available at the Australian Nuclear Science and Technology Organisation have been used in collaboration with the Food Futures Flagship to enhance our understanding of the structural changes occurring in starch-based systems during digestion. Scattering methods offer a unique potential to directly probe materials on length-scales between those of modern crystallography and microscopy, thus bridging the gap in spatial resolution between the two groups of techniques. Our group has applied scattering techniques in multidisciplinary studies of the molecular structure of starch fractions resistant to digestion. Previous studies using native starches subjected to in vitro digestion suggested that enzyme resistant starch is not a specific structure present in predigested starches but is in fact formed during the digestion process through the rearrangement of amylose chains into enzyme-resistant structures. It is of interest to elucidate whether similar principles to the ones observed in simple in vitro systems apply during the in vivo digestion of starch-based products. Understanding the structural mechanisms governing starch digestion will make it possible to design and select those ingredients and processes which render desirable structural morphologies and nutritional properties.

Influence of starch structure on the swelling and leaching of starch microparticles

N. BORDENAVE (1), Y. Yao (1)
(1) Purdue University, West Lafayette, IN, U.S.A.
Cereal Foods World 54:A17

Starch micro-particulate is of great interest as an economic and effective carrier for the protection and controlled release of active substances. The functional properties of starch microparticles are affected by their capability to swell and leach in aqueous system. The current work aims to understand the relationship between the molecular structure of starch and the swelling and leaching behavior of microparticles. Starch microparticles were made using reverse emulsion methodology, in which starch aqueous solution was dispersed in mineral oil. The starch-containing aqueous droplets were allowed to retrograde to solidify for particle collection. To study the influence of starch structure, normal corn starch (NCS) and high amylose corn starch (HACS) were subjected to acid treatment and/or debranching. Particle size, swelling and leaching properties of starch microparticles were evaluated. The molecular weight distribution of treated starch and leached materials were characterized by high performance size-exclusion chromatography. Particles average diameters ranged between 8 and 15 mm. Starch microparticle swelling and leaching was associated with starch sources and the treatments. For NCS, debranching substantially reduced swelling and increased leaching, and acid treatment enhanced leaching and reduced the swelling of native starch. In contrast, for HACS debranching significantly reduced the leaching whereas having minor effect on swelling, and acid treatment had negligible impact on swelling and possibly minor impact on leaching. Conceivably, the difference of amylose content and amylopectin structure between NCS and HACS was a primary factor of different swelling and leaching behaviors. This study provides knowledge on the behavior of starch microparticles as functional carriers.

Isogenic wheat discrimination via *in situ* FT-IR microspectroscopy and imaging

L. R. BREWER (1), D. L. Wetzel (1)
(1) Microbeam Molecular Spectroscopy Laboratory, Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A17

Isogenic waxy wheat lines differ from their non-waxy wild type parents in their functionality, end use, their amylopectin content in place of amylose, and an increase presence of lipids. In breadmaking, blending a portion (non amylose containing) wheat flour with that of normal (wild) wheat has been used to advantage. Genetic expression characterization of waxy kernels vs non-waxy parents in chemical terms, is performed using FT-IR microspectroscopic *in situ* probing and imaging of kernel frozen sections applied to genetically pure, well documented isogenic breeding lines. The motive is to assist the current plant breeding efforts to develop new lines targeted for breadmaking that incorporate desirable traits from both genetic sources by spectroscopically determining the relative compositional change of individual experimental lines. Preliminary InSb chemical imaging in the near IR was successful in sorting parent wheat kernels from nulls. The objective of the present study has been to use microspectroscopy of high spatial resolution on mid IR fundamental vibrations and mass spectrometry of the lipid extracts to elucidate the chemical manifestation of the waxy genetic expression. Isogenic waxy lines of a particular hard wheat for comparison with their parent wild type included a hexaploid triple null involving all three wheat genomes (A B D), three double nulls, and three single nulls. Genetic properties differ slightly for the Durum wheat, used in pasta making which is a tetraploid, only containing the A and B genomes for waxy traits. The genetic expression of the waxy gene influence is shown in dramatic vibrational spectroscopic terms by comparing the spectra from numerous contiguous pixels of the endosperm images of the triple null with a single group of endosperm spectra from the parent. Comparison within groups of spectra tests for homogeneity and establishes a consensus resulting in a mean spectrum. Enhanced visualization is produced via spectral subtraction and multivariate pattern recognition is applied. These resulting spectroscopic criteria for waxy genetic expression are applied to the double null and single null isogenic specimens. The mass spectrometry of lipid extracts is used to compliment the infrared data.

Cellulolytic enzyme system production in mixed fungal culture and its utilization for lignocellulosic biomass hydrolysis

K. BRIJWANI (1), H. S. Oberoi (1), P. V. Vadlani (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A17

To attain the DOE milestone of 60 billion gallons of ethanol by 2030, the emerging cellulosic technologies need to mature. The most crucial stage in bioethanol production from lignocellulosic biomass is the enzymatic saccharification. Efficient enzymatic hydrolysis of lignocellulosic biomass involves synergistic action of several enzymes (cellulases, β-glucosidase and xylanase) that are together called as cellulase enzyme system. Solid state fermentation is a proven approach to produce the enzyme system in a single process. Production and characterization of balanced cellulase enzyme system in mixed-culture solid-state fermentation has been demonstrated in this study. Fermentation was performed using co-culture of *Trichoderma reesei* and *Aspergillus oryzae* on soybean hulls supplemented with wheat bran as solid media. Three parameters - initial moisture content, incubation temperature, and initial pH - were optimized with respect to filter paper and β-glucosidase activities in culture flasks using response surface methodology. Optimized parameters were used for laboratory scale-up in tray fermenters. Fermentation was performed for the period of 120 hours and an incubation period of 96 hours was found to be optimum. Expression profiles of the cellulase complex were characterized using SDS-PAGE. The enzyme broth after 96 hours was concentrated and used for saccharification of pretreated wheat straw. Pretreatment using both acid and alkali were performed and differences in sugar yields were reported. Results showed that alkali treatment generated higher sugar levels than acid pretreatment. This was due to lignin removal and concentration of cellulosic fraction. Current work shows that a well balanced celluloytic enzyme system can be produced in mixed fungal cultures, which can efficiently saccharify lignocellulosic biomass such as wheat straw into fermentable sugars.

Potential influence of ferulate oligomers on physiological effects of cereal dietary fibers

M. BUNZEL (1)
(1) University of Minnesota, Department of Food Science and Nutrition, St. Paul, MN, U.S.A.
Cereal Foods World 54:A18

Young Scientist Research Award

Cereal grain plant cell walls are a major source of dietary fiber. Hydroxycinnamates, i.e. ferulate derivatives, are minor components within the plant cell wall. Due to their ability to act as cross-links between polysaccharides they strongly influence the physico-chemical properties of the cell wall. As most physiological effects of dietary fibers are closely related to their physico-chemical properties ferulate derivatives are supposed to influence the physiological effects of cereal fibers. Two studies will be presented investigating how ferulate oligomers might modulate the physiological properties of cereal fibers. In the first study, we tested the influence of feruloylation on cell wall degradability by human fecal microbiota. Nonlignified primary cell walls from maize cell suspensions, containing varying degrees of ferulate substitution and diferulate cross-linking, were incubated in nylon bags in vitro with human fecal microbiota. Shifting cell wall concentrations of total ferulates from 1.5 to 15.8 mg/g and diferulates from 0.8 to 2.6 mg/g did not alter the release of carbohydrates or the overall degradation of cell walls. The results indicate that low to moderate levels of ferulates and diferulates do not interfere with hydrolysis of nonlignified cell walls by human gut microbiota. In the second study, we tested whether cross-linking of arabinoxylans through ferulate oligomers alter the effects of arabinoxylans on postprandial blood glucose levels. We isolated arabinoxylans from corn bran and cross-linked them by oxidative coupling using laccase/oxygen. The formed gels were dried and used in a one-meal animal feeding study. The starch-based meals contained fibers from different sources including arabinoxylan gels. We demonstrated that arabinoxylan gels blunt the blood glucose maximum and shift this maximum to later time points after feeding. Long-term feeding studies are required to support these promising data.

Prediction of fermentable starch content of corn by near-infrared spectroscopy

A. BURGERS (1), C. R. Hurburgh (1)
(1) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A18

Measuring the fermentable starch content of corn allows ethanol plants to know how much ethanol can be produced from a specific lot of corn. Laboratory fermentable starch measurement can take hours to days to complete. Near-infrared spectroscopy (NIRS) is a rapid nondestructive technique that is able to measure organic substances in minutes. The objective of this study was to develop an NIRS fermentable starch calibration using spectra and reference data, then compare the fermentable starch calibration to the regression analysis of combinations of NIRS- predicted values of protein, oil, starch, and density. Near infrared (NIR) spectra from a FOSS Infratec 1229 Grain Analyzer were obtained for 249 corn samples from the 2006 and 2007 crops. Laboratory fermentable starch measurements came from the Illinois Crop Improvement Association. A partial least squares (PLS) calibration relating fermentable starch content to NIR spectra was developed. A multiple linear regression (MLR) including combinations of current NIR measurements (protein, oil, starch and density on a 15% moisture basis) was also created. The first external validation was conducted using 26 new samples representing a wide range of composition. The second validation used 30 samples from the 2008 corn crop. The NIR calibration for fermentable starch had a R^2 of 0.863 and a SECV of 0.025, while the combination of protein, oil, starch, and density had a R^2 of 0.80 and a SECV of 0.030. However, the calibration had poor results in predicting corn ethanol yield from the new samples, with an SEP = 0.40 and a R^2 = 0.28. The component model gave consistent results with the best combination being protein, oil and density with an SEP = 0.044 and a R^2 = 0.88. Implementing a constituent calculation is easier and more economical than implementing a new NIRS calibration. Any NIRS unit can use constituent regression.

Limitations in the effectiveness of size exclusion chromatography (SEC, or GPC) on the analysis of starch

R. A. CAVE (1), S. A. Seabrook (1), M. J. Gidley (1), R. Gilbert (1)
(1) University of Queensland, Brisbane, QLD, AUSTRALIA
Cereal Foods World 54:A18

The size distributions of starch molecules are important for establishing biosynthesis-processing-structure-property relations. The applicability and reliability of the application of conventional size exclusion chromatography methods to the analysis of starch has been studied using a combination of experimental data and droplet-shear theory. These data were obtained using a solvent/eluent system, DMSO + LiBr, which fully dissolves the starch from a natural source (rice in this case) without degradation. It has been shown that conventional SEC (or GPC) is limited to the analysis of the smaller, less branched, amylose molecules, due to shear forces in the system and their effect on the amylopectin. Although this has been observed previously, it has never been accurately quantified. The amylopectin region, for hydrodynamic radii > ~175 nm, is shown to degrade substantially by shear scission, even at the lowest flow rates. A combination of theory and experiment shows that the flow rate and/or eluent viscosity in the system would need to be reduced by order of magnitude lower than what is currently possible. However, the distribution of the amylose region obtained from SEC with lower flow rates can be shown to be effectively unpolluted by the shear-scission products of larger chains, allowing reliable analysis of this region. This work thus shows that the only way that true full size distributions of starch requires two modes of separation: SEC for the smaller component (largely amylose), with the study being performed over a range of flow rates, and a low-shear separation technique such as field-flow fractionation for the larger component (amylopectin).

Characterisation and functionality of brewers' spent grain proteins and their hydrolysates

I. CELUS (1), K. Brijs (1), J. A. Delcour (1)
(1) Laboratory of Food Chemistry and Biochemistry & Leuven Food Science and Nutrition Research Centre (LFoRCe), K.U.Leuven, Leuven, Belgium
Cereal Foods World 54:A18

Brewers' spent grain (BSG), the residue of barley malt resulting from beer wort production, is the main co-product of the brewing industry. However, its main application is limited to animal feeding. The aim of this work was to provide a scientific basis for the valorization of one of the main constituents of BSG, i.e. the protein constituents. Enzymatic conversion of BSG proteins to hydrolysates with techno-functional as well as bio-functional properties was studied. Proteins in unmalted and malted barley and in BSG were fractionated based on their differential extractability in different media and the resultant fractions were characterized by SDS-PAGE and HPLC. Enzymatic hydrolysis of BSG protein concentrate (BPC), prepared by alkaline extraction of BSG followed by acid precipitation of the extractables, improved solubility and emulsion and foaming properties. Physico-chemical characterization of the hydrolysates indicated the importance of the presence of protein fragments with relatively high molecular weight (MW) (exceeding 14.5 k) and high surface hydrophobicity for favorable techno-functional properties. As BPC hydrolysates consisted of a heterogeneous mixture of peptides, they were further fractionated using precipitation with ethanol or ammonium sulfate to result in more homogeneous peptide fractions. It became clear that the physico-chemical properties required for emulsions differ from those required for foaming. The results clearly show that neither MW nor hydrophobicity alone determine the emulsifying and foaming properties. Angiotensin converting enzyme (ACE) inhibitory peptides, which can result in a blood pressure lowering effect, were purified from the BPC hydrolysates using affinity chromatography. Peptides with ACE inhibitory activity were identified.

Avenanthramides in oats: A new method of producing whole oats and oat ingredients with greatly elevated avenanthramide levels

F. COLLINS (1)
(1) Agric & Agri-Food Canada, Ottawa, ON, CANADA
Cereal Foods World 54:A18

Avenanthramides, of which over 35 distinct components have been found to date, represent the major readily-bioavailable, soluble phenolics present in the oat kernel These hydroxycinnamoyl alkaloids are found only in oats and have been shown to not only act as antioxidants but also to inhibit the pro-inflammatory processes associated with atherosclerotic disease progression. Based on recent *in vivo* pharmacokinetic results in humans and *in vitro* human vascular cell culture models, effective concentrations of avenanthramides required to influence vascular antioxidant status and the inflammatory response can be provisionally projected. Threshold response levels (approximately 30 to 60 mg from a dietary source delivery system such as a 50 g serving of oat bran) would require an oat product with at least 600 to 1,200 ppm total avenanthramides. This is a significantly higher concentration range than those currently recorded for existing oat varieties or existing whole grain oat products. Recently a process has been found that significantly increases the levels of avenanthramides in native oat kernels. Levels ranging from about 900 to 2,000 ppm in the whole groat, representing an enrichment factor of about 25- to 40-fold have been achieved by this process, without significantly altering the milling quality of the product. The process involves the concept of "false malting" wherein selected or pre-treated grain is conventionally malted but does not germinate. The selected oats refer to "dormant oat" varieties, i.e. varieties exhibiting secondary dormancy and preferably hulless, while non-dormant varieties can be made dormant using a

simple dry heat process. In-depth HPLC analyses of avenanthramides from oats treated by this patent-pending process show little if any qualitative differences relative to untreated oats. Abrasion bran fractions show levels as high as 3,500 ppm total avenanthramides.

Basic insights in cereal constituents as a basis for progress in cereal based biotechnological processes

J. A. DELCOUR (1)
(1) Katholieke Univ Leuven, Heverlee, BELGIUM
Cereal Foods World 54:A19

Thomas Burr Osborne Medal Award

The main constituent of cereals by far is starch, but proteins and nonstarch polysaccharides also occur in levels which impact cereal processing and functionality. The present Thomas Burr Osborne address deals with progress in research in which the presenter and members of the research group which he leads participated and which contributed to our basic understanding of cereal starches, proteins and nonstarch polysaccharides over the past two decades. A major element of progress has been in enzyme systems of microbial origin that modify specific cereal constituents and have been used to unravel their role in cereal applications. The address illustrates how acquired insights can be applied to develop and optimise cereal based biotechnological processes, the production of cereal derived health promoting constituents, and contribute to final product organoleptic properties. Thus, different links of the knowledge chain consisting of basic cereal research over application oriented research to final application will be discussed. Particular focus will be on the arabinoxylan system, the insights gained on its functionality by use of xylanases, the concept of xylanase inhibitors and the conversion of arabinoxylan in health promoting constituents.

Hyperspectral image analysis of damaged wheat kernels

S. R. DELWICHE (1), M. S. Kim (2)
(1) USDA-ARS, Beltsville, MD, U.S.A.; (2) USDA-ARS, BARC, Beltsville, MD, U.S.A.
Cereal Foods World 54:A19

While near-infrared (NIR) spectroscopy has been available to the cereals community for more than 30 years and digital image analysis for more than 20 years, the combination of these technologies to this field is a relatively new phenomenon. Known as hyperspectral or spectroscopic imaging, this technology has the potential to offer new rapid, objective methologies for assessment of grade, quality, and food safety issues in bulk samples of grain. Recently, our laboratory has assembled a hyperspectral imaging system that, unlike prevailing systems which operate in the silicon wavelength region (400 to 1000 nm), operates at longer wavelengths (~800–1600 nm). With this longer region, the information conveyed in classical NIR spectra (i.e., protein, oil, and carbohydrate structure) is now combined with morphological information from imagining. Applications of wheat kernel damage, as defined in U.S. wheat standards (e.g., black tip, frost damaged, and Fusarium damaged) are discussed in this presentation.

Dietary fiber methodology: AACC Approved Methods commensurate with dietary fiber research and the CODEX definition

J. W. DEVRIES (1), B. V. McCleary (2), G. Cohen (3), J. I. Rader (4), L. Prosky (5), D. C. Mugford (6), M. Champ (7), K. Okuma (8)
(1) Medallion Laboratories/General Mills, Minneapolis, MN, U.S.A.; (2) Megazyme, Wicklow, Ireland; (3) Kraft Foods, Tarrytown, NY, U.S.A.; (4) U.S. Food and Drug Administration, College Park, MD, U.S.A.; (5) Consultant, Rockville, MD, U.S.A.; (6) Bread Research Institute, North Ryde, NSW, Australia; (7) University of Nantes, Nantes, France; (8) Matsutani Chemical Co LTD, Itami Hyogo, Japan
Cereal Foods World 54:A19

Edith A. Christensen Award

From a nutrition perspective, dietary fiber is unique in that its benefits relate to its resistance to digestion. Consequently, dietary fiber consists of a digestion resistant complex mixture (mostly carbohydrate) of components that vary by source, preparation, and processing but exhibiting similar nutrition properties. Serious research on dietary fiber in the 1950–70's resulted in a definition by Trowell et al in 1976[1]. AACC International validated Approved Methods[2] 32-05, 32-06, 32-07, 32-20, 32-21, and 32-25 to match that definition. Scientific advances in the subsequent two decades resulted in the conclusion that additional components such as resistant starch and non-digestible oligosaccharides are, on a physiological basis, validly included in the Trowell et al definition, therefore AACC Approved Methods 32-28, 32-31, 32-32, 32-33, 32-40, and 32-41 for these components have also been validated. Recently, the CODEX Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU) has produced a single, concise, clarifying definition of Dietary Fiber (see ALINORM 09/32/26) that reflects the scientific findings of the past five plus decades. AACC International scientists are collaborating in the validation of an all inclusive method commensurate with this definition. Over a dozen laboratories have submitted data as part of the effort. A brief history[3], the method and collaborative study results will be covered. [1] Trowell 1976 Trowell, H.C., Southgate, D.A.T., Wolever, T.M.S., Leeds, A.R., Gassull, M.A., and Jenkins, D.J.A. 1976. Dietary fiber redefined. Lancet a:967 [2] 10th Edition Approved Methods of AACC. [3] J.W. DeVries and J.I. Rader. 2005 Historical Perspective as a Guide for Identifying and Developing Applicable Methods for Dietary Fiber. JAOAC International 88(5), pp 1349-1366.

Variation in polar lipid composition within near-isogenic wheat lines containing different puroindoline haplotypes

S. FINNIE (1), R. Jeannotte (2), C. F. Morris (3), M. Giroux (4), J. Faubion (1)
(1) KSU, Grain Science and Industry, Manhattan, KS, U.S.A.; (2) KSU, Division of Biology, Manhattan, KS, U.S.A.; (3) USDA-ARS WWQL; (4) Montana State University, Bozeman, MT, U.S.A.
Cereal Foods World 54:A19

Best Student Research Paper Competition

An extensive amount of research has investigated kernel hardness. However, the exact mechanism underlying this phenomenon is unknown. Puroindoline-a and puroindoline-b proteins must be present in their wild-type form to create soft textured wheat. Similar to puroindoline proteins, polar lipids are presenton the surface of starch granules. However, a full profile of the lipid species found on the surface of starch granules has not been reported. The objective of this research was to determine the specific polar lipid species present on the surface of wheat starch from near-isogenic wheat lines that contain different puroindoline haplotypes and endosperm hardness. Five near-isogenic wheat lines were used in this analysis, all derived from the soft cultivar Alpowa. Water-washed starch was isolated using a modified batter method. Direct infusion tandem mass spectrometry was used to identify the lipid species in both the flour and starch samples. Endosperm hardness had no significant effect on the polar lipid contents in wheat flour, had a slight influence on the polar lipid contents of the whole-meal fractions and had a significant influence on the composition of the polar lipids located on the surface of wheat starch. The greatest quantities of polar lipids on the starch surface occurred when both puroindoline proteins where present in their wild-type form. Starch surface polar lipid content dramatically decreased when one of the puroindoline proteins where null, or if the PIN-B was in the mutated form (Trp-44 to Arg). Within the hard textured samples, more polar lipids where presenton the starch surface when PIN-B was in its wild-type form and PIN-A was null than when PIN-A was in its wild-type form and PIN-B was null; the least amount of polar lipids where present when PIN-B was in its mutated form (Trp-44 to Arg) and PIN-A as in its wild-type form.

Improving the well-being of rice farmers and consumers by improving the tools to select for quality

M. FITZGERALD (1)
(1) Intl Rice Research Institute, Metro Manila, PHILIPPINES
Cereal Foods World 54:A19

The income of rice-farming families is determined by both yield and quality. The value of rice is determined by two traits of physical quality - chalk and broken grain. The secondary factor affecting price is the reputation of the variety in terms of sensory properties. A limitation to maximising farmers' profit is the difficulty of combining high yield with the desired package of quality traits. The International Treaty on Plant Genetic Resources for Food and Agriculture came into force in 2004, providing a clear legal framework for germplasm exchange, facilitating wider transfer of varieties and information. Germplasm is despatched with information on quality traits and this information is used as a selection criterion to determine the hybridisation program in which the variety is used, and generates expectations of grain quality in potential new varieties developed from the crosses. However different rice improvement programs use different methods to measure quality traits, and the low-cost methods for routine phenotyping are not always sufficiently discriminatory. In order to bring new science to old traits and to harmonise methods around the world, the International Network for Quality Rice (INQR) was formed. The INQR consists of every quality evaluator in national rice improvement programs, scientists whose research addresses rice quality, and companies with products relevant to rice quality. The INQR has several taskforces applying genetic, metabolomic, structural and rheological research to rice to understand the science underlying current traits and to identify new traits. The INQR is also carrying out ring tests, surveys and proficiency tests in order to standardise screening programs rice world-wide. This paper will report the work of the INQR and its progress on new traits of quality, and present an analysis of how this can improve the well-being of poor rice-farming families.

Utility of promoter sequence variation in plant breeding

A. FURTADO (1), R. J. Henry (1)
(1) Southern Cross University, Lismore, AUSTRALIA
Cereal Foods World 54:A20

DNA-based markers such as SNP and SSR, rely on the variations in DNA sequence, which in coding sequences can be determined by comparing EST sequences. The public availability of EST sequence data has supported the mining and discovery of a larger number of SNP-based markers. The advent of next generation sequencing (NGS) has accelerated the production of whole genome sequences providing sequence data of coding sequences but also of promoter sequences. The sequence variation within promoter sequences can now be harnessed to develop DNA-based markers for plant breeding. Promoter sequences are crucial for functional genomics where controlled expression of a transgene is desired to determine or confirm its function in transgenic plants. In addition, well characterised homologous and heterogonous promoters would be a valuable tool for successful gene stacking to impart multiple traits. We are interested in altering gene expression in the seed to manipulate grain quality. Several promoters from rice, wheat and barley that control the expression of genes in the grain were investigated to determine their utility to drive gene expression in the grain across these cereals for quality manipulation. Included in our study are the barley B- and D-hordein gene and the bifunctional alpha-amylase and subtilisin gene promoters, the rice glutelin-B1 and globulin gene promoters, and the wheat high molecular weight glutenin and the Early maturing gene promoters. Our data demonstrates that seed-specificity of these cereal promoters is not always maintained in other heterologous cereal suggesting adequate testing of promoters in the desired cereal. We also report the strength of these promoters and their potential to drive high levels of transgene expression in the cereal grain.

Arabinoxylan improves indices of gut health and reduces DNA damage in pigs consuming a high risk "Western diet": A pilot study

M. J. GIDLEY (1), B. A. Williams (1), D. Zhang (1), P. Gunness (1), D. Mikkelsen (1), B. Gorham (1), H. L. Keates (1), W. L. Bryden (1), D. P. Belobrajdic (2), M. A. Conlon (2), S. Kang (3), C. S. McSweeney (3), A. R. Bird (2), D. L. Topping (2)
(1) University of Queensland, St Lucia, QLD, AUSTRALIA; (2) CSIRO Food Futures Flagship; (3) CSIRO Livestock Industries
Cereal Foods World 54:A20

The effects of a wheat arabinoxylan concentrate on a range of gastrointestinal tract health-related indices were studied in a porcine model. Two groups of pigs (n = 5) were fed a highly-digestible Western-type diet containing barbecued red meat, with or without 10% arabinoxylan. After an experimental period of four weeks, the animals were euthanased and samples taken from the small intestine, caecum and large intestine for analysis of short chain fatty acids (SCFA), colonocyte DNA damage (Comet assay), microbial ecology (DNA- and RNA-based from both mucosa and digesta), and re-absorbed bile acids (hepatic portal vein). The results showed that consumption of the high risk diet containing the arabinoxylan fraction: (1) increased SCFA production, (2) reduced DNA damage in colonocytes, (3) modified the colonic microbial population favourably, and (4) decreased re-absorption of bile salts in the small intestine. This pilot study suggests that an arabinoxylan-enriched wheat fraction may improve health markers significantly, with implications for reduced risk of both cardiovascular and large bowel diseases.

Probing the molecular origins of starch properties: Methods and models

M. GIDLEY (1)
(1) Centre for Nutrition and Food Sciences, The University of Queensland, St Lucia, Brisbane, Australia
Cereal Foods World 54:A20

Alsberg-French-Schoch Memorial Lectureship

The deceptively simple text book description of starch as a polymer of glucose hides a multitude of complexity in hierarchical assembly, but also points to the opportunity of describing and modelling structure in ways that would not be possible for chemically more complex polymers. Thus, direct information on the range of polymer chain conformations for solid, solution, and gel forms, and quantitative descriptions of order at the helix and crystallite levels can all be obtained. The effect of chain length on aggregation, crystallisation and gelation properties can also be quantified using near monodisperse chains either separated from debranched starch/glycogen or synthesised by the action of phosphorylase. The resulting information provides baseline knowledge from which the behaviour of the complex polymer architectures found in granules and processed forms of starch can be extrapolated with the aid of materials models. The presentation will summarise learnings from model systems, and discuss how they may be applied to current scientific challenges such as identifying the factors responsible for granule integrity and the control of starch digestibility.

Using size distribution data to understand the mechanisms of starch biosynthesis, digestion and degradation

A. Gray-Weale (1), A. Wu (1), R. A. Cave (1), R. G. GILBERT (1)
(1) University of Queensland, Brisbane, QLD, AUSTRALIA
Cereal Foods World 54:A20

Size separation techniques, eg size-exclusion chromatography (SEC, or GPC) and field-flow fractionation, give various distributions of starch, such as the number of chains with a given size (viscometric detection), the weight of chains of a given size (DRI detection) and mass-squared distribution (MALLS).(These techniques separate by size, not by molecular weight, and can never give a true molecular weight distribution). These distributions contain information about starch biosynthesis and degradation (by processing, digestion or biodegradation). A simplified model for these processes is used to give expressions for the number distribution of fully branched chains, and of the debranched (chain-length) distributions. These solutions show how size separation data can be plotted to test the applicability of assumed mechanisms, and to obtain information on enzymatic rates. The model shows that debranched number distributions can be meaningfully plotted as ln(number distribution/degree of polymerization); fitting this form to extensive experimental data for rice and other starches shows that the rate of propagation by starch synthase is 5 times faster than the rate of action of the branching enzyme, the first time such enzymatic rate data have been obtained for an in vivo (indeed, in rice paddy!) system. This ratio is insensitive to the type of grain, which has implications for conserved processes in evolution. Ways in which data for branched distributions from various detectors can be usefully plotted will be also be presented and illustrated. Thus, for MALLS, rate ratios are obtained by plotting (MALLS signal/mass2) against hydrodynamic volume. DRI and viscometric data for rice starch treated with this methodology show that larger amylopectin molecules are effectively randomly branched on size scales of importance, which is of significance for digestion.

Toward high quality whole grain soft wheat flour

M. J. GUTTIERI (1), C. H. Sneller (1), E. J. Souza (2)
(1) The Ohio State University, Wooster, OH, U.S.A.; (2) USDA-ARS Soft Wheat Quality Laboratory, Wooster, OH, U.S.A.
Cereal Foods World 54:A20

Obtaining whole grain (WG) flours with desirable pastry quality is challenging as the entirety of grain non-starch polysaccharides (NSPs) is present in the WG flour. Moreover, WG flour milling methods developed for hard wheat may produce inferior soft wheat flour because starch damage due to milling, generally beneficial for bread quality, is detrimental to soft wheat quality. Among six soft winter wheat genotypes grown at two locations in 2007, WG flour preparation method significantly affected pastry quality: WG flours prepared from flour + ground bran from a long-flow pilot mill (Miag Multomat) was substantially inferior to WG flour produced from a micro mill (modified Quadrumat) with only a break and a reduction roll pass. Long-flow milling increased starch damage in resulting WG flours. Water-extractable (WE) NSPs, particularly the concentrations of arabinoxylan (AX) and arabinogalactan (AG), and the ratio of arabinose:xylose in the WE-NSPs, are important determinants of white flour soft wheat quality. To examine WE-NSP variation in the bran and bran-associated endosperm and its effect on wire-cut cookie quality, we characterized the bran fraction obtained from micro-milling 16 soft winter wheats grown at two locations in 2007 and 2008. Genotypes varied significantly for cookie quality from the WG flour, as well as bran-associated WE-xylose and WE-galactose concentration and the Ara:Xyl ratio in the WE-NSPs. Diameter of WG wire cut cookies was effectively predicted by a two-parameter regression model containing the Ara:Xyl ratio galactose concentration of bran-associated WE-NSPs. Wheat genotypes with highly substituted WE-AX (high Ara:Xyl ratio) and low AG concentration produced the most desirable WG wire-cut cookies. Selection among wheat genotypes for AX structure and AG concentration in bran-associated WE-NSPs may improve the quality of WG soft wheat flour.

Characterization of starch in pig digesta

J. HASJIM (1), R. Cave (1), M. J. Gidley (1), R. G. Gilbert (1)
(1) University of Queensland, St. Lucia, QLD 4072, AUSTRALIA
Cereal Foods World 54:A20

Data are presented for the *in vivo* digestion of starch granules in the pig digestive track. Pigs were used as model animals because their digestive system is very close to that of humans. The pig test diet contained red meat, maize starch and wheat bran, resembling a typical western diet. Digesta were collected from different parts of the pig small intestine in order to study the starch digestion at different stages of the *in vivo* digestion. Starch granules were isolated from the digesta for further characterization. The size distributions of amylopectin and amylose at different stages of starch digestion were analyzed using size exclusion chromatography (SEC) and asymmetric flow field-flow fractionation (AF^4). The chromatograms of the

maize starch samples in the digesta (*in vivo* digestion) and from a model *in vitro* digestion showed three fractions, whereas that of the native maize starch only showed two fractions. The results also suggested that amylopectin was hydrolyzed more rapidly than amylose. The starch hydrolysis produced a new fraction, which was smaller than amylose: a type of resistant starch. The results of starch hydrolysis in the *in vivo* and *in vitro* digestions were qualitatively similar but displayed significant quantitative differences.

Innovating a laser wheat-perforating technology to reduce kernel hardness for milling

G. G. HOU (1), Q. Ling (2), Y. Zhou (3), B. Lee (1)
(1) Wheat Marketing Center, Portland, OR; (2) Oregon State University Food Innovation Center, Portland, OR; (3) Wheat Marketing Center, Portland, OR, and Dept. of Food Science, Anhui Agricultural University, Hefei, China
Cereal Foods World 54:A21

Wheat kernel hardness has a profound influence on milling performance and end-use quality. The amount of force required for milling a particular wheat grain is directly related to the kernel hardness. The wheat grains are often conditioned with water for up to 24 hrs to soften or mellow the endosperm and make it easier to grind before milling. The time given for the water to penetrate the grain also varies with the grain hardness. If the kernel hardness can be physically reduced, shorter tempering time and less energy power may be required in milling. This research is to innovate a wheat-perforating technique using a novel laser processing technology in wheat milling. Hard red spring (HRS) and soft white (SW) wheat grains were used in the study. Wheat grains were perforated with the laser beam to produce holes spaced by 0.15 cm to full depth of kernels. HRS grains were tempered to 16% moisture for 24 hours and SW grains were tempered to 14% moisture for 18 hours. Grain hardness index (HI) was measured with the Single Kernel Characterization System during tempering. Perforated grains had significantly lower HI values than the control grains for both HRS and SW wheat. For HRS, HI value at 7-hr of conditioning was similar to that of the control wheat at 24-hr of conditioning. For SW, HI value at 5-hr of tempering was less than the control wheat at 18-hr of conditioning. Laser perforation of grains could have facilitated water penetration into endosperm. Laser perforation of wheat grains under these processing conditions substantially reduced kernel hardness and tempering time, but had little effect on flour yield, protein content, ash content, and starch damage level, except that flour L* (whiteness) and b* (yellowness) were slightly reduced. Further optimization of laser processing parameters is needed to achieve maximum milling efficiency for different wheat classes.

Raisin and dried fruit intake is associated with increased whole grain and nutrient intakes and reduced overweight and obesity: NHANES, 1999–2004

J. JONES (1), D. Keast (2)
(1) St. Catherine University; (2) Food and Nutrition Database Consultants
Cereal Foods World 54:A21

NHANES, 1999–2004, data were used to examine the associations of dried fruit consumption with MyPyramid food group and nutrient intake, and with body weight and adiposity in adults over 18 (n = 13, 292), and children 2–18 years (n = 11,093). Anthropometric assessments included adiposity, overweight/obesity, and abdominal obesity based on skinfold thickness, BMI, and waist circumference, respectively. Sample-weighted means, standard errors, and ANOVA (adjusted for covariates including physical activity and other lifestyle factors) were determined using SUDAAN. In adults, consumers of ≥1/8 equivalent cup fruit/day from dried fruit ate more whole grain foods (1.35 ± 0.06 vs 0.60 ± 0.02 oz/d) than non-dried fruit consumers, and had greater intakes of other food groups recommended by MyPyramid guidelines. Further, intakes of many nutrients and dietary fiber were greater for consumers than non-consumers of dried fruit out-of-hand and in food. Between-group difference in subscapular (–1.0 mm, $p < 0.05$), but not triceps skinfold was significant. Weight (–2.7 kg, $p < 0.01$), BMI (–1.1 kg/m^2, $p < 0.01$), and prevalence (%) of overweight/obesity (56.0 ± 2.4 vs. 65.8 ± 0.7, $p < 0.01$); waist circumference (–2.6 cm, $p < 0.01$), and prevalence (%) of abdominal obesity (40.5 ± 2.3 vs. 49.4 ± 0.8, $p < 0.01$) were all lower in dried fruit consumers than non-consumers. Logistic regression also indicated dried fruit consumption was associated with reduced overweight/obesity (OR = 0.64, 95% CI = 0.51–0.81) and reduced abdominal obesity (OR = 0.67, 95% CI = 0.54–0.83). Data for children 2–18 years mirrored that for adults. Dried fruit consumption was associated with increased whole grain and nutrient intakes, lower body weight measures and reduced risk for abdominal obesity in adults. Supported by California Raisin Marketing Board.

Enzymatic and process technologies to increase corn dry grind slurry solids

P. KAUR (1), K. D. Rausch (1), M. E. Tumbleson (1), V. Singh (1)
(1) University of Illinois, Urbana-Champaign, IL, U.S.A.
Cereal Foods World 54:A21

In a conventional dry grind process, corn is ground and mixed with water to produce slurry. The slurry is cooked; slurry starch is liquefied, simultaneously saccharified and fermented to produce ethanol. Typical solids concentrations range from 30 to 33% (db) during slurry preparation. High slurry solids fermentation (above 33%) is important in reducing energy costs through decreased water input leading to less evaporation and dehydration. High ethanol concentrations are expected to reduce distillation cost. High solids fermentation (>33%) increases slurry viscosity and causes osmotic stress on yeast, resulting in incomplete substrate utilization and lower fermentation efficiencies. The objective was to increase slurry solids concentrations using enzymatic and process technologies. A modified conventional process that combines use of conventional amylases and granular starch hydrolyzing enzymes was employed to evaluate slurry solids concentrations at 35 and 40% (db). Liquefaction was conducted at 55°C for 1.5 hr with higher dose of α-amalyse followed by simultaneous saccharification and fermentation using granular starch hyrolyzing enzyme, urea and yeast. Control treatments for 35 and 40% solids were conducted with conventional enzymes (α-amalyse and glucoamaylse) and a higher liquefaction temperature (82°C). The modified process resulted in reduced viscosity of liquefied slurry compared to control treatments. Final ethanol concentrations for the modified process increased by 3% at 35% solids (from 18.9 to 19.5% v/v) and by 4% at 40% solids (from 18.8 to 19.5% v/v). Lower glycerol levels were obtained, 0.98 and 1.06% v/v for 35 and 40% solids, respectively indicating reduced osmotic stress on yeast.

Grain and grain products quality and safety system in the Russian Federation

A. V. KHATUNTSOV (1)
(1) Centre for Grain Quality Assurance, Moscow, Russia
Cereal Foods World 54:A21

In the year 2008, 2.7 mln tones of poor and dangerous grain, cereals, feeds and feeds components were detected, that works out 10% from the inspected ones. This quantity of bread products wasn't permitted of import without relevant treatment and the part of it was returned to the suppliers or annihilated. Much attention is paid to grain and grain products state control during the export. It is particularly topical, considering prospects of Russia enlistment into WTO and importance of country prestige supporting on the international grain market. Suppression of poor and dangerous products exports efforts influenced in an essential way on the food safety in the inside market. During the import 27% of poor inspected production was detected. Import grain and grain products delivers put together the biggest percent of low-grade detections. For example, during the rise import 31.2 thousand tones of products, don't meet the demands of national standards and SanPin, were detected, among them essential safety indexes excess was recorded in some lots: micotoxins content – twice as much; pesticides residue: chlorpyriphos excess – 300 times as much and permethrin excess – 12 times as much; cadmium excess – 56 times as much. Besides, the rise lots with infestation and insect impurity, defective odour, moisture excess, metal-magnetic impurity content excess, damaged and beighted kernels and kernels with other factors were detected. Taking into consideration that rise is the social notional food product and supplied to the consumer including infant food without further technical updating, such detections estimated as the most important.

Ethanol production from hard and soft endosperm corn types

E. KHULLAR (1), E. D. Sall (2), K. D. Rausch (1), M. Tumbleson (1), V. Singh (1)
(1) University of Illinois, Urbana-Champaign, IL; (2) Monsanto Company, St. Louis, MO
Cereal Foods World 54:A21

The conventional dry grind process involves grinding corn to reduce particle size, expose starch granules and increase surface area for enzymatic action. Yeast is used to ferment the glucose to ethanol. Fractionation methods differ from the conventional process in removal of germ and pericarp fiber prior to fermentation. Corn endosperm consists of starch granules held together by a matrix comprised of protein bodies. Two types of endosperm were used: hard and soft. Hard and soft endosperm types differ in protein-starch interactions, starch granule shapes and protein types present. As a result, hard and soft endosperm have different milling properties. Two corn fractionation methods, wet and dry, were compared to the conventional dry grind process using hard and soft endosperm corn types. Four hard endosperm corn types were compared to a soft endosperm corn type using conventional and wet and dry fractionation processes. Final ethanol concentrations and profiles were generated. Germ oil and protein were analyzed. Residual starch content was measured in germ and pericarp fiber from the fractionation processes. Pericarp fiber was analyzed for neutral detergent fiber (NDF) content. Wet fractionation resulted in 0.3% and 1.8% v/v higher final ethanol concentrations respectively, than dry fractionation and conventional processes. Germ from wet fractionation had higher oil (32.2%) and protein contents (14.2%) and lower starch contents than from dry fractionation (17.7% and 12.6%, respectively).

Naked barley – A rediscovered source for functional foods!

M. KINNER (1), S. Siebenhandl-Ehn (1), H. Grausgruber (1), K. Huber (1), S. Nitschko (1), M. Prückler (1), M. Poppernitsch (1), E. Berghofer (1)
(1) University of Natural Resources and Applied Life Sciences, Vienna, AUSTRIA

Cereal Foods World 54:A22

Naked (hulless) barley possesses interesting technological properties and is recognised as valuable nutritional source due to its high content of dietary fibre and secondary plant metabolites. This report deals with intermediate outcomes of a three years nationally funded project (FWF). Out of an existing collection of more than 90 genetic resources of naked barley (blue, black, purple or yellow coloured) 30 genotypes were used to study the variation of the content of a number of phytochemicals and dietary fibres. All varieties were grown in one location around Vienna (Austria) in 2007 and 2008. Wholegrain samples have shown significant differences in the trait of total pentosanes (ranging from 4.05 – 9.12 g/100 g) between the different colour groups whereas beta-glucan ranged not significantly between 3.18 – 6.06 g/100 g. Interestingly, delphinidin glucosides were predominant in blue genotypes contrary to purple genotypes for which cyanidin glucosides were found as the dominant anthocyanins. HPLC analyses of carotenoids revealed that zeaxanthin and lutein varied in a ratio of 1:2 to 1:1, respectively, between the colour groups. Within the technology work package the aim was to investigate the utilisation of such raw materials and to determine changes in the health beneficial components during processing. PCA analysis was used to explore relationships based on dough forming abilities and dough stability properties. PC1 accounted for 51.3% of the cumulative variance and PC2 explained 20.7% of the total cumulative variance. Furthermore, initiating with ICC method 131 an experimental design was done to examine the influence of process parameters to produce tin breads of 100% barley flour. With new evidence about the functional and health beneficial properties of naked barley genotypes, the project will contribute in an important way to consumer health and quality of life.

Development of a benchtop baking method for chemically leavened crackers

M. KWEON (1), L. Slade (2), H. Levine (2), E. Souza (1)
(1) USDA ARS, Wooster, OH, U.S.A.; (2) Food Polymer Science Consultancy, Morris Plains, NJ, U.S.A.

Cereal Foods World 54:A22

Applied Research Award for 2008

Traditionally, the baking performance of soft wheat flours has been evaluated by well-established benchtop cookie-baking methods. In contrast, a benchtop cracker-baking method has not been widely explored or implemented as an official method, due to hurdles including the difficulty in finding ideal diagnostic flours and the absence of suitable benchtop equipment (powerful dough mixer, sheeter, multi-zone oven). Despite such hurdles, there is still a demand in academia and industry for a benchtop baking method to predict the contribution of gluten functionality and performance to overall flour performance for chemically leavened crackers. In an initial investigation, the effects of total solvent (TS) and sugar concentration (%S) were explored to establish a diagnostic cracker formula. Dough rheology was analyzed to evaluate the extent of gluten development during mixing and machining. The effects of enzymes on cracker baking performance were explored to assess the impact of damaged starch and pentosans. Validation of the method for predicting gluten functionality and performance was carried out using various flours. As the diagnostic formula, 38 TS and 23.7% S were selected. Cracker dough rheology, measured in the direction of sheeting, showed a positive correlation with the ratio of cracker height to dough weight, but a negative correlation with the ratio of cracker width to length. Use of alpha-amylase and pentosanase demonstrated the improving effects of enzymes on cracker baking performance, resulting from decreased dough crumbliness and increased cracker height. The gluten performance ratio of SRC LA/(SC+Suc) was found to be a better predictor of cracker geometry than was the gluten functionality value of LA SRC alone. Flours with a gluten performance ratio < 0.52 produced blistering.

Starch-antioxidants interaction: Innovative tracks to improve nutritional quality in food

P. LE BAIL (1), C. Begue (1), C. Genot (1)
(1) INRA, Nantes, FRANCE

Cereal Foods World 54:A22

In food products, natural and processed lipids are frequently used in the form of emulsion. Emulsion consist of two or more immiscible or partially miscible liquids (such as lipid and water) with one liquid being dispersed in the other in the form of droplet. The oxydative deterioration of lipids in emulsions negatively affects the quality of food emulsions by altering the product's flavor, odor, and nutritive value. Antioxydants are an effective tool to control lipid oxidation in oil-in-water emulsion. The phenolic acids from vegetal origin represent an major stake for the research and the industry. Indeed, their use would can constitute an attractive alternative at the synthetic antioxidants which are less accepted by the consumer. Phenolic acids have numerous health benefits too. The main objective of this work is to preserve a part of the phenolic acids nutritional interest in food emulsions An innovative strategy has been developed to incorporate the phenolic acids in the emulsion with the aim of protecting their nutritional properties in the aqueous phase. A protective assembly made of hydrocolloids (using starch in particular) is in charge of embedding the antioxidant. This assembly has been studied by X rays diffraction and differential scanning calorimetry to better understand the interaction and the location of the antioxidant in the assembly. Ageing tests have been carried out to assess the stability of the system. This work demonstrates the importance of the order of incorporation of protective compounds and of health benefit substances during the production of a food.

Behaviour of prefermented dough during refrigeration; impact of CO2 solubility on gas cell equilibrium

A. LE BAIL (1), F. Ben-Aissa (2), G. Domagoj (3), D. Curic (3), J. Monteau (1)
(1) ENITIAA, UMR GEPEA (CNRS 6144), Université de Nantes, Nantes Atlantique - NANTES - FRANCE; (2) ENITIAA - GEPEA - 44322 NANTES FRANCE; (3) Zagreb University, PBF, Zagreb – Croatia

Cereal Foods World 54:A22

The interruption of fermentation during the bread making process and eventually the freezing of prefermented dough offers some advantages such as flexibility for bread production. However, the freezing of pre fermented frozen dough is a challenging process in that the fermented dough is a fragile structure that is exposed to collapse during chilling and freezing. CO2 solubility in dough is a key parameter for dough expansion and stability (ie collapse of dough during refrigeration). CO2 solubility has been evaluated between 15 and 40°C using a protocol based on fermentation at constant volume. Data have been extrapolated to a broader (0 to 50°C) based on an Arrhenius law that rules solubility dependence with temperature. It was found that the solubility of CO2 in dough is increasing from 5 10^{-6} to 1.6 10^{-5} g CO2 kPa^{-1} g^{-1} LPD (Liquid Phase of Dough) between 50°C and 0°C. Tests have been done to track the impact of refrigeration on the volume change of bread during chilling and freezing. A model based on the Young Laplace equation has been developed to model the volume change of fermented dough during pre fermentation and refrigeration (at 4°C). A distribution of gas cells in the dough has been considered. This model accommodates the dependence of solubility and of the Henry coefficient with temperature as well as the impact of temperature on total pressure. The model fits well with experimental results obtained during the chilling of a pre fermented dough at 4°C. It shows that even though the pressure and therefore the volume of the cells embedded in the dough decreases at the onset of refrigeration, the dough re expand for longer times due to new equilibrium between the liquid and gaseous CO2 phases. This project is funded by the EU-FRESHBAKE" (2006–2009) which is supervised by the author of the paper. (http://eu-freshbake.eu/ eufreshbake/)

Starch digestion with human mucosal enzymes

A. LIN (1), Z. Ao (2), B. Nichols (3), R. Quezada-Calvillo (4), D. Rose (5), L. Sim (6), B. Hamaker (7)
(1) Purdue University, West Lafayette, IN, U.S.A.; (2) aozihua@hotmail.com; (3) blnjr@sbcglobal.net; (4) rqc@usaip.mx; (5) drrose@uwaterloo.ca; (6) lsim@uhnresearch.ca; (7) hamakerb@purdue.edu

Cereal Foods World 54:A22

Starches are the major source of dietary glucose in weaned children and adults. The digestion of starches in human body requires 6 known enzyme activities. There are two luminal enzymes, salivary alpha-amylase and pancreatic alpha-amylase, and four small intestinal mucosal enzyme activities related to the maltase-glucoamylase (MGAM) and sucrose-isomaltase (SI) complexes. Our research used different substrates including raw starch granules, solubilized starches and alpha-limit dextrins from various botanical sources to study glucogenesis as it occurs in the human body. Recombinant human N-terminal maltase-glucoamylase (rh-N-MGAM) can attack starch granules or molecules without pre-digestion by alpha-amylase, but alpha-amylase dramatically amplifies the glucogenic activities by producing malto-oligomer as the substrates of mucosal enzymes. The N-terminal mucosal enzymes have higher affinity to substrate than C-terminal enzymes. The N-SI (N-terminal SI) has higher affinity to substrates than N-MGAM, but C-SI (C-terminal SI) has lower affinity than C-MGAM. The released maltotriose and maltotetraose from alpha-amylolysis, and core structure of alpha-limit dextrin might be the main factors that affect the mucosal enzymes digestion. Mucosal enzymes attack alpha-limit dextrins of starches from various genetic backgrounds differently and generate different residues for the mucosal enzymes glucogenesis, which we have defined as slowly digestible dextrin

(SDx). Our research show that alpha-amylase is not an absolute requirement for starch degradation in human body, and human enzymes digest starch substrate of various botanical sources differently and generate different residues in the small intestines.

Dough rheology and breadmaking traits of flour mill streams from a hard spring wheat and relationships to sulfur content and protein size distribution

Y. LIU (1), G. A. Hareland (2), J. Ohm (2)
(1) North Dakota State University, Fargo, ND, U.S.A.; (2) USDA/ARS Wheat Quality Laboratory, North Dakota State University, Fargo, ND, U.S.A.
Cereal Foods World 54:A23

Knowledge of the differences in quality traits among individual flour mill streams (FMS) provides more precise blending techniques that would meet customer's flour specifications. The aim of this study was to evaluate differences in dough rheology and breadmaking traits among FMS and their relationships to sulfur content and protein size distribution. Three break and three reduction FMS were obtained from Buhler laboratory milling trials of the hard red spring wheat variety Glenn that was grown at two locations. Nitrogen and sulfur contents were analyzed by the LECO combustion analyzer. Protein size distribution was analyzed by size exclusion HPLC. Dough mixing and rheology characteristics were determined by farinograph and extensigraph, respectively. Bread quality was evaluated by C-cell digital imaging. The break FMS had higher nitrogen and sulfur contents than the reduction FMS. The third break FMS had the highest nitrogen and sulfur contents among FMS but poor breadmaking quality in addition to high ash content. Partial correlations using ash content as a partial variable indicated that sulfur content had greater associations with bread loaf volume, farinograph development time, and dough rheology properties than nitrogen content in FMS. SDS unextractable high molecular weight polymeric proteins showed greater correlations with dough extensibility and resistance to extension, farinograph development time, and bread loaf volume than the other unextractable protein fractions separated by size exclusion HPLC. Bread traits measured by C-cell imaging also had significant correlations with SDS unextractable high molecular weight polymeric proteins. Results from this study indicated that FMS were significantly different in quality traits; and sulfur content and protein size distribution in FMS affected dough properties and breadmaking quality.

Applying basic research in developing analytical solutions

B. V. MCCLEARY (1)
(1) Megazyme Intl Ireland Ltd, Bray, County Wicklow, IRELAND
Cereal Foods World 54:A23

Applied Research Award for 2009

Much of the food we eat has been processed to some degree. This includes such traditional items as bread, beer, wine, juice and milk, as well as more complex foods and food ingredients. The discerning consumer demands safety, quality and consistency in the foods he/she purchases. Safety, quality and consistency require routine analysis of the raw material (grain, fruit, milk) and the processed product at every stage of the production line. Biochemical test kits have an important part to play in meeting these requirements. At Megazyme, we have focused on quality and consistency issues and have researched and developed a range of test kits to assist the food processor and analyst in their functions. In this presentation, I will give a brief outline of how I became interested in this area of research. In particular, I will discuss the development of a few example test procedures from first principles, and describe some of the challenges in getting the product to market and ensuring proper evaluation and, hopefully, ultimate acceptance. Examples will include the beta-glucan assay kit, tablet tests for alpha-amylase and xylanase, dietary fibre methodology and finally, some of our newer kits for sugars of interest in biofuels research.

Organic rice production systems and their impact on grain quality

A. MCCLUNG (1), K. Bett-Garber (1), C. Bergman (2), C. Grimm (3), M. Chen (1), E. Champagne (3)
(1) USDA, Stuttgaart, AR, U.S.A.; (2) University of Nevada, Las Vegas, NV, U.S.A.; (3) USDA, New Orleans, LA, U.S.A.
Cereal Foods World 54:A23

Interest in organic production of rice has been increasing in the US as a result of expanding demand by consumers and interest by growers in capturing this value-added market. Currently, about 35,000 acres in the US are dedicated to organic rice production with about 10% of the Texas rice acreage under organic management. Typically, organic growers receive a significant premium which offsets lower yields and their greater exposure to risk due to their inability to use standard agricultural chemicals. We have been conducting research on organically grown rice for 10 years with the aims of identifying cultivars that have the best performance under organic conditions, determining the impacts of organic management on cooking, processing, sensory, and nutritional quality, and identifying cultural management options that improve yield and reduce risks for farmers and end users. Initial studies demonstrated that high yielding indica cultivars perform well under organic management and would do particularly well if used in the brown rice market. Subsequent studies compared five cultivars having diverse cooking properties that were grown under conventional management using 100% or 50% of the nitrogen fertilizer requirement or using organic management. The impact of organic management was determined on cooking quality parameters, protein content, mineral content, whiteness, aroma, and texture and flavor sensory analysis. In general, organic production methods improved the whiteness and texture of rice without any negative impacts on quality. Currently, experiments are underway to evaluate a broader range of cultivars, including aromatics, colored bran, and niche market varieties that would be desired by organic consumers and producers. The impact of these factors on yield and various grain quality aspects will be determined.

Cereal-legume pasta: How process, by modifying pasta structure, can change its nutritional properties

V. MICARD (1)
(1) Montpellier Supagro, Montpellier, FRANCE
Cereal Foods World 54:A23

Pasta enriched with legume (35% w/w) were processed. The effects of legume addition and process parameters on pasta structure and its impact on pasta nutritional properties were studied. Protein and starch digestibility, fibre and non digestible oligosaccharides fermentability (in particular the flatus risk associated) and lipids bioavailability were determined *in vitro*. The effect of the food structure on its nutritional properties (matrix effect) was studied at two different scales by: i) comparison of mixed pasta with the same composition but with different structures (small scale matrix effect). These pasta are produced by modifying the drying step of the process; ii) comparison of a mixed pasta produced in standard conditions with a mixed meal made from 65% of pure durum wheat spaghetti and 35% of legume puree, this percentage being those used to produce the mixed pasta (large scale matrix effect). Variations of the pasta structure at small scale changed the digestibility of its protein and starch fractions. Drying pasta with very high temperature decreased, for example, their content in rapidly available starch from 11 to 14 points (% of total available carbohydrate content) depending on the legume. The content in rapidly available starch of a food is linked to the Glycemic Index measured *in vivo*. This strong small scale matrix effect determined on mixed pasta with the same composition but different structure contrasted with the light large scale matrix effect, determined between mixed pasta and the corresponding mixed meal. The demonstration of the link between process, structure and nutritional properties for the mixed pasta shows the nutritional interest to structure durum wheat and legume in a single pasta food. This link, which involves process parameters, emphasizes the key role of industrial in the determination of the nutritional properties of food.

Combining quality and yield: Overcoming barriers to adoption for specialized grains

M. K. MORELL (1), Z. Li (1), J. Ral (1), A. Regina (1), G. J. Tanner (1), C. Howitt (1)
(1) CSIRO, Canberra, ACT, AUSTRALIA
Cereal Foods World 54:A23

Innovation in cereal grains frequently confronts a hurdle in that genetic manipulation (through either GM or non-GM breeding processes) that result in significant and potentially valuable changes to composition and functionality are often found to be associated with a yield penalty incurred as a result of reduced seed weight or decreased plant productivity. The magnitude of yield penalty is critical because throughout the value chain, the additional costs associated with production of the altered grain must be recouped through additional value creation at point of sale. Furthermore, the additional value must be distributed among value chain participants so that each participant is appropriately compensated. While overcoming such yield penalties is an important economic imperative in innovating in developed economies, there is also a significant moral imperative to address this issue from a food security and sustainability perspective. Research in our program has focused on production of novel grain types with specific changes in composition and functionality targeting consumer needs. In this research, we have developed products opportunities where the desired target functionality has been achieved but where a yield penalty is seen. A number of genetic approaches have been successfully applied to restore some, if not all, of the yield penalty, positioning these technologies for sustainable commercial exploitation. This presentation will demonstrate some examples of approaches that have been used to restore grain yield in specialty barley and wheat crops.

Effect of health information on the acceptability of bread fortified with barley beta-glucan

S. MORIARTEY (1)
(1) University of Alberta, Gwynne, AB, CANADA
Cereal Foods World 54:A24

Best Student Research Paper Competition

Cereal beta-glucans have a cholesterol lowering effect. This property is extremely pertinent today as there is a causal relationship between high blood cholesterol and heart disease, the leading cause of death in North America. The Food and Drug Administration (FDA) has approved a health claim for the association between consumption of products containing oat/barley beta-glucan and a reduction in heart disease risk. However, fortifying bread with beta-glucan has been shown to reduce bread quality, though gluten addition may lessen this effect. Consumer acceptance and purchase intent of bread fortified with beta-glucan at levels deemed necessary to be physiologically effective by the FDA (≥0.75 g/serving) in the presence or absence of health information has not been investigated previously. Therefore, the effect of beta-glucan and gluten addition on bread quality, consumer acceptability and purchase intent in the presence or absence of health information was investigated in this study. Bread quality was characterized using height, volume, firmness, and colour measures, while consumer liking of appearance, texture, flavour, and overall acceptance was gauged using a 9-point hedonic scale. A 5-point scale assessed purchase intent. Beta-glucan and gluten addition at 1.5 g/serving improved quality measures greater ($p < 0.05$) than the 0.75 g beta-glucan/serving bread. Consumers (n = 120) rated all breads as acceptable. Health information positively influenced ($p < 0.05$) flavour liking, overall acceptability and purchase intent. Health information had a greater impact ($p < 0.05$) on female consumers' liking of flavour and texture, and overall acceptability. Optimizing beta-glucan fortified bread with gluten and presenting health information at point of purchase may hold the key to creating a readily accepted consumer product with the health benefits of beta-glucan.

Milling behavior of a soft durum wheat line

C. F. MORRIS (1), D. A. Engle (1), A. D. Bettge (1), M. C. Simeone (2), D. Lafiandra (2), K. Shantz (3)
(1) USDA-ARS Western Wheat Quality Laboratory, Pullman, WA, U.S.A.; (2) Department of Agrobiology & Agrochemistry, University of Tuscia, Viterbo, Italy; (3) WestBred LLC
Cereal Foods World 54:A24

During the initial hybridization of two wild grasses to form the wheat species *Triticum turgidum* some 0.5 m years ago, the puroindoline genes from both wild species were eliminated, along with their inherent and mysterious ability to soften kernels. Consequently, all durum wheat varieties have very hard kernels. Humankind's interaction with durum wheat is intricately interwoven with its very hard kernels. Durum milling produces primarily coarse semolina and flour. Through traditional cytological (non-GMO) means, we have rectified the accident of nature and restored the puroindoine genes to durum wheat–and with them, soft kernel texture. We describe our preliminary results on the milling behavior of soft durum. Grain was from Yuma, AZ; protein content 17.1%. Two samples were milled on a Miag Multomat pilot flour mill. The first milling was set up using standard soft wheat milling procedures. The grain was tempered to 14.5% mc. First midd's (M1) produced the lowest ash flour (0.41%) and 10.3% yield. The greatest quantity of flour was off the M2 (25.7% at 0.47% ash). A "straight-grade" flour (10 streams) was obtained at 74.9% yield and 0.58% ash. Dropping the last two streams (3.7% yield) dropped the ash down to 0.51%. The soft durum milled like a typical soft wheat. The second mill run had the objective of testing the premise that semolina could be obtained from soft durum. In this case, only the B1 rolls were used; the sifters were clothed 720 and 145 um and overs were collected manually. The 720 overs were re-sifted on an 850 um sieve (no. 20), and the overs of the 145 on a 150 um sieve (no. 100) to conform more closely to the CFR definition of semolina. As a result, the calculated 'semolina' yield (without bran removal/purifying) was 47.4%, re-iterating from a single roll pass. The original bran (720 overs) was re-milled on B1; recovered products of 145-720 um yielded 25%, break flour 21%.

Time domain ^{2}H-NMR relaxation study of starch-^2H_2O interactions in gelatinized and ungelatinized starches

T. MOTWANI (1), A. Benesi (1), S. Anantheswaran (1)
(1) Pennsylvania State University, University Park, PA, U.S.A.
Cereal Foods World 54:A24

Starch-water interactions are critical for developing a mechanistic understanding of the gelatinization process. The objective of this study was to characterize the molecular jump dynamics of water associated with gelatinized and ungelatinized starches using solid state quadrupole echo and liquid state ^{2}H NMR relaxaometry. Deuterium exchanged native wheat starch was used to prepare 30% starch-^2H_2O slurry, which was heated to 90°C for 30 min and freeze-dried to obtain gelatinized starch. Also, starch-^2H_2O slurry, not given any thermal treatment was freeze-dried to obtain ungelatinized starch. ^{2}H quadrupole echo NMR spectra of starch were obtained at 11.74 T (76.73 MHz) and the spin-lattice relaxation times (T_1) were measured at 7.04 T (46.03 MHz) and 11.74 T at several temperatures between –50 to 90°C. Liquid state ^{2}H NMR measurements indicated presence of 0.99 and 1.26 moles of ^2H_2O per mole of glucose in gelatinized and ungelatinized starches, respectively. At 25°C, the quadrupole echo spectra of both the starches exhibited a sharp isotropic central peak and a broad powder pattern, which were attributed to the tetrahedral jumps executed by O-^{2}H groups of ^2H_2O and starch, respectively. At lower temperatures (≤ –25°C), the sharp central peak was replaced by a powder pattern, attributed to the tetrahedral jumps of O-^{2}H groups of ^2H_2O and starch. The T_1 values of gelatinized and ungelatinized starches exhibited magnetic field dependence. At 25°C, T_1 values for ungelatinized starch were 5.3 ms and 7.4 ms at 7.04 T and 11.74 T, respectively, which were two orders of magnitude lower than those of liquid ^2H_2O. This indicated the presence of yet unreported solid state ice-like ^2H_2O at room temperature in wheat starch (tetrahedral jumps are associated with O-H bonds of water in frozen (ice) state). This is the first study to report jump dynamics of water associated with starch and presents novel insights into starch-water interactions.

The dehydrogenase-mediated recycling of NADPH shows antioxidant activity in intake of oryzanol and ferulic acid extracted from rice bran

S. MYOUNGJIN (1), K. Miyoung (1), K. Sumi (1), K. Juhee (1)
(1) Kyungpook National University, Daegu, KOREA
Cereal Foods World 54:A24

NADPH has important rule in the redox balance of the cell. NADPH is one of the main end products of several metabolic pathways and is essential substrate for reductive biosynthetic reactions in animal and plant. Rice bran oil contains a relatively higher proportion of nonsaponifiable component than that of most vegetable oils have. Oryzanol is a class of nonsaponifiable lipids of rice bran oil and it contains ferulic acid esters of triterpene alcohol and plant sterols in its structure. The aim of this work was to study the function of NADPH-generating dehydrogenases and the antioxidant capacity of rice bran and ferulic acid in the mechanism of oxidative stress induced by hypercholesterol intake. The main enzyme which have the capacity to generate reducing power in the form of NADPH are: Glucose-6-phosphate dehydrogenase (G6P), Malic enzyme (ME), Glutathione peroxidase (GSH-PX), Glutathione peroxidase (GR). Fifty C57BL male mice weighing 12 g of the same age were initially fed with pellet type lab chow for two weeks. Mice were randomly grouped into 5 different groups of 10 animals each group (1) normal diet (AIN76), (2) high cholesterol diet (20%), (3) rice bran (20%), (4) oryzanol (0.5%), (5) Ferulic acid (0.5%). Mice were fed for 7 weeks and allowed free access to the foods and water. The activity of anioxidative enzyme has already showed a significant increase of catalase, superoxide dismutase in rice bran, oryzanol and ferulic acid groups under hypercholesterol intake condition, the activities of G6PDH, ME, GSH-PX, GR were decreased, while showed high level of activities in rice bran, oryzanol and ferulic acid groups. These results indicate that Rice bran and its composition have a great antioxidant capacity and animals respond to the metabolism of inducing antioxidative enzymes of NADPH-producing dehydrogenases by recycling NADPH for the protection against oxidative damages.

Structural differences in diverse barley lines for SKCS hardness index

S. G. NAIR (1), S. Ullrich (1), B. Baik (1)
(1) Washington State University, Pullman, WA, U.S.A.
Cereal Foods World 54:A24

Best Student Research Paper Competition

Increasing awareness about the role of whole grain in controlling life style related diseases has made barley an ideal candidate for functional foods. Recent research highlighting health benefits of β-glucans is rekindling interest in barley as a food source. Due to limited use of barley for food, there is a lack of experience in breeding and cultivating food barley varieties. In order to meet the demand for food barley, thorough understanding of the grain characteristics and their functionality required for food uses is crucial. Grain hardness is an important trait known to influence food processing and product quality in wheat, a close relative of barley. The role of endosperm texture in malting quality is well recognized, but grain hardness has been little investigated for food uses. An objective of our research is to understand the structural basis of endosperm texture in barley lines differing in hardness. Transverse sections of six diverse barley lines for SKCS hardness index (HI) values (31.8–95.0) were used for light (LM) and scanning electron microscopy (SEM) studies. The bulk of the seed was composed of starchy endosperm that showed both A and B type starch granules. Endosperm cell wall thickness measured under LM varied from 1.4–9.6 µ for soft lines while it was 2.3–13.7 µ for hard lines. The average cell wall thickness was 3.0 µ for

soft lines and 5.5 μ for hard lines and showed positive correlation with HI (r = 0.83*) suggesting that hard grain has thicker cell walls than soft grains. Under SEM, soft lines showed loosely packed endosperm with numerous A and B type granules. Hard lines exhibited tighter packed endosperm and numerous A type granules covered by protein matrix but fewer B type granules which appeared to be obscured by the protein covering. These results suggest that barley HI is associated with cell wall thickness and packing of the endosperm.

Role of starch granule surface components in pasting

D. NATH DE OLIVEIRA (1), S. Finnie (1), M. Giroux (2), J. Faubion (1)
(1) Kansas State University, Manhattan, KS, U.S.A.; (2) Montana State University, Bozeman, MT, U.S.A.
Cereal Foods World 54:A25

Endosperm texture is an important characteristic in determining wheat processing requirement and end use. The presence of puroindoline proteins on the starch granule surface are a biochemical marker for endosperm softness in wheat. Even though polar lipids are present in soft and hard wheat flour in equal quantities, starch isolated from soft wheat presents higher amounts of polar lipids attached to the starch granule surface compared to starch isolated from hard wheat. Polar lipids are involved in the interaction of puroindolines with soft wheat starch surfaces. The objective of this study is to investigate the role starch surface components play in the pasting process. Prime starch from soft (HGAB18) and hard (Hi-line) near-isogenic wheat samples was isolated using a batter method. Lipids were extracted from HGAB18 starch to provide a comparison between native and lipid-removed-starch. A Brabender MicroViscoAmylograph was used to create the pasting profiles. Amylograms demonstrated a lower final viscosity for Hi-line (497 BU) starch compared to starch isolated from HGAB18 (707.5 BU). The final viscosity of the lipid-extracted-HGAB18 (678.5 BU) starch decreased in relation to native HGAB18 starch. These results indicate that starch surface components, in this case lipids, effect starch pasting viscosity. Characterizing the relationships between starch granule surface components and pasting profiles provides insight into how endosperm texture affects flour and dough characteristics.

Saltiness enhancement in bread by inhomogeneous spatial distribution of salt

M. NOORT (1), M. Stieger (2), R. Hamer (1)
(1) TI Food & Nutrition (formerly known as Wageningen Centre for Food Sciences), 6700 AN Wageningen, The Netherlands, and TNO Quality of Life, 3700 AJ Zeist, The Netherlands; (2) TI Food & Nutrition (formerly known as Wageningen Centre for Food Sciences), 6700 AN Wageningen, The Netherlands, and NIZO Food Research, 6710 BA Ede, The Netherlands
Cereal Foods World 54:A25

There is a wide consensus that the western diet leads to a sodium (Na) intake twice the recommended level. Cereal products -and bread in particular- are main contributors of Na in the diet. A reduction of Na in bread will lead to significant health benefits. As a consequence, governments throughout the world are stimulating reduction of Na levels in food. However, it is difficult to decrease the Na content of bread and maintain the organoleptic quality at the same time. Several strategies have been described to reduce the Na content in bread, such as replacement of Na by blends of other ions, enhancement of saltiness by addition of taste boosters or gradual salt reduction over longer time periods. In this study we present an alternative approach to enhance saltiness perception in bread following the concept of taste contrast. An inhomogeneous spatial distribution of salt in bread was obtained by preparing breads consisting of several dough layers varying in salt concentration. The ratio of salt between layers varied between 1:1, 1:5 and 1:11 at constant overall salt concentrations ranging from 1.0% to 2.0% (on flour base). The influence of the inhomogeneous salt distribution on saltiness perception was determined using a naïve consumer panel (n = 63) which rated perceived saltiness in duplicate. A significant enhancement of perceived saltiness ($p < 0.05$) was observed for breads which had an inhomogeneous distribution of salt when the salt concentration gradients were large (1:11). The results demonstrate that an inhomogeneous distribution of salt in bread can be used as a new tool to allow significant reductions in Na concentration, while maintaining organoleptic properties.

Hybrid rice improves sustainability

B. OTTIS (1)
(1) RiceTec, Inc., Sikeston, MO, U.S.A.
Cereal Foods World 54:A25

Hybrid rice has been cultivated since the mid 1970s and is now grown on approximately 50% of the rice area in China and accounts for 60% of its rice grain production. Only in the last decade has this technology gained commercial popularity in the United States. Since the release of hybrid rice in the southern United States, hybrid rice production area has risen substantially. Hybrid rice has many agronomic advantages over pureline cultivars due to heterosis, or hybrid vigor, which is the result of combining germplasm with diverse heritages. Some of these advantages include increased yield, better water use efficiency, greater disease and insect tolerance, greater photosynthetic rates, and better yield stability across a range of environments. Hybrid rice worldwide typically shows an average 20 to 30% yield advantage over pureline cultivars with equal or less fertilizer input. Additionally, increased resistance to disease and insect pressure lessens the need for costly fungicide and insecticide applications, reducing the pesticide load on the environment. As with other hybrid crops, such as corn and grain sorghum, seed from hybrid rice cannot be saved for planting. Producing hybrid seed has become much more efficient in recent years as parent lines have been developed with increased seed yield. Mechanization has also facilitated increased hybrid seed production rates and efficiencies in the United States.

Genotypic and environmental characterisation of seed composition in Australian pulses cultivars

J. PANOZZO (1), N. Neumann (1), M. Jason (1), C. Walker (1)
(1) Department of Primary Industries, Horsham, VIC, AUSTRALIA
Cereal Foods World 54:A25

Australia is a leading producer of pulses, particularly lentils, kabuli chickpeas and field-peas, of which approximately 90% are exported as a minimally processed product. Unlike cereal grains, the marketing of pulse varieties is based primarily on visual grain characteristics such as seed size, shape and colour. The perceived impact of these physical characteristics is often linked with processing quality, for example splitting efficiency and cooking quality and very little emphasis is placed on composition. It is generally agreed that pulse grains should be a major part of the human diet, yet in western diets, pulse grains are seldom used even though most consumers are aware that pulses are high in protein, starch fibre and other nutrients. Pulses also contain a range of secondary plant metabolites which are biologically active compounds and may exert metabolic benefits to humans when consumed on a regular basis. There is increasing evidence to suggest that these compounds may be beneficial in reducing the probability of diabetes and coronary heart disease. To date there has been very little emphasis in incorporating physical grain characteristics and quality traits associated with grain composition in the development of new varieties. There are increasing market demand for pulses that can be used in a wide range of food applications and therefore there is a need for increased knowledge on grain composition particularly secondary plant metabolite compounds. This paper discusses the genetic and environmental variation in the composition of Australian grown pulses and the identification of pulse cultivars with enhanced seed composition profiles that may lead to increased consumption of pulses.

The impact of redox agents on sugar-snap cookie quality

B. PAREYT (1), K. Brijs (1), J. A. Delcour (1)
(1) Laboratory of Food Chemistry and Biochemistry and Leuven Food Science and Nutrition Research Centre (LFoRCe), Katholieke Universiteit Leuven
Cereal Foods World 54:A25

Sugar-snap cookies of superior quality generally have large diameters. Their diameter depends both on the spread rate and the set time. The spread rate largely depends on the sugar and fat levels and on how much water is bound by the flour used. The set time is dictated by a sudden viscosity increase which stops the spread. Since starch does not gelatinize, it is believed that proteins impact cookie dough setting. This was earlier related to the occurrence of an 'apparent' glass transition. However, there is no consensus on the mechanism. In our work, we used of reducing (L-cysteine, glutathione) and oxidizing agents (KIO_3, $KBrO_3$) to understand the mechanism whereby gluten stops dough spread. Reducing agents significantly decreased dough setting, while the opposite was true for oxidants. This resulted in smaller (83.7 to 84.9 mm) or larger (87.8 to 88.3 mm) diameters respectively than those of the control cookies (87.3 mm). This was related to more pronounced entanglement and subsequent cross-linking when reducing agents were used to modify the gluten, and less pronounced entanglement and cross-linking whenever oxidants were added. Furthermore, more cross-linking led to reduced collapse. Microfocus computer tomography, a technique based on differences in X-ray absorption between pores and cookie material, clearly showed that modifying the gluten largely influences the internal cookie structure. In conclusion, pronounced formation of gluten networks limits sugar snap cookie dough spread, but, at the same time, increases resistance to structural collapse.

A novel approach in the determination of estimated glyceamic response of some breads commonly consumed in Republic of Ireland by RP-HPLC

A. PATRAS (1), E. Gallagher (1)
(1) Teagasc, Dublin, IRELAND
Cereal Foods World 54:A25

In this study, a new technique for determination of hydrolysis index (HI) and estimated glyceamic response (eGI) of seven different breads, white (C),

wholemeal (W), multigrain (M), petit pan (PP), brown soda (S) and gluten-free (GF) was developed. Bread samples were subjected to an in vitro enzymatic starch digestion over a 3 hr period and dialysates were analysed for total dialysable sugars (fructose, glucose, maltose and sucrose) with a reversed-phase high-performance liquid chromatographic (HPLC) method. The separation was carried out on carbohydrate column (4.6 mm i.d. × 250, Waters) using refractive index detection. The developed HPLC method showed good intra- and inter-day precisions, good accuracies, and high correlation coefficients for standards subjected to the entire procedure. A non-linear model was applied to describe the kinetics of starch hydrolysis and estimate the area under the curve for bread samples. As expected, the eGI, based on the hydrolysis index, for bread samples varied significantly ($p < 0.05$). The HPLC based method requires less time and proved to be sensitive, precise and accurate for measuring total dialysable sugars. Therefore, the proposed method could be used in routine analysis for eGI calculations.

Study of gas cells during proofing and baking using biaxial rheology and X-ray microtomography

M. PICKETT (1), H. Dogan (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A26

Wheat flour dough exhibits extremely complex rheological properties which make it capable of occluding and retaining gas cells. Gas retention, even distribution of gas cells, and their stability throughout the proofing and baking process is critical to final bread structure and volume. The objectives of this study were to establish a method for using X-ray microtomography to study the microstructure of proving dough as well as bread, to compare the stability of wheat flours of varying strength (Karl92, BZ20 and Alpowa) throughout the proofing and baking process, and to understand the interrelationship between protein quality, biaxial rheological properties and microstructure. Amount of total polymeric and unextractable polymeric proteins in three wheat flours were determined using SE-HPLC. Doughs were prepared according to AACC method 10-10B. Biaxial rheological properties of dough samples were studied using D/R dough inflation system (Texture Technologies, NY). The strain hardening indices of Karl92, BZ20 and Alpowa were found as 2.41, 2.74 and 1.83, respectively. Sections from unproofed (0 min), underproofed (20 min) and optimally proofed (40 min) doughs were cut and frozen at –80°C. 96 specimens cut from both proofed and baked loaves were scanned using a high resolution X-ray micro-CT system (Skyscan1072, Belgium). 3-D analysis of dough samples indicated that the void fractions increased dramatically over the proof time from 31.7% for the unproofed dough (0 min) to 63.2% and 72.7% for the underproofed and optimally proofed doughs, respectively. Oven spring caused further expansion in the baked loaves which increased average void fraction to 84.4%. A corresponding decrease in cell wall thickness was observed due to expansion on gas cells. Understanding the factors affecting gas cell stability during breadmaking process is important when creating the distinct structural and textural characteristics.

Effects of sulfhydryl oxidase from *Saccharomyces cerevisiae* on baking and rheological properties of wheat flour

L. POPPER (1)
(1) Muehlenchemie GmbH & Co. KG, Ahrensburg, GERMANY
Cereal Foods World 54:A26

About two decades ago, sulfhydryl oxidase (SOX, EC 1.8.3.2) from *Aspergillus sojae* was suggested for use in baking and dairy applications. SOX specifically oxidizes sulfhydryl groups in protein and peptides. In relation to the number of oxidized sulfhydryl groups, much less hydrogen peroxide is formed by SOX than by glyco-oxidases. Due to its small molecular size of only 17 kDa and the strong binding of its co-enzyme FAD sulfhydryl oxidase (SOX, EC 1.8.3.2) from *Saccharomyces cerevisiae* is extraordinarily stable towards heat and oxygen as compared to glucose oxidase (GOX, the most commonly used oxidase in baking). The potential of SOX from *S. cerevisiae* was tested in diverse baking applications, such as French baguette, pan and hearth bread, breakfast rolls, Chinese steamed bread, butter croissants and sponge cake. With the exception of sponge cake it showed good potential to improve the shape, the baking volume and the crease, in particular in applications involving lamination steps and prolonged fermentation. In butter croissants made from frozen dough, no formation of off-flavour was noted, while GOX-treated samples developed a strange smell. In dough rheology, SOX was effective even under the time-limited Farinograph and Alveograph conditions, where it increased dough stability and resistance, respectively.

Current fiber regulations affecting existing products and new product launches

S. POTTER (1)
(1) Tate & Lyle, Decatur, IL, U.S.A.
Cereal Foods World 54:A26

Dietary fiber has catapulted to the forefront of research and debate in recent years. While many domestic and multinational food companies are gearing up for new product launches with fiber, they may not be aware of the most recent fiber regulations affecting their businesses. Although a definition has been agreed upon in Europe and reflects consensus at the Codex level, debate among scientists regarding what is classified as dietary fiber continues to exist. This session is designed to provide the most recent information about changes in fiber regulations and pinpoint key information needed by product developers to help ensure compliance with current regulations.

Amylose-lipid complexes as additives in starch based food systems

J. A. PUTSEYS (1), L. Lamberts (1), J. A. Delcour (1)
(1) Laboratory of Food Chemistry and Biochemistry and Leuven Food Science and Nutrition Research Centre (LFoRCe), Katholieke Universiteit Leuven
Cereal Foods World 54:A26

While amylose-lipid complexes have been studied profoundly, little information is available about the possible functionality of such complexes when used as additive in starch based systems. We here studied the impact of both monodisperse short-chain semi-enzymically synthesized and more polydisperse longer-chain solution-grown complexes on starch gels and breadmaking. Semi-enzymically synthesized type I complexes induced severe viscosity changes when added to starch in a Rapid Visco Analyzer heating, constant temperature and cooling cycle. During heating of starch suspensions, these complexes (partly) dissociate (in line with their differential scanning calorimetry properties) thereby liberating both lipids as well as short amylose chains. The latter subsequently contribute to network formation during cooling of the gel by participating in double helix formation with long amylose chains leached from the starch granules, resulting in a viscosity increase. We next used *in vitro* methods for the determination of resistant starch levels and hydrolysis indices which were both based on chewing of the starch containing material. The gels containing amylose-lipid complexes had higher resistant starch levels and lower *in vitro* degradabilities than the controls. When the complexes were added in breadmaking, they decreased bread volume and changed its *in vitro* digestibilities. Resistant starch content increased especially for semi-crystalline type II amylose-lipid complexes. Amylose-lipid complexes can hence be used as a tool for the controlled release of lipids and short amylose chains, on the one hand, and, on the other, as an ingredient reducing starch *in vitro* degradability by increasing resistant starch contents.

Relationships among viscosity of β-glucan found in oat foods, starch digestibility and human glycaemic response

A. Regand Ramirez (1), S. M. TOSH (1), P. J. Wood (1)
(1) Agriculture and Agri-Food Canada, Guelph, ON, CANADA
Cereal Foods World 54:A26

Soluble fibre, such as mixed linkage β-glucan found in oats, has been identified as a bioactive component in many foods with low glycaemic indices. The viscosity of a β-glucan solution which is extracted from food under physiological conditions has been correlated with the decrease in peak blood glucose rise (PBGR) after consumption of oat bran foods containing 4 to 12 g of β-glucan. The mechanism is believed, in part at least, to be slowed absorption of glucose from the gastrointestinal tract, but exactly how this operates with starchy foods is not well understood Snack foods were formulated using rolled oats and oat bran to contain 6 g of β-glucan and either 40 or 60 g of starch. Some foods were prepared as is, to maintain the native β-glucan molecular weight (MW), whereas β-glucanase was added to the batter of some batches to partially depolymerise the β-glucan before baking. By adding different amounts of β-glucanase, medium and low MW products were produced for both starch doses. Equivalent control products were made from white flour and whole wheat flakes. Postprandial blood glucose responses were measured in human subjects ($n = 12$). As shown previously, β-glucan solubility decreased in the lowest MW foods. The proportion of rapidly digestible starch (RDS, Englyst method) decreased as the viscosity of the extract increased and, conversely, the slowly digestible starch (SDS) increased with increasing viscosity. The average PBGR was correlated with log (viscosity), percent reduction in RDS and percent increase in SDS. The effect was larger for the 40 g starch dose, where the ratio of β-glucan to starch was higher. This study demonstrates that a decrease in the rate of starch digestion related to the increased viscosity in the gut due to the presence of oat β-glucan is at least in part responsible for the reduction in glycaemic response to these starch containing foods.

Field-flow fractionation as a means to find true molecular weights and sizes of undegraded starch

A. ROLLAND SABATÉ (1), P. Colonna (2)
(1) INRA, Nantes, FRANCE; (2) colonna@nantes.inra.fr
Cereal Foods World 54:A26

Starch consists of a mixture of two α-glucans built mainly upon α-(1,4) linkages: amylose an essentially linear polymer, and amylopectin a branched

polymer by the presence of 5–6% α-(1,6) linkages. Functional properties of starches are determined by their macromolecular characteristics and the conformation in solution of both constitutive polymers. The need to investigate the biological variability is reinforced by the recent opportunity to create easily new genotypes using results from genomic studies. To characterize starch polysaccharides, the method usually used is high-performance size-exclusion chromatography (HPSEC) combined with multi-angle laser light scattering (MALLS). The limitation of HPSEC columns is their low exclusion limit regarding amylopectin size. Further technical improvements are necessary to gain fractionation systems effective on the entire distribution of amylopectin to achieve its complete structural characterization. The present work analysed the structural properties of starches with different amylose content and from different cereal sources using a combination of AFFFF (Asymmetrical Flow FFF) and HPSEC with MALLS, on-line quasi-elastic light scattering (QELS) -which provides the RH distributions- and DRI (Differential Refractometric Index) techniques. The procedure, involving a dimethylsulfoxide (DMSO) pretreatment and then a solubilisation in water, provides a representative injected sample without alteration of the degree of polymerisation. Amylopectin M_w and R_G were around respectively $1.05–3.78 \times 10^8$ g.mol^{-1} and 163–255 nm. HPSEC and AFFFF data are matchable but AFFFF allows a better separation of amylopectins and thus an enhanced structural characterisation of starches. One advantage of this experimental approach is to get both distributions as function of molar masses and hydrodynamic radii as well.

Quantification of the antifungal compounds phenyllactic acid and 2, 5 diketopiperazines in sourdough and bread

L. A. RYAN (1), F. Dal Bello (2), P. Koehler (3), M. Czerny (3), E. K. Arendt (2)
(1) University College Cork, Cork, IRELAND; (2) Department of Food and Nutritional Sciences, University College Cork, Ireland; (3) Deutsche Forschungsanstalt fur Lebensmittelchemie, Garching, Germany
Cereal Foods World 54:A27

Fungal growth is the most common type of microbial spoilage in bread leading to significant economical and health problems worldwide. Lactic acid bacteria (LAB) in the form of sourdough have a proven history as an antifungal agent in bread. *Lactobacillus plantarum* FST 1.7 (LP 1.7) has previously been identified as having strong antifungal activity *in vitro*. However on addition of sourdough fermented by LP 1.7 a significant increase in the mould free shelf life of bread was found. The compounds responsible for this activity *in vitro* were isolated and identified at a chemical level using solid phase extraction, high performance liquid chromatography and nuclear magnetic resonance as well as liquid and gas chromatography in combination with mass spectrometry. The compounds were identified as lactic, acetic and phenyllactic acid (PLA) as well as cyclo ($_L$-Leu-$_L$-Pro) (CLP) and cyclo ($_L$-Phe-$_L$-Pro) (CPP). The quantification of these compounds in sourdough and bread was then performed using, liquid (CLP and CPP) and gas (PLA) chromatography in combination with mass spectrometry. PLA was quantified at a maximum level of 33.48 mg/kg of dough after 48 h of fermentation. This level is almost 1000 times below the minimum inhibitory concentration (MIC) of *ca.* 7.5 mg/ml. CLP and CPP were also quantified at a maximum level of 34.08 and 24.28 µg/kg of sourdough respectively after 48 h of fermentation. At this level the compounds are present at approximately one million times below the MIC of *ca.* 20 mg/ml. Interestingly, in bread crumb (100°C) and crust (230°C), both CLP and CPP were present at 10 and 1000 higher magnitude respectively than those quantified in sourdough alone. The results of this study clearly show that analytical techniques can be applied to identify compounds responsible for the antifungal activity of LAB.

X-ray photoelectron spectroscopy analyses of wheat flour: Comparison between surface and bulk composition

M. SAAD (1), C. Gaiani (2), J. Scher (2), B. Cuq (1)
(1) INRA - Montpellier SupAgro - UMR IATE, Montpellier, FRANCE; (2) ENSAIA, Nancy, France
Cereal Foods World 54:A27

Best Student Research Paper Competition

Wheat flour is used as raw material in several food products. The surface of wheat flour particles is considered to play a significant role as the interface to particle-particle and particle-water interactions. While a lot of studies were conducted to characterize the bulk chemical composition of wheat flour, only few work have focused on the surface chemical composition of particles. In this study, we develop a method to quantify the relative coverage of flour main components on the surface of particles by using the X-ray photoelectron spectroscopy. We selected a native flour and separated it to its main components (protein, starch, arabinoxylan, and lipids). Physically modified flours were prepared from the native flour by regrinding and/or sieving. Simplified flours were obtained by mixing protein and starch (separated from the native) with different proportions. Four wheat flours with different bulk compositions were also selected. XPS analyses were realized on samples from separated components, native, modified, simplified, and the four wheat flours. XPS identified elements (O, C, N, and S) on surface of particles and determined their relative concentrations. Based on these concentrations we calculated the relative coverage of components for native and simplified flours by using a matrix. XPS is not able to distinguish starch and arabinoxylan but it is able to distinguish polysaccharides (starch and arabinoxylan) protein and lipids. The calculated relative coverage and the bulk chemical composition are similar for the simplified flours but different for the native flour. Compared to bulk chemical composition we could suggest that, on the surface of particles, there is an overrepresentation of protein and lipids, but there is underrepresentation of polysaccharides. Surface composition results are discussed in regards with changes in bulk chemical composition, particles size, and wheat origin.

Effect of ozonated wheat flour on bread quality

H. S. SANDHU (1), F. A. Manthey (1)
(1) North Dakota State University, Fargo, ND, U.S.A.
Cereal Foods World 54:A27

This project was aimed at studying the effect of ozonated wheat flour on bread quality. All purpose unbleached wheat flour was procured from three different companies. Two experiments were conducted to evaluate the effect of ozone on wheat flour and bread quality. In the first experiment, wheat flour was ozonated at 1,500 ppm for 4.5, 9, 18, 27, 36 and 45 min. In the second experiment, wheat flour treated with ozone gas at 1,500 ppm for 45 min was added to non treated wheat flour at concentrations from 10 to 100% (w/w). All the results were compared with the control flour that was not ozonated. Flour samples were evaluated for pasting properties using Rapid ViscoAnalyzer (RVA), color analysis using Minolta Colorimeter and lipid oxidation by determining peroxide value according to AOCS Official Method Cd 8-53. Twenty-five gram breads were baked according to AACC basic straight-dough bread-baking Approved Method 10-09. Bread texture analysis studies were done using a texture analyzer. The C-Cell-Digital Imaging Instrument was used to study bread crumb structure. Increased ozonation time and amount of ozonated wheat flour added to the control flour resulted in increased peak viscosity, final viscosity and setback values (based on RVA analysis), and in increased peroxide values. Color results indicate that wheat flour became whiter and less yellow with increased ozonation time and amount of ozonated wheat flour added to the control flour. Ozonation of wheat flour for 4.5 min and addition of 10% ozonated flour to control flour significantly increased the loaf volume. C-Cell data showed that the crumb of the bread made from wheat flour blended with 10% ozonated wheat flour was less dense, had same number of holes and crumb texture was slightly coarse.

Combining low frequency ultrasound with large strain techniques to evaluate the properties of wheat flour doughs

M. G. SCANLON (1), J. H. Page (1), Y. Fan (1), A. Kiefte (1), K. L. Mehta (1)
(1) University of Manitoba, Winnipeg, MB, CANADA
Cereal Foods World 54:A27

Ultrasound is particularly sensitive to the presence of bubbles contained within the dough's viscoelastic matrix, so measurements of ultrasonic velocity and attenuation over a wide range of frequencies have allowed us to identify three distinct regions that are associated with the mechanical response of the dough matrix and its bubbles. New information on dough properties can be derived from ultrasonic measurements at low frequencies, where the properties of the dough as a whole (matrix and bubbles) are investigated. Ultrasound is a low strain technique, but ultrasonic measurements of doughs made from flours with a range of breadmaking quality correlate well with parameters acquired from conventional large strain techniques such as the alveograph and farinograph. Ultrasound techniques can also be combined with large strain techniques. By subjecting samples of dough to uniaxial compression and monitoring their relaxation with ultrasound, markedly different behaviour is evident in air-mixed doughs compared to those mixed under vacuum. Therefore, bubbles appear to substantially affect the short-time relaxation behaviour of air-mixed dough samples. Substantial changes in ultrasonic parameters were also observed as dough samples were subjected to triaxial tension by applying a vacuum so that the expanding bubbles induced a large strain in the dough. In conclusion, ultrasound is an emergent technique with the potential to provide new information on dough properties.

Influence of glycolipids on the technological properties of wheat dough

P. L. SELMAIR (1), P. Koehler (1)
(1) German Research Centre for Food Chemistry, Garching, GERMANY
Cereal Foods World 54:A27

The aim of this study was to determine the potential of glycolipids from lecithins in breadmaking in comparison to classical surfactants and two synthetic glycolipids. The most important glycolipid classes in commercial

lecithins, such as soybean, rapeseed or sunflower, were found to be sterol glucosides, acylated sterol glucosides, cerebrosides and digalactosyl diacylglycerides. These classes were isolated and characterized for their techno-functional properties by micro-scale baking and extension tests (10 g of flour). The baking tests revealed the excellent baking potential of all isolated glycolipid classes, with clearly better or equal baking activities than commercial surfactants. The synthetic monogalactosyl monoglyceride and the isolated digalactosyl diglycerides showed the highest bread volume increases. Furthermore, the glycolipid classes influenced the crumb structure significantly by improving the crumb softness and grain. Interestingly all glycolipid classes showed no significant antistaling effect, except the synthetic monogalactosyl monoglyceride with a considerably weaker effect than the commercial surfactants used for this purpose. A direct effect on the overall rheological behavior of the dough was only found for the commercial surfactants. However, the rheological effect seen on Glutomatic-obtained gluten revealed that the surfactants could be divided into two main groups. One group, acylated and non-acylated sterol glucosides, only had a significant influence on the resistance to extension of the gluten and the other group, this being all other glycolipid classes and the reference compounds, only had a significant influence on the extensibility of the gluten. In conclusion these results indicate that in wheat dough glycolipids rather seem to have an impact on the dough liquor than on the gluten-starch-matrix and here with different modes of action.

Study on saccharification experiment for extrusion of rice with or without enzyme added as beer adjunct

D. SHEN (1)
(1) Shandong University, Zibo, Province Shandong, China
Cereal Foods World 54:A28

Researchers in China and abroad had studies on the extrusion-cooking of beer adjunct from early 1980's to early 1990's. However, these researches came to a halt due to the difficulties in the saccharification and filtration of the resulting mash. The investigation relating to the extrusion of beer adjunct with or without enzymes added is carried on at our laboratory at all times from early 1989 to now. Based on lots of test results of the laboratory, the productive experimental study was conducted for brewing 100 t beer at Wuchang Beer Brewery of Heilongjiang Province in China in September/October, 2002. The results indicate that the main indices that the problem of difficult saccharification and filtration of wort of extruded adjunct has solved. The main indices of beer quality of extruded and non-extruded adjuncts are all reached to the indices of nation standard (GB4927-2001). The recoverable ratio of wort extract for extruded adjunct is about 1~2% more than that of non-extruded adjunct. Nevertheless, both the magnitude and the stability of the increase in recoverable ratio of wort extract was not ideal. After this, the studies on the extrusion of beer adjunct with enzymes added are carried on at our laboratory from early 2005 to now. The process of saccharification and filtration of wort of extruded adjunct with enzymes added was carried on better. The productive experimental study was conducted for brewing 200 t beer at Wuming Beer Brewery of Shandong Province in China on 29 to 30 March, 2008. The main indices of beer quality of extruded adjuncts with enzymes added are all reached to the indices of nation standard (GB4927-2001). The recoverable ratio of wort extract of extruded adjunct is 2.1%~3.57% more than that of traditional non-extruded adjunct. About research results has applied the invention patens in China and USA.

Addressing rice industry sustainability; assessing hybrid rice processing characteristics

T. J. SIEBENMORGEN (1), M. I. Saleh (1), R. C. Bautista (1), J. Meullenet (1)
(1) University of Arkansas, Fayetteville, AR, U.S.A.
Cereal Foods World 54:A28

Sustainability typically connotes production-related topics and opportunities. However, the spectrum of sustainability must encompass post-harvest processing issues as well, such as energy efficiency, packaging, and water use. These analyses should also include an assessment of sustainable production practices in terms of their effects on processing and end-use qualities that are especially critical in the rice industry. This presentation will address the properties and processing performance of hybrid rice, given the inherent production characteristics of hybrids that favor many sustainable production practices. Post-harvest properties, including kernel-to-kernel moisture content and dimensional distributions, will be compared between hybrid and pureline rice cultivars. Similar comparisons will be made in terms of milling quality characteristics, specifically head rice yield and degree of milling. Preliminary data indicate that the milling durations required to attain desired degrees of milling are considerably less for hybrids than pureline cultivars. Possible explanations for this finding are provided through micrographs indicating bran layer thickness differences between hybrids and purelines. The ramifications of these bran layer thickness differences for milling and subsequent quality measurements, including rheological and cooking properties, will be discussed.

Analysis of cereal starches by high performance size exclusion chromatography

S. SIMSEK (1)
(1) North Dakota State University, Fargo, ND, U.S.A.
Cereal Foods World 54:A28

Starch has unique chemical and physical characteristics among other carbohydrates. It occurs naturally as distinct particles, called granules. The other uniqueness of the starch is that most starch granules are mixture of two sugar polymers: a highly branched polysaccharide named *amylopectin*, and a basically linear polysaccharide named *amylose.* Amylopectin is a very large, highly branched glucose polymer and constitutes about 75% of the cereal starches. Amylose is a linear, relatively smaller glucose polymer. The objective of this study was to develop new, simple, one-step and accurate method suitable for simultaneous determination of amylose and amylopectin ratio in cereals. Starch from ground samples of wheat (spring and durum), barley, oat, rye, buckwheat, rice and corn were extracted using KOH, urea and ethanol. Starch samples were solubilized and, then neutralized using HCl. Samples were run on a Agilent 1200 series High Performance Liquid Chromatography (HPLC) system with a refractive index detector using a Waters Ultrahydrogel column. To verify the identity of the peaks, fractions were collected and soluble starch assay was performed additional to Gas Chromatography (GC) analysis. We found that all the fractions contain only glucose and soluble starch assay is correlated to the HPLC fractionation. This method can be used to determine amylose amylopectin ratio in cereal samples.

Affect on pasta quality and *in vitro* starch hydrolysis with non-traditional ingredients

M. SISSONS (1), N. Aravind (2), C. Fellows (2)
(1) NSW Dept of Primary Industries, Calala, NSW, AUSTRALIA; (2) School of Biological, Biomedical and Molecular Sciences, University of New England, Armidale, Australia
Cereal Foods World 54:A28

With growing popularity of functional foods, our work involved evaluating the addition of various fibres to durum wheat spaghetti to investigate affects on technological quality and the extent of *in vitro* starch hydrolysis. The aim of this work was to prepare pasta with lower *in vitro* starch hydrolysis while minimising impact on the textural and sensory properties. Ingredients selected included durum bran and pollard, inulin, guar gum (GG), carboxy-methylcellulose (CMC), Novelose 330Jä (resistant starch source) and Barley Balanceä (β-glucan concentrate, BG). Both bran and pollard had negative impacts on pasta cooking loss, water absorption and yellowness. The extent of pasta starch hydrolysis was increased probably due to interference with starch-gluten matrix formation as shown by microscopy. Inulin had minor impact on quality but starch hydrolysis reached a minimum at 5% inclusion due to encapsulation of starch granules. GG greatly increased pasta stickiness and decreased starch hydrolysis due to forming a mucilaginous protective layer. BB increased β-glucan content in pasta, with increased firmness and stickiness but a yellow-brown colour. BB significantly lowered starch hydrolysis extent. CMC had little impact on quality but decreased starch hydrolysis extent. Novelose 330J RS when added to semolina had a subtle affect on pasta quality at 10% and 20% substitution. The ingredients investigated show a range of affects on pasta quality and starch hydrolysis of pasta with possibilities to further lower the glycaemic index of pasta.

Improved glucose recovery from hydrolysis of rice straw for bioethanol production using fungal enzymes

S. SRICHUWONG (1), M. Ike (1), M. Fujiwara (1), L. Wu (1), J. Park (1), Y. Arai-Sanoh (2), M. Kondo (2), K. Tokuyasu (1)
(1) National Food Research Institute, Tsukuba, Ibaraki, Japan; (2) National Institute of Crop Science, Tsukuba, Ibaraki, Japan
Cereal Foods World 54:A28

Rice straw is one of the most important lignocellulosic biomass that can be utilized as a feedstock for bioethanol production. Recently, rice straws containing significant amounts of starch and soluble sugars (total 20–25% w/w) have been identified in our laboratory. These carbohydrates can be readily converted to fermentable sugars by enzymes without severe pretreatment. In this study, fungal enzymes possessing cellulolytic, hemicellulolytic and amylolytic activities were produced from solid-state fermentation using six strains of *Aspergillus*. The crude enzymes supplemented with commercial cellulase showed improved glucose recovery from rice straw and other lignocellulosic materials. High glucose yield of 25–30% (w/w) was obtained from hydrolysis of native rice straw (cv. leaf star). In addition, the combination of fungal enzymes and commercial cellulase enhanced glucan saccharification of alkali-treated sugar cane bagasse to greater than 75% within 24 h. Correlations among greater cellulose degradation, removal of

hemicellulose and β-glucosidase activity were also observed. This study should be useful for biofuel industry by providing guidelines on appropriated enzyme cocktails for effective saccharification of lignocellulosic materials.

Effect of fractionation of distillers dried grains with solubles (DDGS) on pelleting characteristics of broiler diets

R. SRINIVASAN (1), A. Corzo (1), K. Koch (2), M. Kidd (1)
(1) Mississippi State University, Mississippi State, MS, U.S.A.; (2) Northern Crops Institute, Fargo, ND, U.S.A.
Cereal Foods World 54:A29

Recently, the Elusieve process, a combination of elutriation (air classification) and sieving (screening) was developed to separate fiber from distillers dried grains with solubles (DDGS) to increase DDGS utilization in nonruminant (poultry and swine) diets. Elusieve process produces three products; 1) a product (Pan DDGS) with 5% higher protein content than the conventional DDGS, which would be used at higher inclusion levels in broiler diets because of low fiber content, 2) a product (Big DDGS) that with nearly same protein content as conventional DDGS, which would be used at same inclusion levels as conventional DDGS, and 3) Fiber product. The objective of this study was to determine and compare pellet-mill throughput, power consumption and pellet quality for broiler diets incorporating different levels (0%, 10%, and 20%) of conventional DDGS and DDGS products from Elusieve process. Poultry oil contents were lower (1.5 to 1.6%) in diets comprising Pan DDGS and diet without DDGS than in other diets (2.2 to 3.1%). The feed throughput was not affected by inclusion levels or type of DDGS. Pellet quality (pellet durability index; PDI) for diets comprising Pan DDGS (both 10% and 20% inclusion levels) was significantly better than PDI for diets comprising conventional DDGS, Big DDGS, and the diet without DDGS. Better pellet quality of diets comprising Pan DDGS could be due to lower quantity of poultry oil used as well as compositional characteristics such as low fiber and high protein. Diets with Big DDGS had similar pelleting characteristics as those with conventional DDGS. Pellet quality deteriorated at higher inclusion levels of conventional DDGS, Big DDGS, and Enhanced DDGS. Considering that Pan DDGS would be included at higher inclusion levels in broiler diets, superior pellet quality of diets comprising Pan DDGS is beneficial.

Low salt – low sugar – great taste: Three ways to enhance taste perception

M. STIEGER (1), H. Bult (1), K. Burseg (1), P. de Kok (1), C. Mosca (2), M. Noort (3), G. Sala (2), F. van de Velde (1), R. Hamer (4)
(1) NIZO Food Research, Ede, NETHERLANDS; (2) Wageningen University & Research Centre, Wageningen, NETHERLANDS; (3) TNO Quality for Life, Zeist, NETHERLANDS; (4) TI Food and Nutrition, Wageningen, NETHERLANDS
Cereal Foods World 54:A29

The reduction of sugar and salt in cereal products and other foods remains a challenge due to the importance of those ingredients in providing a highly desired taste quality, enhancing flavor, determining the behavior of structuring ingredients, and ensuring microbiological safety. Several technologies have been used to reduce sugar and salt content in foods such as replacement of sugar by sweeteners, replacement of sodium salts by blends of other salts, taste enhancement by aromas and taste boosters or gradual reduction of sugar and salt over time. In this study we present three alternative approaches to enhance taste perception. First, the use of an inhomogeneous spatial distribution of sugar in food gels is introduced as a way to enhance sweetness perception. The translation of the concept of taste contrast to bread applications is discussed. Secondly, it is demonstrated how the intensity of sweetness can be enhanced through pulsed delivery of sugar stimuli under well defined experimental conditions. The results show that sweet taste enhancement depends on pulse frequency and peaks at a pulsation period range of 0.5 up to 2 times the sweet taste fusion point suggesting an involvement of frequency-dependent neural integration of subsequent stimulus responses. Thirdly, we demonstrate how the serum release under compression of mixed polysaccharide/protein gels can be engineered to enhance sweetness perception. An increase of serum release by 5x allowed to reduce sugar content of gels by 30% while maintaining sweet taste intensity. These approaches can be used to further optimize the development of cereal products with reduced sugar and salt content while maintaining taste intensity.

Barley limit dextrinase and its interaction the proteinaceous barley limit dextrinase inhibitor

B. SVENSSON (1), M. B. Vester-Christensen (2), J. M. Jensen (2), P. Hagglund (2), M. Abou Hachem (2)
(1) Enzyme and Protein Chemistry, Kgs Lyngby, DENMARK; (2) Enzyme and Protein Chemistry, Department of Systems Biology, Technical University of Denmark
Cereal Foods World 54:A29

The starch debranching enzyme limit dextrinase (LD) hydrolyses α-1,6-glucoside linkages in limit dextrins and amylopectin during seed germination. LD is highly activity towards pullulan with $K_m = 0.16 \pm 0.02$ mg·ml^{-1} and $k_{cat} = 79 \pm 10$ s^{-1}. Besides a role in germination, LD is important in brewing by hydrolysing a-limit dextrins[1] during mashing and malting. LD occurs in aqueous malt extracts in a free, active and a "bound" inactive form[2]. The inactive form stems partly from binding of the endogenous limit dextrinase inhibitor (LDI). LDI is a CM family member of about 12 kDa, contains 4 disulfide bonds and has a free thiol group present in mixed disulfide with cysteine or glutathione. LDI competitively inhibits LD hydrolysis of pullulan with subnanomolar K_i. Both LD and LDI were produced recombinantly in *Pichia pastoris* and fitting of a 1:1 binding model to surface plasmon resonance data of LDI and LD confirmed very tight binding of $K_D = 40 \pm 3 \times 10^{-12}$ M. This high affinity stemmed from very slow k_{off} of ~5×10^{-5} s^{-1}, while k_{on} of 1×10^6 M^{-1}·s^{-1} was in the usual range for proteinaceous inhibitor and amylolytic enzymes. Binding was optimal at slightly acidic to neutral pH and 0.15–0.3 mM NaCl. The interaction was monitored at 15–45°C and analysis of the van't Hoff thermodynamics showed favourable enthalpic and entropic components of binding free energy ($\Delta G° = -58$ kJ mol^{-1}) suggesting that the LD-LDI complexation is driven by hydrophobic interactions. The available systems for recombinant production of LD and LDI is utilised in mutational analysis of pivotal structural elements in the very high affinity interaction. *This work is supported by a DTU Ph.D. scholarship, (MBVC), Danish Natural Science Research Council, the Carlsberg Foundation.* References 1. Kristensen M et al. 1999, *Biochim. Biophys. Acta* 1431,:538-546. 2. MacGregor AW et al. 1994, *Cereal Chemistry* 71: 610-617.

Mechanical and barrier property modeling of starch, polyvinyl alcohol based nanocomposites and their characterization

X. TANG (1), S. Alavi (1), S. Shaur (1), J. Faubion (1)
(1) Kansas State University, Manhattan, KS
Cereal Foods World 54:A29

In this study, nanocomposites consisting of starch and Polyvinyl Alcohol (PVOH) filled with silicate clay particles are investigated. Recent and ongoing research has shown that dramatic enhancement can be achieved in mechanical and barrier properties in these nanocomposites with just a small amount of particle concentration. The resulting nanocomposite properties are intimately related to the compatibility of the multiphase system and dispersion of the particles in the polymer matrix. In the Experiment, extrusion processing was used to produce nanocomposites. Morphological characterization and determination of film properties were conducted to understand the effect of montmorillonite/dispersion/compatibility on the tensile and barrier properties of starch, PVOH-based nanocomposites. Mechanical and barrier property models of multiphase system, including starch, PVOH, glycerol, exfoliated clay and intercalated/aggregated clay layers were developed respectively. The mechanical model, which was based on Mori-Tanaka method with some modifications, was applied to predict properties of the nanocomposites as a function of the clay concentration, the exfoliation ratio and the compatibility of starch, PVOH and glycerol. The barrier model was developed from permeability model taking into consideration the influence of tortuous pathway, clay concentration and compatibility factor. For our experiments, tensile strength and elongation at break of films ranged from 22.1 to 28.0 MPa and 160 to 320%, respectively, while water vapor permeability ranged from 0.8 to 1.02 g.mm/kPa.h.m^2. Predicted results are in a good agreement with the experiments and show that the mechanical and barrier property model can be used as an indirect characterization technique to predict the properties of glycerol plasticized starch, PVOH nanocomposites.

Potential applications of kafirin microparticles

J. TAYLOR (1), J. Taylor (1)
(1) University of Pretoria, Pretoria Gauteng, REP OF SOUTH AFRICA
Cereal Foods World 54:A29

It has been found that kafirin, the prolamin protein of sorghum can be used for the preparation of microparticles (microspheres) by phase separation from an organic acid. Kafirin microparticles made by this method are small, (1–10 mm), mainly spherical particles, with internal holes or vacuoles, resulting in a very large surface area. Kafirin microparticles may have many potential applications in the food, biomedical and pharmaceutical industries. For example, kafirin microparticles were used to make very thin (< 15 mm) bio-plastic films, which are relatively strong but not extensible, with good water barrier properties and low protein digestibility. In addition, kafirin microparticles made by this method were used for encapsulation, as a method to deliver dietary antioxidants by controlled release. Approximately 70% and 50%, respectively total antioxidant activity was released under simulated gastric conditions over a period of four hours, when the model antioxidants, catechin and sorghum condensed tannins were encapsulated within kafirin microparticles.

Soft carbohydrates in culm of rice straw as new substrates for bioethanol production

K. TOKUYASU (1), S. Srichuwong (1), M. Ike (1), M. Arakane (1), T. Seyama (1), S. Riki (1), Y. Arai-Sanoh (2), M. Kondo (2), J. Park (1)
(1) Carbohydrate Laboratory, National Food Research Institute, Tsukuba, Ibaraki, JAPAN; (2) National Institute of Crop Science, Tsukuba, Ibaraki, JAPAN

Cereal Foods World 54:A30

Rice straw has been attracted a keen interest as a feedstock for bioethanol production, without competition with food/feed production. Soft carbohydrates (SCs), defined as carbohydrates readily recoverable by mere extraction from the biomass or brief enzymatic saccharification, were found in significant amounts in rice straw in the form of free glucose, free fructose, sucrose, starch, and β-1,3-1,4-glucan. We found that 75% of total SCs exist in the culms of straw from the "Leaf Star" cultivar and that the total amount of SCs in the culm was about 55% of dry weight. Taking cellulose into account, the total amount of hexose in the culm reaches 72% of the dry weight. During the storage of rice straw, we observed quantitative and/or qualitative changes in the SCs component of culms, suggesting the importance of quality control during the storage period. We developed a simple method for bioethanol production from the culm, by a heat treatment for sterilization and starch gelatinization, followed by simultaneous saccharification / fermentation with *Saccharomyces cerevisiae*. This method would offer an efficient process for bioethanol production without the aid of harsh thermo/chemical pretreatment step.

Activity-guided fractionation of cereal phytochemicals according to their antioxidative properties and their phase I enzyme modulating activity

C. TYL (1), M. Bunzel (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.

Cereal Foods World 54:A30

Best Student Research Paper Competition

Whole grain consumption is correlated with a decrease in the risk of diseases associated with chronic inflammation, such as colonic cancer. Certain phytochemicals isolated from cereal grains have been shown to possess antioxidative and anti-tumor activities. Moreover, wheat bran extracts have been found to modulate xenobiotics metabolizing enzymes (XME), but the responsible constituents have not been identified yet. The aim of this study is to find out which phytochemicals from whole wheat are key compounds exhibiting antioxidant and XME modulating activities by using activity guided chromatographic fractionation. Ground whole wheat is consecutively extracted with solvents of different polarity, and cell-wall bound components are obtained by extraction after alkaline hydrolysis. The Folin Ciocalteu assay, the TEAC assay and the leucomethylene blue test are used for the evaluation of the extracts' reducing and radical scavenging properties. Modulation of the phase I enzyme cytochrome P-450 1A2 (CYP1A2) is investigated in a yeast model. Only extracts with the most pronounced effects in these tests are selected for further purification by size exclusion chromatography and HPLC. Finally, the structure of the most bioactive compounds will be elucidated by mass spectrometry and nuclear magnetic resonance spectroscopy. Results obtained so far include trolox equivalents of crude extracts in the above-mentioned antioxidant-tests and the determination of their effect on CYP1A2 activity. The highest antioxidative activity was found in the extracts obtained after alkaline hydrolysis. Purification of crude extracts with subsequent testing is currently underway. This study is intended to be the first approach towards investigating how technological processes may release bioactive compounds and also towards the breeding of cereal lines enriched in health-promoting phytochemicals.

Starch derivatives and their properties

W. VORWERG (1), S. Radosta (1), B. Volkert (1), K. Hettrich (1)
(1) Fraunhofer Institute for Applied Polymer Research, Potsdam, U.S.A.

Cereal Foods World 54:A30

The feedstock starch provides a manifold potential for desired polymer applications, predominantly in the areas of food and pharma industry, technical specialies and packaging materials. The development and optimisation of starch products is focused besides fermentation processing on applications like regulation of viscosity or gel rigidity in hydrophilic or lipophilic systems, functional additive in binder formulations, encapsulation or embedding of agents, usage as emulsifier, cationic or anionic polyelectrolyte and production of films or injection moulded materials. Processing and product properties are determined by the choice of starch type, composition of the starch, the kind of enzyme or depolymerisation agent, applied oxidation agents or reagents for the preparation of esters or ethers, the substituent pattern of introduced functional groups and the molar mass distribution. Compared with the methods of physical treatment and acidic and enzymatic hydrolysis the chemical derivatisation becomes more important. Ionic, neutral and hydrophobic substituents cause a broad spectrum of different physical properties. The different ways to establish structure-property-relationships are described by several examples of modification for enzymatic conversion, preparation of viscosity stable non aggregating products, the suitability as emulsifier or encapsulation agent, the development of retention and surface sizing aid in papermaking and the replacement of polyvinyl alcohol and polyolefins in packaging materials. Methods for the characterisation of physical properties comprise the molar mass distribution, degree of substitution as information about the chemical composition, rheological behaviour like flow curves and oscillation measurements, adsorption isotherms of cationic starch on cellulose fibre, paper strength, water stability, printability, flocculation and mechanical properties of films.

Synchrotron infrared confocal microspectroscopic imaging reveals chemical modification sites on single starch granules

D. L. WETZEL (1), Y. Shi (1), J. A. Reffner (2)
(1) Microbeam Molecular Spectroscopy Laboratory, Kansas State University, Manhattan, KS, U.S.A.; (2) John Jay College, New York, NY

Cereal Foods World 54:A30

This is the first attempt to pinpoint modification sites on single starch granules by FT-IR microspectroscopic techniques involving small step mapping to achieve localization. The spatial resolution achievable with the combination of synchrotron infrared microspectroscopy and the confocal image plane masking of the double-pass single mask Continuum™ on the U10b beamline of the National Synchrotron Lightsource of Brookhaven National Laboratory was used in this study. Commercial use of modified starch is well established and widespread. Octenyl succinic anhydride modified starch has had approval for food use for decades. Starch from grains such as corn or wheat exists in granules. The size of the granules depends on the plant from which the starch is produced. In this study, the granules typically had a median size of 15 µm. In the production of modified starch, typically an acid anhydride is reacted with OH groups of the starch polymer. On any one granule, there are a large number of sites available. With a two-phase solid starch and liquid reagent reaction mixture, homogeneity in coverage is not predictable. The resulting ester formation at a modification site adds the ester carbonyl (1740 cm^{-1}) organic functional group as well as contributing to CH_2 stretching vibration from the hydrocarbon chain of the ester to enhance the 2927 cm^{-1} band intensity. Detection of the modifying group at any of these locations on a single granule can be accomplished from the baseline adjusted peak area the added carbonyl functional group. By stepping a confocal 5 µm x 5 µm mask 1 µm at a time in both the x and y directions, location of adduct functional groups is localized in spite of the limitations of diffraction. Results of this study are shown for granules of corn starch modified with octenyl succinic anhydride. Additionally, a modified wheat starch granule, extended the study to another starch. Several individual modified corn starch granules were mapped in small steps with a 5 µm × 5 µm confocal image plane masking in a raster scan procedure. A ratio of the 1740 cm^{-1} carbonyl bond area to a band representative of starch in the 1150-1025 cm^{-1} region produced images that revealed the locus of modified sites in 10 µm × 10 µm areas.

Mapping composition of cereal products by NIR hyperspectral imaging

M. B. WHITWORTH (1), S. J. Millar (1), A. Chau (1)
(1) Campden BRI, Chipping Campden, Gloucestershire, GL55 6LD, UNITED KINGDOM

Cereal Foods World 54:A30

Near infrared reflectance (NIR) spectroscopy is widely established in the cereals industry for rapid analysis of average properties for bulk samples. New technology enables images to be taken for which an NIR spectrum is available for each pixel, enabling the distribution of composition to be mapped. This paper describes applications to cereal grains, flour and baked products. Measurements were taken using a system supplied by Gilden Photonics Ltd. (Glasgow, UK) incorporating a Specim (Oulu, Finland) SWIR camera with a cooled 14 bit HgCdTe detector and N25E spectrograph. Samples were scanned in a pushbroom mode using a motorised stage. The system has a spectral resolution of 256 pixels covering a range of 970–2500 nm and a spatial resolution of 320 pixels covering a swathe adjustable from 8 to 300 mm. Images are acquired at a rate of up to 100 lines/s, enabling samples to be scanned within a few seconds. An application is shown for measurement of changes in moisture distribution in baguettes during storage. Replicate samples were taken at intervals of time after production. Hyperspectral images were taken for slices and reference moisture measurements were made for core samples by oven drying. A moisture calibration was developed by PLS analysis using mean spectra for regions corresponding to those from which cores were cut. The calibration was applied to map the distribution of moisture for each pixel in the slices. Results are presented as a function of storage time and humidity. Further examples for baked products include a comparison of crystalline and non-crystalline sucrose in biscuits and a cream filling, and measurement of moisture and fat distributions in fried products

including doughnuts. Results will also be presented from ongoing studies of moisture diffusion in starch pellets, wheat and flour homogeneity, and malting of barley grains.

Modified starches reveal starch and protein functionality in a model pound cake system

E. WILDERJANS (1), A. Luyts (1), H. Goesaert (2), K. Brijs (1), J. A. Delcour (3)
(1) Laboratory of Food Chemistry and Biochemistry and Leuven Food Science and Nutrition Research Center (LFoRCe), Katholieke Universiteit Leuven; (2) KULeuven LRD; (3) jan.delcour@biw.kuleuven.be
Cereal Foods World 54:A31

Different modified wheat starches were used in a pound cake formula using gluten-starch blends as flour models. The impact of incorporation of 30% cross-linked starches on batter properties during baking was much smaller than that of incorporation of the same level of hydroxypropylated starches. Incorporation of hydroxypropylated starch in the recipe fastened batter viscosity increase during baking and diminished oven rise. Furthermore, cakes containing hydroxypropylated starch rather than native starch had higher protein extractability. During cooling, control cake collapsed less than cross-linked starch containing cake, which itself collapsed less than hydroxypropylated starch containing cake. Presumably, most of the cake collapse takes place before the starch gel is formed during cooling. Protein aggregation during baking, on the other hand, provides cell walls with structural material and a higher resistance to collapse. Furthermore, the starch gel as well as reacted protein influenced the cell wall texture. Obviously, the combination of a protein network, formed during baking, with a starch gel, formed during cooling, makes up the crumb cell walls and determines cake quality.

A consumer packaged goods company perspective on rice sustainability

M. WILSON (1)
(1) Mars Food US, Rancho Domiguez, CA, U.S.A.
Cereal Foods World 54:A31

Global warming, greenhouse gas, water stress index and carbon footprint are all terms that have been added to our daily vernacular to describe the various aspects of sustainability. More and more consumers are making informed choices on the products and brands they purchase based on their environmental impact. Rice feeds nearly half of the world's population and is responsible for over 20% of calories consumed. Thus, growing rice and its processing, distributing, preparation and disposal have significant impacts on the environment and even small improvements can make an important difference. It is now obvious that creating a more sustainable rice industry is not just the responsible thing to do, it's vital for the long term viability of our industry. Although the US rice industry accounts for a small percentage of the global rice market, we clearly have an opportunity and obligation to work together to demonstrate our leadership on sustainability and environmental stewardship.

Preparation and properties of reversibly swellable starches

K. WOO (1), P. A. Seib (2)
(1) MGP Ingredients Inc, Shawnee, KS; (2) Kansas State University
Cereal Foods World 54:A31

Reversibly swellable starches were prepared from wheat, waxy wheat, potato, corn, waxy corn, and high-amylose (70%) corn by pre-swelling, cross-linking, gelatinizing and drying. Starch was subjected to pre-swelling for 30–90 min at 45°C in water (15–20% w/w starch solids) with sodium hydroxide (1–3%, starch basis) and sodium sulfate (5–15%, starch basis). Then, cross-linking was done by adding 10% (sb) of a mixture (99/1, w/w) of sodium trimetaphosphate and sodium tripolyphosphate and stirring at 45°C for 2–8 h. After isolation the modified starch was gelatinized in excess water by boiling for 30 min, and oven-dried (40°C) to give practically a quantitative yield of reversibly swellable starch containing up to 0.4% phosphorus and 5–60% total dietary fiber. Reversibly swellable wheat starches exhibited reversible swelling in excess water at 25°C and 95°C that was equal to swelling power, 3–12 g/g at either temperature. The equal swelling powers at 25°C and 95°C imply that the hydratable starch chains in the reversibly swellable starch do not retrograde into intractable solids upon oven drying, probably because of the limited mobility of the cross-linked network. During six cycles of hydration in excess water at 95°C followed by oven drying at 100°C, the modified wheat starch with moderate swelling (swelling power 8 g/g) maintained the same swelling properties without losing granular structure or soluble starch. Reversibly swellable wheat with moderate swelling power of 8 g/g did not develop sufficient viscosity to register a pasting curve at 8% starch solids. A pasting curve was observed at 20% starch solids. Reversibly moderately swellable wheat starch hydrated with 8–9 parts of water produces a smooth, fat-like semisolid. Reversibly swellable starches show potential as non-gelling, opaque thickeners, as well as fat replacers, recyclable desiccants, flowing agents, drug and flavor carriers, and off-odor absorbers.

Evaluation of waxy grain sorghum for ethanol production

S. YAN (1), X. Wu (2), S. Bean (3), J. Pederson (4), T. Tesso (5), R. Chen (3), D. Wang (2)
(1) Kansas State University, Manhattan, KS; (2) Kansas State University, Biological and Agricultural Engineering, Manhanttan, KS; (3) USDA-ARS Grain Marketing and Production Research Center, Manhattan, KS; (4) USDA-ARS Grain, Forages and Bioenergy Research, University of Nebraska, Lincoln, NE; (5) Department of Agronomy, Kansas State University, Manhattan, KS
Cereal Foods World 54:A31

The objective of this research was to investigate the fermentation performance of waxy grain sorghum for ethanol production Waxy grain sorghum varieties were evaluated using a laboratory dry grind procedure. Total starch and amylose contents were measured using Megazyme assay procedures. The range of total starch and amylose contents were 65.4–76.3% and 5.5–7.3%, respectively. Fermentation efficiencies were 89–95%, corresponding to ethanol yields from 2.61–3.03 gallon/bushel. The major advantages of using waxy sorghums for ethanol production are low energy input for cooking process, high starch and protein digestibility, high free amino nitrogen content, and short fermentation time. The results showed there was strong linear relationship between free amino nitrogen and fermentation rate. Fermentation rate increased as free amino nitrogen content increased, especially during the first 30 hours of fermentation ($R^2 = 0.91$). Total starch content in distillers dried grains with solubles (DDGS) was less than 1% for all the waxy varieties.

Inhibitory effect of sorghum 3-deoxyanthocyanin structure on esophageal cancer cell proliferation *in vitro*

L. YANG (1), J. M. Awika (1)
(1) Dept. of Soil & Crop Sciences, Texas A&M University, College Station, TX, U.S.A.
Cereal Foods World 54:A31

Best Student Research Paper Competition

Epidemiological evidence has correlated consumption of sorghum with reduced incidences of gastrointestinal (GI) tract cancer, especially esophageal cancer. We recently found that the level of pigmentation in sorghum affected their potency to inhibit human GI cancer cell growth *in vitro*. This study aims to determine how structure of isolated sorghum 3-deoxyanthocyanin pigments affects their antiproliferation potential. Inhibitory capacity of pigments isolated from black sorghum (Tx430) on human esophageal carcinoma cells (OE33) growth were evaluated using MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) and PicoGreen assays. The 3-deoxyanthocyanins found in black sorghum were luteolinidin, apigeninidin and their derivatives. Luteolinidin and apigeninidin showed a 50% inhibition (IC_{50}) of OE33 proliferation at 169.5–283.3 μM, which was comparable to genistein, the isoflavone in soybean (IC_{50}s117.5–144.2 μM); 7-methoxylated luteolinidin and apigeninidin exhibited stronger inhibitory potential with IC_{50}s from 41.0–192.0 μM; the 5,7-dimethoxylated forms had strongest potency: IC_{50}s were 47.2–102.0 μM for 5,7-dimethoxyluteolinidin and 17.9–18.5 μM for 5,7-dimethoxyapigeninidin. Glycosides had lower potency compared with their aglycones. Higher molecular weight 3-deoxyanthocyanin fractions showed inhibitory potential with IC_{50}s 73.2–103.4 μg/mL, which was stronger than the crude extract from black sorghum (IC_{50} 251–422 μg/mL). Apigeninidin and its derivatives have stronger inhibitory potency than respective luteolinidin derivatives. Methoxylation generally improved the inhibitory capacity of the molecules. Sorghum 3-deoxyanthocyanins, which are known to be stable colorants, have strong inhibitory capacity against human esophageal cancer cell growth and could be valuable functional ingredients in health-related products.

Novel thermo-mechanical pretreatment of lignocellulosic biomass for efficient ethanol production from agricultural residues

J. YOO (1), S. Alavi (1), P. Vadlani (1), V. Amanor-Boadu (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A31

The 2008 National Biofuels Acti gallons of annual ethanol production in the U.S. by 2022, most of which is expected to be met by advanced biofuels. This study was to investigate an efficient pre-treatment process based on thermo-mechanical extrusion processing foron Plan envisions 36 billion low cost lignocellulosic ethanol production along with optimum process parameters for enzymatic saccharification. Sugar yield was determined by using a dinitrosalicylic acid sugar assay and HPLC. The enzyme combination for maximum reducing sugar yield from soybean hulls, pre-treated using dilute acid hydrolysis, was found at 84.3, 82.2 and 111.3 ml/g cellulose for cellulase,

cellobiase, and cell-wall degrading enzyme, respectively, following response surface methodology. However no optimum could be found in the studied range from alkali hydrolyzed or extruded soybean hull. After 48 hrs incubation, more than 80% of starch and non-starch polysaccharides in the extrudate were hydrolyzed, and the saccharification rate stabilized. The effect of extrusion process parameters on sugar yield, such as barrel temperature, in-barrel moisture, and starch addition was compared. Extrusion processing was facilitated by the addition of corn starch. Maximum sugar yield was obtained with 20% starch, 20% in-barrel moisture, and 80°C barrel temperature. For samples extruded at 80°C, glucose content ranged from 24 to 28 g/L, which corresponded to 59 to 71% conversion of cellulose. Extrusion processing increased cellulose conversion to glucose by up to 42.7% compared with non extruded soybean hull-starch mixture. High in-barrel moisture content (40%) without starch addition also helped extrusion processing of soybean hulls, and its sugar yield was comparable to traditional pre-treatments. The extrusion process resulted in less change in cellulose crystallinity than did acid or alkali hydrolysis.

2009 Annual Meeting
Abstracts of Poster Presentations

Abstracts submitted for poster presentations at the 2009 annual meeting in Baltimore, Maryland, September 13–16. 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.

Cooling procedure after sterilization in a liquid of a specific starch determines the *in vitro* digestion and particle size characteristics

E. ABRAHAMSE (1), F. Dijk (1), J. Knol (1), H. Bouritius (1)
(1) Danone Research - Centre for Specialised Nutrition, Wageningen, NETHERLANDS
Cereal Foods World 54:A33

In a previous study it was shown that a specific sterilization temperature applied to an aqueous suspension of (modified high amylose starch) mHAS makes it slowly digestible *in vitro* and low glycemic in rats (J Nutr, 2007. 137(10): 2202-7). In the current pilot study the effect of different cooling procedures after sterilization on *in vitro* digestion characteristics as well as particle size distribution was investigated. After heating the starch suspension at 121°C in an oil bath, the products were placed in a water bath of 4, 20, 30 or 40°C to let starch retrogradation take place. After 24 hrs the nutritionally important starch fractions RDS (rapidly digestible starch), SDS (slowly digestible starch) and RS (resistant starch) were determined with the method of Englyst. Particle size distribution was determined using laser diffraction. The digestibility appeared to increase with decreasing cooling temperature; the amount of RS dropped from approx. 55% at 40°C to 8% at 4°C. The amount of SDS and RDS both increased with decreasing cooling temperature, although more pronounced for SDS; from approx. 6% at 40°C to 32% at 4°C versus 30% at 40°C to 52% at 4°C for RDS. The particle size distribution also appeared to be temperature dependent; the specific surface area, calculated from the surface weighed mean particle diameter, increased with decreasing temperature. The resulting higher surface to volume ratio may be an explanation for the higher digestibility. These results show that by means of heat and especially cooling treatment the characteristics of the starch source mHAS can be designed for a specific need; in this case highly but slowly digestible for inclusion of a low glycemic, high energy diet for malnourished diabetic patients.

Physical, texture and preference characteristics of pasta added with unripe banana flour

E. AGAMA-ACEVEDO (1), J. J. Islas-Hernandez (1), P. Osorio-Diaz (1)
(1) CEPROBI-IPN, Yautepec, Morelos, MEXICO
Cereal Foods World 54:A33

Banana is a starchy food that contains a high proportion of indigestible compounds such as resistant starch and non-starch polysaccharides. Products with low glycemic response such as pasta are considered favorable to health. The objective of this study was to use unripe banana flour to make spaghetti with low-carbohydrates digestibility and evaluate its physical and texture characteristics, as well as consumer preference. Formulations consisting of 100% durum wheat semolina (control) and mixtures of semolina:banana flour of 85:15, 70:30 and 55:45 were prepared for spaghetti processing. The addition of banana flour decreased the lightness and diameter of cooked spaghetti, and increased the water absorption of the product. Hardness and elasticity of spaghetti were not affected by the addition of banana flour, but adhesiveness and chewiness increased when banana flour level in the blend rose. Spaghettis prepared in the laboratory (control and those added with banana flour at different levels) did not show difference in the preference by the consumers. In general, the preference of spaghettis added with different banana flour level was similar. Addition of a source of indigestible carbohydrates (banana flour) to spaghetti did not produce changes in preference by consumers and is possible to elaborate a nutraceutical product.

Characterization of sorghum starch

Y. AI (1), R. Wongsagonsup (1), D. Wang (2), J. Jane (1)
(1) Iowa State University, Ames, IA, U.S.A.; (2) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A33

Sorghum, a drought-tolerant cereal crop, has considerable potential for food and bioethanol applications. Objectives of this study were to characterize the physicochemical properties and digestibility of starches isolated from five sorghum lines (6B73, 6C21, 6C69, 7R34, and X789). The sorghum kernels consisted of 71.7 to 77.7% starch (db). Starches of X789 and 7R34 lines had the lowest onset gelatinization temperature (T_o, 66.6°C), and that of the 6C69 had the highest T_o (67.4°C). The starches had different amylose contents. The X789 starch had the least amylose content (27.1%), whereas the 7R34 starch had the largest (29.6%). The pasting temperatures of the five starches varied from 72.4 to 74.0°C. The X789 starch showed higher peak viscosity (183.0 RVU) than other starch samples (152.1-173.3 RVU). All starches displayed the A-type X-ray pattern with percentage crystallinity of 25.8–29.6%. Among all the starches studied, the X789 starch displayed the greatest susceptibility to porcine pancreatic α-amylase hydrolysis, and the starch hydrolysis reached 47.2% after 48 h, whereas for other starches it ranged from 36.3 to 40.0%. The mass ratio of long branch-chains ($27 < DP < 118$) to short branch-chains ($DP < 27$) of amylopectin of the X789 starch, determined using HPSEC, was smaller (0.37) than other starch samples (0.41–0.45). The fewer long branch-chains of the X789 starch could result in its lower T_o and greater digestibility to enzyme hydrolysis than other starches.

Separation and isolation of intact parenchyma cells from raw (uncooked) potato (*Solanum tuberosum*) tissue

A. ANANTACHOTE (1), H. Kim (1), K. C. Huber (1)
(1) University of Idaho, Moscow, ID, U.S.A
Cereal Foods World 54:A33

During processing of commercial potato products, heat processing renders starch within tubers readily digestible, leading to high glycemic, low resistant starch products. The overarching goal of this research was to develop and characterize a dehydrated potato-based food ingredient possessing an intact

parenchyma cell structure (potential for RS1) and ungelatinized starch granule fraction (potential for RS2). Two potato cultivars, Russet Burbank (RB) and Russet Norkotah (RN), and two isolation schemes, alkaline (ALK) and enzyme (ENZ) treatments, were evaluated for generation of parenchyma cell flours (i.e., 'Cell' fractions). Isolated 'Cell' fractions representing cultivar/isolation methods were analyzed in regard to fraction yield, microstructure, chemical composition, and physical properties. Cultivar/isolation method combinations yielded 'Cell' fractions in the range of 40–60% (w/w) of fresh potato dry solid contents. 'Cell' fraction yields from raw potato tissue for the four cultivar/isolation scheme combinations followed the order: RN/ENZ > RB/ENZ > RN/ALK > RB/ALK. RN produced greater 'Cell' fraction yields than RB, while the ENZ method was more productive than the ALK method. Scanning electron microscope (SEM) and light microscope (LM) observations revealed that 'Cell' fractions were comprised of intact parenchyma cells possessing ungelatinized starch granules. Swelling, gelatinization, and pasting characteristics of isolated 'Cell' fractions varied according to isolation method (ALK vs. ENZ). These products could potentially be utilized 'as is' in low-moisture food applications (e.g., baked or snack products), or be subjected to additional physical and/or chemical treatments to modify physical properties, moderate digestibility, and/or enhance resistant starch content and stability.

Effect of retrogradation and dehydration process on physicochemical and texture properties of maize tortillas

G. ARAMBULA-VILLA (1), A. Escalante-Aburto (2), I. Verdalet-Guzman (2), E. Gutierrez-Arias (3)
(1) CINVESTAV-IPN Queretaro, Queretaro, Qro., MEXICO; (2) Instituto de Ciencias Basicas. Universidad Veracruzana. Veracruz, Mexico; (3) Cinvestav-Qro., Queretaro, Qro., Mexico
Cereal Foods World 54:A34

The maize tortillas lose their texture characteristics after theirs elaboration and during storage. The staling of maize tortillas could be caused by retrogradation of starch granules, but the water loss due the dehydration can affect this property also. The aim of this study was to evaluate the effects of retrogradation and dehydration process on the main physicochemical and textural properties of maize tortillas. Two types of maize grain (*Conico norteño* and *QPM*) were used to make tortillas by the traditional "nixtamalization" process. To evaluate the retrogradation effect, the tortillas were kept at constant relative moisture, and to evaluate the dehydration process, the temperature and relative moisture were kept constant. Three relative moisture, 30, 40 and 50%; and three temperatures, 25, 35, y 45°C were tested. The physicochemical properties of experimental tortillas were similar to that from tortillas elaborated with other types of maize considered as adequate for nixtamalization. The moisture content for tortillas elaborated with *Conico* and *QPM* was 47.01% and 42.94%, respectively. Tortillas from both types of maize showed adequate puffing degree and rollability, but the tensile strength showed significant differences. The values of cutting force were similar in tortillas from two types of maize. Tortillas elaborated with *Conico* and *QPM* maize showed similar behavior, increasing the tensile strength and cutting force as the storage time was increased. The retrogradation enthalpy was higher for tortillas storage with non-controlled relative moisture with temperature 5°C. In the first hour of storage, the higher value of retrogradation enthalpy was showed. The values of Effective Moisture Diffusion Coefficient were 6.97×10^{-7} cm^2s^{-1} for *QPM* tortillas and 11.43×10^{-6} cm^2s^{-1} for *Conico* tortillas, this indicated higher rate of dehydration for *Conico* tortilla samples.

Irradiation as a tool for modifying physiochemical characteristics of rice flours and rice cake quality

B. BAIK (1), J. Lee (2), M. Byun (2), J. Kim (2), J. Kim (3), S. Lim (3)
(1) Washington State University, Pullman, WA, U.S.A.; (2) Korea Atomic Energy Research Institute, Daejeon, Korea; (3) School of Life Sciences and Biotechnology, Korea University, Seoul, Korea
Cereal Foods World 54:A34

Gamma irradiation is an effective way to control insects and microorganisms in food ingredients, and is also known to cause modifications of food components, affecting their physicochemical properties and, subsequently, food product quality. Irradiation may be used as a rapid and convenient tool for modifying properties of major food components. We irradiated two rice flours of different amylose content at doses of 1, 3, 5 and 10 kGy, and determined their functional properties and rice cake quality. Both pasting viscosity and setback of rice flour of 12% concentration decreased consistently as irradiation dose increased, probably due to the breakdown of both amylopectin and amylose molecules by irradiation. While normal rice flour of 12% concentration formed a relatively strong gel before irradiation, it failed to form a gel even with irradiation dose of 1 kGy and remained as a paste after 7 days at 4°C, indicating that amylose molecules of rice starch sustained severe damage with irradiation. DSC onset temperature and enthalpy for gelatinization of waxy rice flour of 50% concentration was little affected by irradiation dosage up to 10 kGy. For melting retrograded waxy rice flour of 50% concentration, irradiation of 1 to 10 kGy showed no influence on onset temperature, but lowered enthalpy from 14.2 in non-irradiated flour to 11.3–11.8 J/g with little dosage effect. Rice cakes prepared from both normal and waxy rice flours showed shrinkage with irradiation to a greater degree in normal than in waxy flour. Normal rice flour irradiated at 1 kGy and waxy rice flour at 1 to 3 kGy produced rice cakes of similar or lower hardness compared to non-irradiated flour. When stored for 1 day, rice cakes of waxy rice flours irradiated at 1 to 3 kGy exhibited lower hardness compared to rice cakes of non-irradiated flours.

Total phenolics, flavonoids, antioxidant capacity in rice grain and their relations to grain color, size and weight

J. BAO (1), Y. Shen (1), L. Jin (1)
(1) Zhejiang University, Hangzhou, PEOPLES REP OF CHINA
Cereal Foods World 54:A34

Total phenolics, flavonoids contents and antioxidant capacity from a wide collection of rice germplasm were measured, and their relations to grain color, grain size and 100-grain weight were investigated. Highly significant genotypic differences were observed in total phenolic, flavonoid content and 2,2-azino-bis-(3-ehylbenzothiazoline-6-sulphonic acid) diammonium salt (ABTS) radical cation antioxidant capacity. Significant positive pair-wise correlations were found among the phenolic, flavonoid content and antioxidant capacity, and the coefficient between the phenolic content and antioxidant capacity was extremely high ($r = 0.96$). Among all rice accessions, the grain color parameters had negativet correlations with the phenolic, flavonoid content and antioxidant capacity ($p < 0.001$). The negative correlation between color parameter a^* and antioxidant capacity, and the positive correlation between color paramter *hue* (H^o) and antioxidant capacity were consistent within the respective white rice and red rice groups. Flavonoid content had positive correlation with grain length and length to width ratio, and had negative correlation with the 100-grain weight among all rice accessions. It was also found that 100-grain weight still had negative correlations with phenolic, flavonoid content and antioxidant capacity within the white rice genotypes. These relationships may be served as index to indirectly select breeding lines high in the phenolics, flavonoids and antioxidant capacity. This project was funded by Zhejiang Provincial Natural Science Foundation (R3080016) and the New-Century Young Investigator program from the Ministry of Enducation, China.

Optimized combinations of fibers used as nutritional stabilizers in cereal based products

S. BARAY (1)
(1) Colloides Naturels International, Rouen, France
Cereal Foods World 54:A34

Colloides Naturels International (CNI) has developed a line of functional and nutritional food ingredients based on two all-natural co-processed dietary fibers: acacia gum, a soluble fiber, and wheat fiber, a gluten-free insoluble fiber. This Fiber Innovation is manufactured using a proprietary and unique technology developed exclusively by CNI and contains a minimum level of 90% dietary fiber on a dry weight basis. This Fiber Innovation combines the numerous proven nutritional and health benefits of acacia gum (notably a strong prebiotic effect and the ability to reduce blood glycemia) with the well-known positive effect of wheat fiber on transit regulation. An optimized and balanced ratio between the two essential types of fibers has been achieved in this range of healthy ingredients to deliver the highest level of functionality in a variety of food products. Many application studies have been completed to show that Fiber Innovation mimics the rheological properties of fat while enhancing the freshness of different foodstuffs. Not only the nutritional profile of food products is improved through the enrichment with soluble and insoluble fibers, but also the overall caloric value can be significantly reduced by replacing fat with non digestible fibers. In bakery products such as muffins, cakes and cookies, 1% Fiber Innovation can substitute up to 50% of the fat while noticeably improving the texture and the shelf life. This new ingredient is dispersible in cold water and requires no heating or shearing for activation, in order to develop its unique smooth texture. The Fiber Innovation is a pre-activated dust free and instantized pure powder that is tasteless and odorless. It is easy to use and tolerant to most processing conditions (high shear, temperature or pH extremes).

Cluster analysis of lowland and upland rice cultivars based on grain quality attributes

P. Z. BASSINELLO (1), O. P. de Morais (1), J. P. de Oliveira (1), M. Chen (2), A. McClung (3)
(1) EMBRAPA Rice and Beans, Santo Antonio de Goias, GO, BRAZIL; (2) USDA, Beaumont, TX; (3) USDA, Stutgart, AR
Cereal Foods World 54:A34

Rice is cropped in many countries all over the world and plays an important role in human nutrition as well as in agricultural economics, besides its social

importance. Embrapa Rice and Beans is responsible for national rice enhancement programs and is conducting breeding projects to increase yield and grain quality. A big challenge has been to characterize rice quality based on indirect methods and, especially for lowland cultivars, differentiate the cooking or technological properties of those samples with similar amylose content. The aim of this work was to evaluate some quality parameters in different rice cultivars from upland and lowland systems and submit them to the cluster analysis. The following analyses were done: apparent amylose content, gelatinization temperature (alkali test), RVA and cooking test according to standard methods. Data analyses were performed based on cluster and corr procedure using Statistical Analysis System (SAS institute 2002). Based on the results, most of samples were classified as intermediate apparent amylose, but presented different gelatinization temperatures (low and intermediate) and viscoamylographic profiles. The cluster analysis showed at least three main groups based on all studied parameters and it was possible to separate one group for lowland rice and two others for upland rice. Only one irrigated rice recommended for tropical areas was out of lowland group. The main attributes which seem to affect this pattern were the apparent amylose content and gelatinization temperature, when considering all the attributes together. When only the RVA results are considered, a different profile is exhibited by the cluster analysis, showing new combinations. The analysis also revealed the cultivars from both systems with similar patterns for almost all attributes.

Algae as a nutritive valuable ingredient in food

K. S. BECH (1)
(1) Danish Technological Institute, Aarhus C, DENMARK
Cereal Foods World 54:A35

Algae (seaweed and phytoplankton) are generally speaking an unexploited source of a large number of nutritive valuable ingredients which can be used to increase the nutritional value of food. The Danish Technological Institute, a government approved technological service institute, is developing cost-effective ways of using algae components in food to improve the nutritional value of food products. For centuries algae have been used as an important source of food for humans and feed for domestic animals in Denmark as well as in numerous other countries but are now mostly used in Asia. In the future it is expected that the use of algae as supplements in food products will increase due to the beneficial compounds in algae. Depending on the algae species and growth conditions the chemical composition can vary enormously. Phytoplankton can under certain conditions contain up to 90% lipids (dw) and not uncommonly above 50% (dw). Lipids in algae generally have an omega-3/omega-6 polyunsaturated fatty acids (PUFAs) ratio of approximately 1 which is as low as recommended in human diet. Seaweed has generally a low content of lipids but accumulates large concentrations of carbohydrates (i.e. alginate and carragenaan which are used as food stabilizers). Both seaweed and phytoplankton can contain high concentrations of protein with a very high amino acid score (based on the amount of essential amino acids) of up to 91-100. These values are substantially higher than what is found in cereals and are equal to what is found in animal protein. Interestingly, algae also contain several minerals and vitamins which can be used to enrich food products that are not nutritionally optimal. To enrich human food with algae extracts in the future appears to be highly beneficial as the production of algae is ecological as well as economic sustainable.

Effects of minimisation of sodium chloride in baked goods

M. BECK (1), M. T. Jekle (1), T. Becker (1)
(1) Technische Universität München - Lehrstuhl für Brau- und Getränketechnologie - 85350 Freising-Weihenstephan - Germany
Cereal Foods World 54:A35

The traditional use of sodium chloride (NaCl) in baked goods has technological and sensory reasons. Besides a controlled fermentation, an improved gluten structure, prolonged shelf life and improved processability, NaCl is most important for the sensory impression of baked goods. The sensory perception is, however, not only determined by the salty taste. In addition, salt also induces other sensory impressions, e.g. sweet taste and masks metallic aromas or bitter taste. Using NaCl in the production of food has been discussed controversely. An increased intake of sodium has been shown to be correlated with hypertension, which is associated with cardiovascular disease. Therefore, NaCl has been classified as an unwanted constituent of foods in the EU Health Claim regulation. As about 35% of the sodium demand are covered by baked goods. Baked goods contain about 1–1.6 g salt /100 g and are therefore critical according to the planned regulations. Hence, the aim of the present study was to investigate the effects of varying amounts of NaCl on rheological, sensorial and wheat bread texture properties. The technology effects were in particular studied by baking tests and DSC effects. Textural properties were measured by a Texture Analyser over a seven-day storage period. The addition of NaCl improved the hardness of wheat bread crumb and result in decreased retrogradation as determined with DSC. Further sensorial investigations were done. An optimum of bread popularity was recognized between 1,5 and 2% NaCl concentration in wheat bread. The results of this work confirm that NaCl owns important effect on wheat dough and on bread and sensorial quality and because of the above mentioned reasons the baking industry needs replacers for NaCl preserving the high quality of the products and a pure salty taste.

Structural studies of maize and barley starches: Amylose and amylopectin

L. A. BELLO-PEREZ (1), S. Rodriguez-Ambriz (1)
(1) CEPROBI-IPN, Yautepec, Morelos, MEXICO
Cereal Foods World 54:A35

Cereal starches such as maize, wheat, rice are widely used at the industrial level, and the molecular and structural characterization of its components (amylose and amylopectin) is an important step to predict and explain their physicochemical and functional behaviour. Solubilization procedures were tested, and that with the highest solubilization percentage was chosen to study the structural characteristics of amylose and amylopectin. To study the amylase molar mass a size-exclusion chromatography with refractive index (SEC-RI) system using a pullulan standard curve was used. Besides, microbatch system using a MALLS detector was used to determine the molar mass and gyration radius of starch and amylopectin. Difference in the shape and size of maize and barley starches were evident by the microscopy analysis, and intact granules were obtained after the isolation procedure. Microwave heating, produced higher solubility percentages than autoclave, and differences were found between both starches. The sample solubilized with microwave heating presented higher molar mass and gyration radius values than autoclave, showing that this process gives representative information of the initial starch sample in structural studies. When starch components were separated, amylose showed lower purity than amylopectin. Lower purity was obtained for amylose separated from barley starch, but no difference was obtained from purity of amylopectin separated from both starches. Barley amylopectin had higher solubility percentage than maize amylopectin. Molar mass of barley amylose was 1.03×10^5 g/mol and for maize of 2.25×10^5 g/mol. The molar mass of amylopectin separated from both starches was lower than its starch counterpart, although the same solubilization procedure (microwave heating) was used. The difference might be due to during separation of the starch components depolymerization was produced.

Effect of the acetylation degree in the morphological, physicochemical and structural characteristics of barley starch

L. BELLO-PEREZ (1), P. B. Zamudio-Flores (1), G. Mendez-Montealvo (1), S. L. Rodriguez-Ambriz (1)
(1) CEPROBI-IPN, Yautepec, Morelos, MEXICO
Cereal Foods World 54:A35

Barley (*Hordeum vulgare*) is one of the major cereal crops. Barley grain is mainly used in the brewing and malting industries and for animal feeds. Although the interest in barley as a component of food systems is mainly for the potential health benefits of β-glucans, barley still presents an important starch source for food and industrial applications. The objective of this study was to investigate the morphological, physicochemical and structural characteristics of acetylated barley starch at two different levels. Barley starch was acetylated at two levels (low degree (LD) and high degree (HD) substitution) and the morphological, physicochemical and structural of the resultant acetylated barley starch were determined. The acetylated barley starches presented the signal at 1226 cm^{-1} that corresponds to the C-O stretching of acetyl groups. The morphological study showed fusion of starch granules in the acetylated starch with HD. This effect was evident in the pasting test, because the viscoamylograph profile of HD starch showed the absence in peak viscosity, viscosity breakdown and viscosity setback. The peak gelatinization was similar for native and LD and decrease in the HD acetylated starch. The gelatinization enthalpy value showed difference among the samples, indicating that the loss of the ordered double helices more than the crystallinity loss was higher in the HD acetylated barley starch. In the retrogradation test, HD substitution avoided the retrogradation because the lowest enthalpy value was obtained in this acetylated starch. The Mw and Rz values decreased due to the acetylation process, indicating depolymerization of starch components as it was evidenced by the increase in short chains level in the acetylated samples.

Small scale and rapid starch isolation using a combination of ultrasound and sucrose gradient

M. BENMOUSSA (1), B. Hamaker (1)
(1) Whistler Center for Carbohydrate Research, Dept. of Food Science, Purdue University, West Lafayette, IN
Cereal Foods World 54:A35

Generally, the conventional procedures of starch extraction from cereal grains are longer than 48 hr and require a large amount of grain material. In any

starch isolation procedure, grain milling, protein extraction and starch granule separation are the main steps. An efficient procedure with reduced extraction time and material weight would be beneficial for analytical work. For this purpose, we propose a modification of all steps. Our goal in the present study was to develop a rapid starch isolation method with non-harmful chemicals and from dry-grinded flour. Maize and sorghum grains were selected for dry and wet milling. Our proposed procedure starts the dry milling and mixing the flour (100 mg) with NaCl solution (0.05 M) in a ratio of 1/5, w/v. Ultrasound was then used to reduce protein extraction time. Flour slurries were treated using an ultrasound probe at 25% amplitude followed by filtration through a nylon screen (52 µm). The slurry was again treated by ultrasound and then layered on top of a sucrose gradient solution (65%, w/v) for protein and starch granule separation. Tubes were centrifuged at low speed for 15 s. The pellet was washed three times with water or ethanol and then dried. Light microscope observation of separated fractions showed that starch granules were found in the pellet and proteins and damaged starch are collected from the top layer of the gradient. Isolated starch quality was tested using a birefringence microscope showing intact starch granule from the pellet. The proposed extraction method showed 67% yield for sorghum and 68% for maize. Protein content in isolated starch was below 0.5%. Isolated starch physicochemical properties were investigated. The combination of dry milling, ultrasound and sucrose gradient methods offers a small scale, rapid method for starch granule separation.

Prevalence and detection of mycotoxins in dried distillers grains from Nebraska

A. BIANCHINI (1), J. Stratton (1), L. B. Bullerman (1), S. Chung (1), T. Jackson (1)
(1) University of Nebraska, Lincoln, NE
Cereal Foods World 54:A36

Dried distillers grains are corn co-products produced by the ethanol industry, which primarily go into farm animal feed. A major concern is the possible presence of mycotoxins, which are not destroyed during the grain-to-ethanol conversion process. Mycotoxins can have deleterious effects on animal health, but few studies have been done to determine their prevalence in distillers grains. The objective of this study was to conduct a survey of distillers grains from ethanol plants in Nebraska for aflatoxin and fumonisin levels, and to optimize the methods of detection by high performance liquid chromatography. Forty-five samples of distillers grains were collected from ethanol plants and analyzed using a Dionex UltiMate™ 3000 HPLC system with Chromeleon® software. Waters Nova Pak® 4 µm 3.9 × 150 mm reversed phase C18 columns were used to perform the chromatographic separations and quantification. Of the samples surveyed, 45 of 45 samples were positive for one or more of fumonisin B1, B2, and B3, with the mean total detected at 7.0 ppm. The highest level detected was 17.6 ppm. For aflatoxin, 41 of 45 samples were positive for one or both aflatoxin B1 and B2, with the mean total detected at 2.0 ppb. The highest level detected was 14.4 ppb. Optimization of the detection methods for aflatoxin and fumonisin consisted of adjusting the mobile phase solvent ratios and the use of immunoaffinity clean-up columns. In addition, 15 samples were tested for aflatoxin and fumonisin using commercially available ELISA rapid detection kits. The overall results were comparable with the HPLC method, supporting their use for rapid screening. Distillers grains tested for deoxynivalenol by the ELISA method averaged 0.4 ppm per sample, with the highest level detected at 2.3 ppm.

Near IR Focal Plane Array imaging determines uniformity and composition in formula feed production using an edible tracer

M. D. BOATWRIGHT (1), D. L. Wetzel (1), L. R. Brewer (1)
(1) Microbeam Molecular Spectroscopy Laboratory, Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A36

Consumption of grain either directly or indirectly is responsible for a very large portion of the human diet. Bread, the “staff of life”, a product of cereals is consumed directly. Many grains find their way to human consumption by conversion of plant protein to animal protein, through the feeding of livestock. Formula feeds have a prominent role in the production of meat, dairy and poultry foods. The protein content of formula feeds is one of the primary guaranteed specifications. Essential nutrients and other ingredients, customized to suit the feeding objective and animal health, are blended during processing. The addition of trace nutrients and other additives requires a uniform distribution throughout the finished product. Assessing efficiency of the mixing operation is subject to the physical form in which the feedstuffs exist. To assure uniformity in the product, the performance of the mixing devise that typically has a capacity of 1000 lb or more, must be determined experimentally. Tracers commonly used that have a different granularity do not necessary have the flow characteristics of some of the nutrient additives. A tracer with granularity similar to the base material (ground corn, ground sorghum) offers an advantage. Near-IR spectral differences of an edible porphyrin from those of the commodities used allows a tracer function to be performed from near-IR images produced by an InSb focal plane array instrument that yields 82,000 pixels. Per image, spectra for each pixel are produced simultaneously in 3 minutes with no moving parts by electronic wavelength switching of a Liquid crystal tunable filter (LCTF). Imaging of samples collected at in regular 30 second intervals of the process from which the tracer population is assessed relative to the major commodity may be used to determine completeness of the mixing operation and avoid inefficient overmixing. Homogeneity of the mixed materials is reached when the tracer spectral response relative to the matrix reaches a steady state. Future flow rates and residence times in the mixer may be planned from such a test procedure. A spectroscopic difference in the tracer that maintains flow characteristics compatible with the commodity are the key to its employment and success in the procedure recommended in this study.

Bread making prediction for breeders from 50 grams of flour

N. BOINOT (1), O. Le Brun (1), A. Dubat (1)
(1) CHOPIN Technologies, Villeneuve la garenne, FRANCE
Cereal Foods World 54:A36

Bread making is the most accepted quality control tool for determining wheat flour quality. Nevertheless, Breeders often face the problem of small amount of sample, making it impossible to perform laboratory bread making tests following the standard method. A possibility is to use available laboratory instruments and to develop predictive models able to approach, as close as possible, the real “breadmaking” value. Normally developing such models require summing up results obtained from different laboratory devices. This leads to an increase uncertainty (cumulative uncertainty of each instrument) and need to higher sample quantity. The development of a new method based on the Chopin Technologies’s new Mixolab is under development in our applications department. The goal is to use the complete information given by the instrument (protein behavior, starch behavior, enzymes actions and interactions) in one single test and with a limited amount of samples (50 grams). We studied 191 wheat samples from two French crops, every sample was referenced in bread making characteristics following the French Standard NF V03-716. Each sample was tested on the Mixolab following the standard procedure (ICC N°173). Data Treatment and statistical treatment were made using Minitab® 1.15. For baking water absorption, the model allowed to have 88% and 99%. For the volume, we obtained 66% and 95%. For Dough Scoring we reached 63% and 93% and for bread scoring we obtained 58% within the repeatability limits and 81% within the reproducibility limits. This promising study continues by adding more samples and incorporating new crops. If confirmed, these results can offer a good alternative for breeders in order to evaluate the bread making potential of new lines. Such a method, first developed from French bread making, can be applied to any other type of processes.

Gelatin as functional ingredient in gluten-free bread

S. E. BOSWELL (1), C. M. McDonough (1), L. W. Rooney (1)
(1) Cereal Quality Laboratory, Texas A&M University, College Station, TX, U.S.A.
Cereal Foods World 54:A36

Interior crumb and grain structure development of gluten-free bread in certain non-scientific publications (recipe books) has used gelatin for promoting structure. The objective was to create a traditional gluten-free bread with and without gelatin using one pound and pup loaves to determine if gelatin is necessary in baking to set crumb structure that was acceptable to older and newly diagnosed gluten sensitive patients. Replicated baking trials were compared and no significant differences in volume were found between breads with and without gelatin, however significant baking behaviors and results were noted. Breads containing gelatin had consistently smaller loaf volume (41 cc) in one pound loaves. These differences in loaf volume were not statistically significant by using a paired t-test, indicating that gelatin is not a necessary ingredient. More importantly however, the baked loaves were significantly different in appearance, smell, and taste. The interior crumb properties of bread containing gelatin had a more random distribution of air bubbles in both one pound and pup loaves. This has been confirmed using electron microscopy. Informal sensory panels with non-gluten sensitive people indicated the crumb properties were more gummy and higher in moisture than breads without gelatin; this is currently being confirmed using texture profile analyses using a TA.XT2i. This is most likely due to syneresis. Sensory panels also noted that the bread containing gelatin had a bitter aftertaste. We conclude that gelatin addition is not necessary for gluten-free bread formation, it requires modifications in baking procedures, and may decrease the overall quality and acceptance of the final product. Formal tasting panels with and without celiac patients are planned to confirm these conclusions.

Testing for mycotoxins using LC/MS/MS

C. BREWE (1), D. Houchins (1), M. Prinster (1)
(1) Romer Labs, Inc., Union, MO, U.S.A.
Cereal Foods World 54:A37

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.

The effect of cooling, freezing and freeze-thawing on slowly digestible starch formation in mashed potatoes

T. BUI (1), Q. Liu (2), R. Yada (1)
(1) University of Guelph, Guelph, ON, CANADA; (2) Agriculture and Agri-Food Canada
Cereal Foods World 54:A37

Starch retrogradation is responsible for the formation of slowly digestible starch (SDS) which could provide some human health benefits. It is also known that the digestibility of potato products is influenced by the crystalline structure of starch. It is possible that the degree of crystallinity could be varied under differing processing conditions. Thus, the purpose of this study was to investigate the SDS formation in mashed potatoes using different cooling, freezing and freeze-thawing conditions: (1) two cycles of cooling at 4°C for 3 days and reheating using microwave; (2) cooling at 4°C for 24 hrs before freezing at –20°C for 1, 2, and 3 months; (3) three cycles of freeze-thawing (freezing at –20°C, thawing at room temperature). The *in vitro* digestibility and physicochemical and structural properties of mashed potato and its starch will be studied using analytical techniques including Englyst method for rapidly digestible starch, slowly digestible starch, and resistant starch; differential scanning calorimetry for starch retrogradation; light microscopy and scanning electron microscopy for starch morphology; and Fourier transform infrared spectroscopy with attenuated total reflectance for short-range order in starch. Cooling and reheating produce little SDS fraction while reheating partially disrupted the ordered structure. Freeze-thawing produced high SDS fraction with slow thawing at room temperature resulting in starch macromolecules having greater mobility resulting in faster aggregation to form ordered structures. The results of this study may provide effective processing conditions to achieve the desired level of SDS which can improve the nutritional value of mashed potatoes.

Combined protein and starch rheological measurements for evaluation of bread-making potential in hard red spring wheat breeding lines

M. CAFFE (1), K. Glover (1), P. Krishnan (1)
(1) South Dakota State University, Brookings, SD, U.S.A.
Cereal Foods World 54:A37

Major characteristics for bread-making (bake mixing time, bake absorption and loaf volume) were predicted using Mixolab and Mixograph parameters. The Chopin Mixolab is a newer apparatus that is able to collect data concerning protein and starch rheological characteristics. The temperature is controlled which provides accuracy and enables measurements of starch gelatinization and retrogradation, as well as enzymatic activity. The Mixograph is probably the most widely used method within US wheat breeding programs for prediction of baking characteristics and was therefore used as a reference method. Our objective was to evaluate use of the Mixolab as a new tool for end-use quality characterization by comparing it with the Mixograph to predict bread-making quality. In 2006 and 2007, eighteen spring wheat entries from our Advanced Yield Trials were grown at six locations throughout Eastern South Dakota. Flour from the resulting 216 samples was analyzed using both Mixograph and Mixolab methods. Additionally, samples were sent to the USDA Hard Red Spring Wheat Quality Laboratory in Fargo, ND, where standard end-use quality data were collected. Data were analyzed as location means and each year was considered separately. Using Mixolab parameters collected in both years, we were able to successfully predict bake mixing time, bake absorption and loaf volume with R^2 values higher than 0.76. Prediction models derived from Mixolab parameters had higher R^2 values than those from Mixograph parameters for bake absorption and loaf volume. Mixolab stability was a prominent variable in the predictability of loaf volume. Starch gelatinization measured by the Mixolab had a negative effect on loaf volume. Data from 2008 field trials are currently being compiled and will be added to the analysis.

Structure and digestibility of debranched waxy wheat, waxy corn, and waxy potato starches

L. CAI (1), Y. Shi (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A37

Starch is the most important source of food energy, yet the fundamental relationship between starch structure and digestibility is not well understood. Our overall objectives are to understand starch architecture, structural formation of different types of crystals and to establish the relationship between the starch crystalline structure and its digestibility. The specific aim of this work is to compare the structure and digestibility of debranched waxy wheat, waxy corn and waxy potato starches. Native waxy wheat and waxy corn starches give an A-type X-ray diffraction pattern whereas waxy potato starch has a B-type X-ray pattern. When these three waxy starches were cooked, debranched at 5% solids and crystallized at 50°C for 24 h and 25°C for another 24 h, they all resulted in crystallites with a typical B-type X-ray diffraction pattern, indicating that low solid concentration (5%) favored the formation of B-type crystals. The average chain length of waxy potato starch was larger than that of waxy corn and waxy wheat starch, resulting in a higher yield of crystalline aggregates (72.6%). An endothermic peak ranged from 80°C to 140°C were observed for all three debranched starch crystallites, as determined by differential scanning calorimetry. The debranched waxy potato crystallites showed slightly higher peak temperature (116.2°C) and enthalpy (19.2 J/g) than the debranched waxy corn (99.88°C and 18.6 J/g, respectively) and waxy wheat crystallites (99.73°C and 18.3 J/g, respectively). The *in vitro* digestion results indicated that crystallites from waxy potato starch had higher resistant starch content (77.8%) and lower slowly digestive starch content (8.75%) than that of waxy corn (68.14% and 14.35%, respectively) and waxy wheat starch (63.43% and 19.64%, respectively). These differences suggested that we may debranch and crystallize different waxy starches and produce products with different rates and extents of digestion.

Relationships between the 'MixoLab' outputs and the sensory assessment of Udon noodle eating quality

L. CATO (1), G. B. Crosbie (1)
(1) Dept. of Agric and Food WA, Bentley Delivery Ctr, WA, AUSTRALIA
Cereal Foods World 54:A37

A number of studies have indicated that the excellent quality of selected Western Australia wheat varieties for Japanese Udon noodles can be largely attributed to the quality of the starch component of this wheat and its effect on the eating characteristics of the boiled noodles. The high quality of this wheat has been associated with high starch paste peak viscosity as determined by the Brabender Viscograph. Flour swelling volume is also highly correlated with starch paste peak viscosity and various aspects of the texture of boiled noodles. Other important factors influencing noodle texture include protein content and protein quality. The main objective of this study was to evaluate a range of wheats using the 'MixoLab' (Chopin, Paris, France) and to investigate the relationship between outputs derived from the 'Mixolab' and various noodle properties. Preliminary results indicated that the difference between Mixolab parameters C3 and C4 appeared to be linked with boiled noodle yield and noodle firmness, suggesting that the 'Mixolab' may have a role in the assessment of potential noodle quality in advanced wheat breeding lines.

Fractionation of wheat middlings, soybean meal and cottonseed meal using combination of sieving and air classification

R. K. CHALLA (1), R. Srinivasan (1), F. D. To (1)
(1) Mississippi State University, Mississippi State, MS, U.S.A.
Cereal Foods World 54:A37

Recently, it was found that Elusieve process, the combination of sieving and elutriation (air classification) was effective in separating fiber from distillers dried grains with solubles (DDGS). The objective of the study is to evaluate the combination of sieving and air classification for fiber separation from wheat middlings (WM), soybean meal (SBM), cottonseed meal (CSM). Feed were sieved into size fractions and the size fractions were then air classified into lighter and heavier fractions. The product obtained by combining the heavier fractions is called "enhanced feed" and the product obtained by combining the lighter fractions is called "fiber product". Unprocessed feeds, size fractions and air-classified fractions from all the feeds were analyzed for neutral detergent fiber (NDF), protein, fat, ash and moisture contents. At low yields of lighter fraction (5%), the quantity of fiber product separated was 4.8, 3.7 and 1.3% by weight of WM, SBM and CSM, respectively. At high yields of lighter fractions (15%), the quantity of fiber product separated was 11, 8.9 and 3.5% by weight of WM, SBM and CSM, respectively. Processing resulted

in enhanced feeds with higher protein content than unprocessed feed by 0.2 to 0.6% points for WM, by 1.4 to 2.0% points for SBM and by 0.6% points for CSM. Fiber purity (NDF content) was higher at lower yields of lighter fractions as compared to high yields of lighter fraction.

Thermal properties and heat-stable resistant starch content of corn starches after acid-methanol and heat-moisture treatments

Y. CHANG (1), J. Lin (2), C. Wen (1)
(1) Providence University, Shalu, TAIWAN, REP OF CHINA; (2) MingDao University, Peetow, TAIWAN, ROC
Cereal Foods World 54:A38

Waxy, normal, Hylon V and Hylon VII corn starches with different molecular size (DP 10^5~10^2) were prepared by treating in ethanol containing 0.36% HCl at 45°C for 1 to 15 days. The acid-ethanol-treated starches were then heat-moisture treated with 30% moisture content at 100°C for 80 min. The thermal properties and heat-stable resistant starch (RS) content of starches after treatments were determined, and the effect of molecular structure on thermal properties and heat-stable resistant starch content of corn starches were investigated. Results showed that the gelatinization onset, peak and conclusion temperatures of starch increased after heat-moisture treated. The gelatinization temperatures of treated starches were unchanged or slightly increased with decreasing molecular size of starch, while the increment on gelatinization peak temperature with decreasing molecular size for Hylon V and Hylon VII starches were more obvious than that of waxy and normal corn starches. The heat-stable RS content of all starches obvious increased after treated, and increased with decreasing molecular size of starch. The heat-stable RS content of waxy and normal corn starches, for both native and treated starch, were less than 10%. However, higher heat-stable RS contents (12~36%) and more obvious increases in heat-stable RS content were observed for Hylon V and Hylon VII starches after treated. This is inline with the alternation on gelatinization peak temperature of Hylon V and Hylon VII starches after treated, reflecting that the heat-moisture treatment increases the heat stability and enzyme resistance of starch molecules. Results also indicate that long chain fraction, such as amylose or long chains of amylopectin, favors the formation of heat-stable RS, and partial degradation of starch improves the aliment of starch chains.

Interaction of iodine with different homo-glucan structures

F. CHAUHAN (1), K. Seetharaman (1)
(1) University of Guelph, Guelph, ON, Canada
Cereal Foods World 54:A38

The helical complex formation between iodine and a linear glucan polymer has been the cornerstone of research on starch. This reaction and resultant color/absorbance properties have been used to interpret many different properties and attributes of starch. The objective of this study was to investigate the interaction of iodine vapor with different branched homo-glucan polymers. The different glucan polymers studied included native granules, non granular starches, beta limit dextrins of the starches, and starch lintners from corn and potato starches, and their waxy counterparts, and high amylose corn starch. Glycogen, pure amylose, and cellulose were also studied. All of these materials were exposed to iodine vapor for 24 h and the resultant material was evaluated for their absorption spectra (K/S) and for their X-ray diffraction spectra. Except for cellulose all the structures bound iodine to different degrees, including beta-limit dextrins and 40-day lintners. Within each starch type, the beta limit dextrins exhibited the highest amount of absorption, followed by non-granular starches. The absorption spectra exhibit absorption values as high as 630 nm for many of these structures. The X-ray diffraction spectra also supports the iodine binding observation as is evident from the peak at 20 2-theta. These observations are interesting because they highlight the ability of a range of branched homo-glucan polymers to bind iodine; an observation that implies the presence of long enough linear regions that can form an alpha helix without stearic hindrances, even in structures like a beta limit dextrin that have very short A-chains.

Isolation of anticancer phytochemicals obtained from black sorghum bran

R. A. CHAVEZ-SANTOSCOY (1), J. Gutierrez-Uribe (2), S. Serna-Saldívar (1)
(1) Tecnologico de Monterrey, Monterrey Nuevo Leon, Mexico; (2) ITESM, Monterrey, N.L., MEXICO
Cereal Foods World 54:A38

Isolation of phytochemicals associated to the bran of black Shawaya sorghum (*Sorghum bicolor L. Moench*) was carried out based on their *in vitro* anticancer effect. The effectiveness of compounds first extracted with 80% methanol and then partitioned with butanol: water: ethyl acetate (47:13:40) and water: ethyl acetate (98:2) was tested against the activity of quinone reductase (QR), key phase II enzyme for protection against oxidative stress and cancer. Fractions were assayed for antioxidant capacity (ORAC), anthocyanins, ferulic acid and QR using murine hepatoma cells Hepa 1c1c7. The most bioactive fractions were further partitioned and isolated in a preparative-HPLC system and the resulting compounds identified via HPLC-MS-TOF, the masses obtained from the HPLC-MS analysis did not correspond to previously reported compounds from sorghum: the simple phenolics usually have masses ranging from 94 to 126; phenolic acids from 138 to 196, flavonoids from 269 to 290 and anthocyanins from 255 to 447. However, there are many other phytochemicals that have not been fully characterized. The chromatograms of the bioactive sub-fractions had a predominant peak with a molecular mass $[M+H]^+$ m/z = 452 that has not been previously reported in sorghum.

A modified alveograph method for dough evaluation of wheat breeding lines

R. Y. CHEN (1), B. W. Seabourn (1), T. J. Herald (2)
(1) USDA, ARS, GMPRC, Hard Winter Wheat Quality Lab; (2) USDA, ARS, GMPRC, Grain Quality and Structure Research Unit
Cereal Foods World 54:A38

Dough rheological characteristics, such as resistance-to-extension and extensibility, are very important wheat flour quality traits evaluated in wheat-based food industries and wheat breeding programs. However, small sample size, rapid testing time, and large sample throughput are necessary in breeding programs, and are formidable challenges when using the standard Alveograph method (AACC method 54-30A). Therefore, a modified Alveograph test method was developed to measure dough extension characteristics that utilized 80 g flour at 60% water absorption and 2.5% salt solution. The dough was mixed for 4 min in a 100-g micro-mixer and then sheeted under a sheet roll (National Manufacturing Division, TMCO, Lincoln, NE). Three dough patties were prepared under controlled conditions and tested on the Alveograph. Test results from this method modification showed that the flour sample size could be reduced 68% compared to the standard method, while simultaneously reducing analysis time by one third as well as making dough preparation more convenient in terms of dough mixing, dough forming, and cleaning. Data generated by this modified Alveograph method was significantly correlated with data generated by the standard Alveograph method. The correlation coefficients (r) for each of six Alveograph dough characteristics for 40 advanced breeding lines and wheat varieties grown in Texas, Oklahoma, Kansas, Colorado, Nebraska, and South Dakota were 0.92 for P (tenacity), 0.73 for L (extensibility), 0.83 for W (area under the curve), 0.90 for P/L (curve configuration ratio), 0.90 for le (elasticity), and 0.76 for G (swelling index). Therefore, this modified Alveograph method could be very useful for wheat breeding programs, and could also be used as a viable alternative for milling and baking industries as well as wheat research.

A new engineering method for understanding extrusion cooking process

H. CHENG (1)
(1) Technical University of Denmark, Lyngby, DENMARK
Cereal Foods World 54:A38

A new engineering method is proposed to understand extrudate expansion and extrusion operation parameters for starch based food extrusion cooking process through dimensional analysis principle, i.e. Buckingham pi theorem. Three dimensionless groups, i.e. pump efficiency, water content and temperature, are suggested to describe the extrudate expansion. Using the three dimensionless groups, an equation is derived to express the extrudate expansion. The model has been used to correlate the experimental data for whole wheat flour and fish feed extrusion cooking. The average deviations of the correlation are respectively 5.9% and 9% for the whole wheat flour and the fish feed extrusion. An alternative 4-coefficient equation is also suggested from the 3 dimensionless groups. The average deviations of the alternative equation are respectively 5.8% and 2.5% in correlation with the same set of experimental data.

Sugar sensing by Caco-2/TC7 cells

M. CHENG (1), B. R. Hamaker (1), G. Zhang (2)
(1) Department of Food Science, Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A; (2) School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu Province, China
Cereal Foods World 54:A38

Individuals show different glycemic responses after they consume different types of glycemic carbohydrates that may result from the different structures of these carbohydrates and the digestion and absorption rate. To understand the relationship between the structure of simple carbohydrates and the coordination between digestion and absorption rate, caco-2 cells/TC7 were selected to use as a model to mimic human digestion. In this study, glucose, maltose, isomaltose, fructose, and sucrose were tested as energy substrates for caco-2 cells/TC7. Cells were cultured in complete growth Dulbecco's modified Eagle's medium (25 mM glucose DMEM) on 6-well porous supports. After cultured for 21 days (about 10 days post-confluent), cells were

then switched to glucose-free DMEM supplied with glucose, maltose, isomaltose, fructose, or sucrose for 2 days. Glucose/fructose production, glucose/fructose transportation, sucrase-isomaltase (SI) protein expression, and other glucose transporter expressions of the cells were analyzed. Caco-2/TC7 produces only SI, though this enzyme has sucrase, isomaltase, and maltase activities. Caco-2/TC7 cells transported glucose from the apical to basolateral part of the transwells. They were shown to have the ability to digest maltose, however, cells showed little ability to utilize sucrose and isomaltose and sucrase activity was lower in these cells. Western blot analysis showed that cells produced more sucrase-isomaltase when they were fed with glucose or maltose suggesting a higher enzyme synthesis.

Raw material changes and their processing parameters in an extrusion cooking process

H. CHENG (1), H. Rasmussen (2), A. Friis (1)
(1) National Food Institute, Technical University of Denmark, Lyngby, DENMARK; (2) Renewable Energy and Transport Centre, Pilot Plant, Danish Technology Institute
Cereal Foods World 54:A39

In this work, the effects of raw material and process parameters on product expansion in a fish feed extrusion process were investigated. Four different recipes were studied with a pilot-scale twin-screw co-rotating extruder according to a set of pre-defined processing conditions. In the four recipes, wheat and protein contents were adjusted and compared with a reference sample. It has been found that a dimensionless equation can well correlate the process parameters and product bulk density for the four different recipe extrusion. The average deviation of the correlation for bulk density is 2.4%. The experimental data show that product expansion decreases with increase of protein content. Several different methods have been applied to quantitatively correlate the changes of raw material composition with product bulk density.

Starch characterization by asymmetric flow field-flow fractionation with multi-angle light scattering and refractive index detection (AF^4-MALS-RI)

E. T. CHIARAMONTE (1), H. Yang (1), D. R. White (1)
(1) The Procter & Gamble Company, Mason, OH, U.S.A.
Cereal Foods World 54:A39

In addition to being the most common source of carbohydrates in the diet, starch is used in a variety of applications in pharmaceuticals, household and beauty products. Both native and modified starches are employed as thickeners or extenders and, more recently, have received important consideration for use as low-cost replacements for synthetic polymers. The rheological and functional properties of starch are influenced by the size and molecular weight distribution of the polymer, the ratio of amylose to amylopectin, and branching characteristics. AF^4-MALS-RI was applied for the fractionation of starches from different sources. The AF^4 technique offers the advantage of an open-channel separation without shear degradation and/or column adsorption effects in size-exclusion chromatography (SEC). Unlike SEC, resolution can be controlled by varying cross-flow. Detection by MALS-RI enables absolute molecular weight determination without the need for calibration standards. A sample preparation procedure was used that involved DMSO treatment followed by ethanol precipitation, filtering, washing, and finally resolubilization in water with the aid of pressurized microwave digestion. Separation of amylose and amylopectin could be achieved by applying a gradient cross-flow. The weight-average molecular weights (M_w) were calculated to be in the 10^5 range for amylose and 10^8–10^9 for amylopectin, which agree reasonably with values in the literature. Ratios of amylose to amylopectin agreed well with expected values where available.

What consumers want: Weight management, digestive health and immunity defense

H. CHIMOFF (1)
(1) Tate & Lyle, Decatur, IL, U.S.A.
Cereal Foods World 54:A39

Not long ago, fiber was considered a bland, grainy necessity to help support regularity in adults and children. Times are changing. Tate & Lyle's multinational market research finds that more than 50 percent of consumers now believe fiber can taste good and many are looking for benefits beyond regularity. Through qualitative research of more than 7,000 people living in the United States, Mexico and Brazil, Tate & Lyle found that consumers want healthier fare and that fiber is a top nutrient to help them achieve their healthy eating goals. This presentation will reveal the fiber applications in the grain-based food categories that consumers find appealing, and label claims that command their attention and prompt them to pay extra dollars for fiber's functional benefits.

The effects of selected hydrocolloid ingredients on the attributes of instant fried noodles

A. Choy (1), L. Cato (2), D. M. SMALL (3)
(1) Applied Chemistry, School of Applied Sciences, RMIT University, Melbourne, Australia; (2) Department of Agriculture and Food W.A. (DAFWA), Perth, Western Australia 6151, Australia; (3) RMIT Univ, Melbourne, VIC, AUSTRALIA
Cereal Foods World 54:A39

The objective of this study has been to investigate the effects of two ingredients i) acetylated potato starch and ii) sodium carboxymethyl cellulose (CMC) on the textural attributes and appearance of instant noodles. Varying proportions the two ingredients were studied using a central composite design. Noodles were prepared from a low protein soft wheat flour (Australian Soft) and product texture, color and fat uptake were measured. Textural characteristics were assessed using the TA-XT2, color by the Minolta Chromameter and the data were analyzed by response surface methodology. The two ingredients enhanced the hardness and reduced adhesive values of cooked instant noodles. Electron microscopy showed enhancement of the structure within the noodles. Addition of CMC increased the slipperiness attributes which provides enhanced mouthfeel of the noodles. There was relatively little effect of the various combinations on product color with the various treatment combinations. Overall, noodles prepared using these variables had slightly dull color appearances, that is less white and less yellow. Trials to reduce the fat uptake and lower the stickiness indicated that a combination of 10% acetylated potato starch and 0.5% CMC was optimal. This suggests that a variable formulation can be used with low protein wheat flour to produce the required eating quality and color attributes. It is concluded that acetylated potato starch and CMC have the potential to enhance the acceptability of instant noodles made from low protein wheat flour.

Effect of steam flaking in fusel alcohol production during fermentation with *Saccharomyces cerevisiae*

C. Chuck-Hernandez (1), E. Perez-Carrillo (1), S. O. SERNA-SALDÍVAR (1)
(1) Tecnológico de Monterrey, Monterrey, N.L. MEXICO
Cereal Foods World 54:A39

The aim was to study the effect of steam flaking on higher alcohols production during fermentation with *Saccharomyces cerevisiae*. A bifactorial experiment with a level of confidence of $P < 0.05$ was designed to study differences among grains (sorghum and maize) and the efficiency of the steam flaking treatment. Grains were steam-flaked and a ground into meals that were further processed into ethanol. N-propanol, isobutanol and isoamyl alcohols were determined. During the first 30 hr fermentation the concentration of fusel alcohols was similar among treatments; however after 72 hr, the mashes produced from whole grains had significantly higher fusel alcohols compared to the steam-flaked counterparts. Among fusel alcohols, the isoamyl alcohols had the highest concentration followed by isobutanol and propanol. The total concentration of fusel alcohols at the end of fermentation was: 513 mg/L for whole maize treatment, 420 mg/L for whole sorghum and 354 and 384 mg/L for steam-flaked maize and sorghum.

Solvent Retention Capacity (SRC) profile in relation to flour characteristics and baking volume in mini pup-loaf

W. CHUNG (1), R. Gan (1), M. Morrical (1), T. Hansen (1)
(1) Kraft Foods, Inc., Glenview, IL, U.S.A.
Cereal Foods World 54:A39

Determination of the quality of hard wheat flour depends on the functional properties of flour components and their interactions. These flour component interactions affect milling and baking performance. SRC methodology has been developed for predicting soft wheat flour functionality. The objectives of this study were (1) to evaluate the solvent retention capacity profile, mixing characteristics, and bench-top mini pup-loaf baking performance in hard wheat flour, (2) to investigate the possibility of SRC as a predictor of hard wheat flour functionality by finding the relationships among SRC profile, baking performance, and flour characteristics, and (3) to stimulate further discussion on applying SRC methodology in various different dough systems. The chemical analysis, SRC of four solvents (water, 5% sodium carbonate, 50% sucrose, and 5% lactic acid), mixing properties, and bench-top mini pup-loaf baking test were conducted on 23 hard wheat flour samples. This sample set showed quite a narrow range of protein content of 10.3 – 13.0% among 23 flour samples. Since the protein quantity and quality as well as damaged starch content play a critical role in bread system for dough strength and water retention in bread, the investigation was focused on 5% sodium carbonate SRC and 5% lactic acid SRC. The 5% lactic acid SRC and 5% sodium carbonate SRC exhibited positive correlation trends with mini pup-loaf volume, and 5% lactic acid SRC value plus 5% sodium carbonate SRC value showed also positive correlation with mini pup-loaf volume. The water SRC value and 5% sodium carbonate SRC value were positively correlated with

bandwidth of mixograph that indicated dough strength and stability. Since this sample set is relatively small, flour samples from various sources will be added to the database and further data analysis will be conducted.

Susceptibility of different forms of wheat starch to enzymic attack

L. COPELAND (1)
(1) University of Sydney, NSW, AUSTRALIA
Cereal Foods World 54:A40

Starch is a major constituent of the human diet. How we digest this polysaccharide has important implications for health and nutrition, and relating digestibility of starch to its structure is a major challenge in food science. In this study we have examined the susceptibility of different forms of starch from various wheat varieties to *in vitro* digestion by alpha-, beta- and iso-amylases and amyloglucosidase. Native starch granules were attacked readily by pancreatic alpha-amylase, and also to a lesser extent by beta-amylase, isoamylase and amyloglucosidase. Starch granules from a waxy wheat variety were degraded more rapidly than granules that contained amylose, and differences in degradation patterns were observed between starches with small differences in amylose content. The results indicate that the form of starch granules, and the structure and internal organization of the starch molecules, influence susceptibility to enzyme attack. There were no differences in digestibility of gelatinized starches, but monopalmitin reduced the digestibility of all but the waxy starch. Retrogradation of gelatinized starch led to the decrease in digestibility of both amylose-rich and waxy starches. We conclude that digestion of starch *in vitro* is determined by a combination of the amylose content and amylopectin architecture, with other underlying varietal factors also involved.

Biaxial extensional viscosity in cooked spaghetti in relation to its firmness

A. COTA-GASTELUM (1), M. Salazar-Garcia (2), M. Silveira-Gramont (2), A. Islas-Rubio (3)
(1) Univ De Sonora, Hermosillo, Sonora, MEXICO; (2) Departamento de Investigacion y posgrado en alimentos, Universidad de Sonora, Hermosillo Sonora, Mexico; (3) Centro de Investigacion en Alimentacion y Desarrollo, Hermosillo Sonora, Mexico
Cereal Foods World 54:A40

Besides the firmness, it is important to have other objective measures of the quality of the cooked spaghetti. To evaluate such measuring, an experiment was planned where commercial spaghetti was used, subjected to three cooking times (9.5, 12.5, and 15.5 min), and three holding times (0, 2 and 5 h). The biaxial extensional viscosity and the firmness of the cooked spaghetti were measured; also, the relationship between the two measurement was analyzed. For measuring biaxial extensional viscosity in spaghetti, the method of uniaxial compression with lubrication, at a speed of deformation of 0.3 mm min^{-1} was selected. The spaghetti firmness was measured in the texture analyzer TA-XT2. It was observed that biaxial extensional viscosity measurement as well as firmness decreased significantly with the cooking time, and also with the holding time. The biaxial extensional viscosity behavior profiles for cooking and holding times were similar to those of the firmness. There was a highly significant correlation ($r = 0.83$) between the biaxial extensional viscosity and firmness values. This indicates that the changes in the quality of the cooked spaghetti shown by the firmness were also detected by the biaxial extensional viscosity, which could be a new useful complementary measure of quality of the cooked spaghetti.

Effect of xylanase addition on quality characteristics of pan bread prepared from refined or whole-grain wheat flour

C. B. da Silva (1), L. Z. Jaekel (1), C. J. STEEL (1), Y. K. Chang (1)
(1) University of Campinas (UNICAMP), Campinas, SP, BRAZIL
Cereal Foods World 54:A40

The effect of the addition of the enzyme xylanase on quality characteristics of pan bread prepared from refined or whole-grain wheat flour was studied in this work. The loaves were produced by the modified straight dough method and the enzyme was tested at three different levels: 4, 8 and 12 g/100 kg flour. Bread quality characteristics measured were: specific volume and the variation of moisture and firmness during storage. Loaves produced with refined wheat flour and added xylanase presented higher specific volumes (5.12 to 5.16 mL/g) than the control (without enzyme) (4.38 mL/g); however, there was no significant difference ($p \leq 0.05$) among the loaves with the different enzyme concentrations. All formulations prepared with whole-grain flour and added xylanase also presented specific volume significantly higher than the control (4.09 mL/g), the highest value being that for the formulation with 8 g xylanase/100 kg flour (4.96 mL/g). With respect to the moisture content of the loaves prepared from refined wheat flour, on day 7 of storage, it could be observed that it ranged from 39.80 to 40.73% for the formulations with the different enzyme concentrations, presenting only a small significant difference in relation to the control (39.99%). For the loaves produced with whole-grain flour, moisture content varied from 39.41 to 43.30%, while the control presented 40.23%. In general, the loaves obtained with the addition of 8 g enzyme/100 kg flour presented the lowest firmness values (211.00 g for the loaves from refined wheat flour and 254.73 g for the loaves from whole-grain wheat flour), and were considered having the best technological characteristics.

Real-time PCR assay for quantification of *Fusarium graminearum* in cereals and correlation with deoxynivalenol and fusarium damaged kernel values

T. DEMEKE (1), R. Clear (1), T. Graefenhan (2), A. Phan (1), I. Ratnayaka (1), S. Patrick (1), D. Gaba (1)
(1) Canadian Grain Commission, Winnipeg, Manitoba; (2) Agriculture and Agri-Food Canada, Ottawa
Cereal Foods World 54:A40

Fusarium graminearum is a major fungal pathogen that affects the yield and quality of cereal grains. The relationship between Fusarium damaged kernel (FDK) and deoxy-nivalenol (DON) has been used to roughly estimate the DON levels in wheat, but is unsuitable for even estimating DON levels in barley or oat. Real-time PCR (RT-PCR) assay was optimized to determine the fungal mass of *Fusarium graminearum*. 50 ng total DNA was used for RT-PCR assay. The standard curve was generated by serial dilution of pure *F. graminearum* DNA (10,000, 2,000, 400, 80, 3.2 and 0.64 pg DNA). Samples of red winter wheat, red spring wheat, barley and oat were assessed for *F. graminearum* mass and DON levels. The wheat samples were also assessed for correlation with FDK. Overall, there was a positive correlation between fungal mass determined by RT-PCR and DON level determined by gas chromatography-mass spectrometry. Details of the results including statistical analysis carried out will be presented.

Identity confirmation of a processed cereal product using near infrared fingerprinting: The example of Belgian Trappist beer

G. DOWNEY (1)
(1) TEAGASC, Ashtown, Dublin 15, IRELAND
Cereal Foods World 54:A40

Beer is an economically-important product of cereal fermentation. In Belgium, beers from Trappist monasteries enjoy particular status on account of their perceived high and consistent quality. To protect this status and as an aid to marketing, beers brewed in monastic sites under the control of Trappist monks are entitled to display a Trappist logo on their label. A number of breweries which were once under monastic control produce beers in the Trappist style but are not entitled to use the label logo. Near infrared spectroscopy has been deployed as a fingerprint technique to develop models for confirming the claimed identity of Trappist beers. A collection ($n = 124$) of Trappist and non-Trappist beers (mainly sourced in Belgium) have been collected from several production batches and analysed by NIR in transflectance mode. Models have been developed using a number of chemometric methods; the general approaches used have involved discriminant and class-modelling techniques. Each has particular merits and these, together with their respective prediction accuracies, will be presented and discussed. Implications for the deployment of this approach for identity confirmation in processed cereal foods will be addressed.

Description of a laboratory milling process to obtain Quinoa flour and pericarp

A. DUBAT (1), S. Geoffroy (1), O. Lebrun (1)
(1) CHOPIN Technologies, Villeneuve la garenne, FRANCE
Cereal Foods World 54:A40

Quinoa (or Quinua) (*chenopodium quinoa* Willd.) is a pseudo-cereal native to the Andes Mountains of Bolivia, Chile and Peru. It names in the Inca language means “mother grain”. The grain size of the Quinoa is about 1.0 mm thick and ranges in diameter from 1.0 to 2.5 mm. The seed weight ranges from 1.9 to 4.3 g/1.000 seeds. Quinoa has excellent nutritional quality which was compared to dried whole milk by the Food and Agriculture Organization (FAO). The protein quality and quantity of Quinoa are superior to those of cereals. Quinoa has a rather high oil content (1.8 to 9.5%, average is 5.8%). The major antinutritional factor of quinoa is the presence of saponins, mainly present in the outer layers of the grain. The aim of the work was to propose a laboratory milling process of quinoa able to separate the endosperm and the pericarp. We applied the conventional wheat laboratory milling using a Standard Chopin CD1 mill. Three different processes where studied: 1/ dry quinoa, breaking and reducing, 2/ tempered quinoa, breaking and reducing; 3/ tempered quinoa, reducing only. We started with small sample of 300 grams and we analyzed the quantity of products as well as the color index Lab in order to measure the purity of every fraction. When protocol was adjusted a larger sample (1 kg) was milled allowing obtaining 70% extraction rate for flour and 30% remaining bran. The conclusion is that Quinoa laboratory milling is easily possible by using a standard Chopin CD1mill without any modification. Best results were achieved when quinoa is prepared (mix with

water for 15 minutes). This poster gives an easy to use protocol for persons dealing with Quinoa and aiming to obtain laboratory scale flour (possible mix with wheat flour) or bran fraction (increasing the saponin concentration).

Finger millet and sorghum phenolics: Effects on malting and malt quality, and gene expression in caco-2 cells

G. DUODU (1), M. Siwela (2), J. Taylor (1), Y. Bao (3), P. Belton (3)
(1) University of Pretoria, REP OF SOUTH AFRICA; (2) University of Kwazulu-Natal, South Africa; (3) University of East Anglia, UK
Cereal Foods World 54:A41

Finger millet and sorghum are important cereal grains in the semi-arid and tropical regions of Africa and Asia. They are processed into various food products including fermented beverages such as opaque beers, and porridges. These cereals are also important sources of phenolic compounds which possess antioxidant properties and therefore provide potential agronomic and health benefits. Finger millet grain and malt were studied to determine potential effects of content of phenolics on their malting and malt quality. Aqueous extracts of sorghum flour and bran were also studied to determine their effects on gene expression for quinine reductase in caco-2 cells. Unmalted finger millet grain types were infected by various fungal species (*Eurotium*, *Fusarium*, *Phoma, Penicillium*, *Cladosporium* and *Aspergillus*), while their malts were infected by a larger variety of fungal species. Total fungal load was negatively correlated with phenolic content in finger millet grain and malts. Finger millet types with high levels of phenolics had higher malting and malt quality than types with low levels of phenolics. Thus phenolics in finger millet grain impact positively on its malting and malt quality by contributing to limiting its fungal load. Aqueous extracts from sorghum bran and flour had a heterogenous chemical composition, containing phenolic compounds as well as sugars, amino acids and small peptides. The extracts appeared to have random effects on gene expression for quinine reductase in caco-2 cells with no consistent trends.

Potential of hyperspectral imaging for monitoring post-production changes in food structure

C. Esquerre (1), V. Di Egidio (2), A. Gowan (3), C. McDonnell (3), G. DOWNEY (1)
(1) TEAGASC, Ashtown, Dublin 15, IRELAND; (2) University of Milan, Italy; (3) University College Dublin, Ireland
Cereal Foods World 54:A41

Processed food products undergo a wide range of chemical and physical changes during post-production storage and distribution which often negatively impact on the consumer experience. A number of physico-chemical approaches have been deployed to monitor these changes and help devise recipe or process alterations to minimise their magnitude but traditionally these approaches have followed changes at the macro level e.g. in the entire finished product or have applied non-destructive technologies such as NIR spectroscopy for point measurements. Recently, near infrared hyperspectral camera systems have become available which have the capability to collect digital images from a large sample surface, enabling more effective information gathering. In parallel, chemometric methods for analysis of these large datasets have appeared allowing for the extraction of spectrally and spatially-resolved information. The facility for simultaneously extracting such information may facilitate greater understanding of molecular events underlying complex post-production structural changes. The potential of this technique will be explored using changes in conventional and gluten-free breads as an example.

Preparation and partial characterization of a whole wheat based product fortified with mesquite (*Prosopis glandulosa*)

M. R. FALCON (1), J. M. Barrón (1), A. L. Romero (1), M. G. Salazar (1), N. G. Heredia (1)
(1) Universidad de Sonora, Hermosillo, Sonora, México
Cereal Foods World 54:A41

The growing consumer concern for increasing the amounts of dietary fiber in their daily diet has trigger the interest of the food industry for development of high fiber breakfast cereals, usually prepared by extrusion. In the present study, a whole wheat fortified with mesquite (*Prosopis glandulosa*) and prepared by extrusion was developed. The effect of the extrusion process on the total dietary fiber (soluble and insoluble fractions) of the fortified product was determined. Sensory evaluation of the fortified breakfast cereal product was also conducted, to determine the preference related to the level of fortification. Three levels of fortification (whole wheat : mesquite) were tested: 90:10, 70:30 and 50:50. A single screw experimental extruded (Brabender Md. KE19) was used. Experimental condition were: Z1 = 65°C, Z2 = 62°C, Z3 = 61°C and Z4 = 140°C; 100 rpm screw speed, 50 rpm feeding rates, and 3.0 mm die plate. Extruded products were evaluated in their chemical composition, total, soluble and insoluble dietary fiber contents. Sensorial evaluation of the extruded products was also performed. Results showed an increase in % total protein and ash, and a decrease in the total fat and carbohydrates contents due to the extrusion process. Extruded products showed an increase in total and insoluble dietary fiber for the 70:30 and 50:50 mixtures, but these dietary fractions decreased in the 90:10 mix. Soluble dietary fiber fraction increased in all three combinations mixtures. Sensory evaluation using a hedonic scale showed that the 50:50 extruded mix was the most accepted one. This extruded mix of 50:50 gave a proximate chemical analysis of: 12.3% total protein, 9.68% moisture, 3.9% ash, 2.09% fat and 25.9% total dietary fiber. According to these results the 50% addition of mesquite to whole wheat is highly recommended for the preparation of extruded high fiber breakfast products, with viable commercial potential.

Adsorption of polyethylene from solution onto starch film surfaces

F. C. FELKER (1), G. F. Fanta (1), J. H. Salch (1), R. L. Shogren (1)
(1) USDA/ARS/NCAUR, Peoria, IL, U.S.A.
Cereal Foods World 54:A41

Since starch adsorbs onto polyethylene (PE) surfaces from cooled solutions of jet cooked starch, this study was carried out to determine whether adsorption of PE onto hydrophilic starch film surfaces would also take place if starch films were placed in hot solutions of PE in organic solvents, and the solutions were allowed to cool. Methods such as this for reducing the water sensitivity of starch films through the application of hydrophobic coatings are of interest because of their potential for expanding the range of end-use applications for biodegradable, starch-based products. Starch films were prepared by jet cooking aqueous dispersions of high-amylose starch and then allowing the jet cooked dispersions to air-dry on Teflon surfaces. When the starch films were immersed in 1% solutions of PE in 1-dodecanol, dodecane and xylene at 120°C and the solutions were allowed to slowly cool, PE precipitated from the solutions and adsorbed onto the starch film surfaces. FTIR spectroscopy was used to estimate the µg of PE adsorbed per cm^2 of starch film. PE was preferentially adsorbed onto the film side that was in contact with the Teflon surface during drying. The amount of PE adsorbed ranged from about 8 to 45 $\mu g/cm^2$ and depended upon the solvent used and the final temperature of the cooled solution. SEM of starch film surfaces showed discontinuous networks of adsorbed PE on the Teflon side and widely spaced nodules of adsorbed PE on the air side. NMR analysis showed that the PE adsorbed onto the starch surface was more linear and/or had a higher molecular weight than the starting PE. Possible reasons for selective adsorption of PE onto the Teflon side of the starch film surface are discussed.

Study of compressive strength properties (Poisson's ratio) of different wheat classes

J. FIGUEROA CARDENAS (1), Z. J. Hernández (1), P. Rayas-Duarte (2), K. Khan (3)
(1) CINVESTAV Unidad Queretaro, Queretaro, Qro., MEXICO; (2) Robert M. Kerr Food & Agricultural Products Center, Oklahoma State University, Stillwater, OK; (3) Department of Cereal and Food Sciences, North Dakota State University, Fargo, ND
Cereal Foods World 54:A41

Large amounts of losses of grain and other food commodities are due to poor kernel quality and handling during operations such as harvesting, transportation, storage, conditioning and milling. The evaluation of elastic properties of wheat kernels such as Poisson's ratio, elastic, shear (rigidity) and bulk (incompressibility) moduli to compare the relative strengths of different cereals and their technological characteristics may increase the efficiency of grain selection for processing, marketing and end-use. The average Poisson's ratio (ν) in wheat kernel classes ranged from a value of 0.27 for small kernel size to 0.49 for large kernel size at 13% moisture content. Bread wheat kernels changed from a Poisson's ratio of 0.358 at 13% moisture content and reduced the compressibility of ν to 0.282 with additional 6% moisture content. Durum wheat also showed similar behavior except that for the same force applied, the deformation was lower as indicated by the strain and the bulk modulus. The kernel sizes in Durum wheat showed differences in ν values where 30% of kernels in the sample were small kernels with ν values of 0.34 and 75% were large kernels with good strength and showed ν mean values of 0.43. Therefore, by removing the small kernels, the final product may be improved significantly. These findings have important implications for using ν and elastic, shear and bulk moduli in processing and end-use quality.

Quantitative characterization of polar lipids from wheat whole-meal, flour and starch

S. M. FINNIE (1), R. Jeannotte (1), J. Faubion (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A41

While lipids comprise only a minor proportion of total flour components, they have a significant influence on loaf volume and crumb grain of bread. Because the composition and structure of wheat flour polar lipids have an influence on the end-use quality of bread, it is important to determine

specifically which lipid class and molecular species are present in wheat. Lipid profiling is a targeted, systematic characterization and analysis of lipids. The use of lipid profiling techniques to analyze grain-based food has the potential to provide new insight into the functional relationships between a specific lipid species and its functionality. The objective of this study was to utilize lipid profiling techniques to quantitatively determine the polar lipid species present in whole-wheat meal, flour, and starch. Two commonly grown wheat cultivars were used in this study, Alpowa and Overley. Direct infusion electrospray ionization tandem mass spectrometry was used to identify and quantitatively determined 145 polar lipid species in wheat. The predominant polar lipid classes were DGDG, MGDG, PC, and LPC. ANOVA results concluded that wheat fraction contributed a greater source of variation than did wheat cultivars on total polar, total phospholipid, and total galactolipid contents. Wheat meal, flour and surface starch contained greater concentration of total galactolipids while internal starch lipids contained greater concentrations of monoacyl phospholipids. The overall hypothesis was, that lipid profiling will provide the ability to determine the functional relationships between specific lipid species and their impact on end-use quality.

Water absorption and mixing behavior of hard and soft wheat flours with bran inclusions

H. GAJULA (1), J. Faubion (1), H. Dogan (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A42

Whole grain products are a rich source of fiber. Wheat bran, in particular, is one of most important dietary fiber sources in the bread making industry. The objective of this study was to investigate the effects of bran source and inclusion level on water absorption and rheological properties of dough systems of different strength. Cleaned hard red spring (HRS) and soft white (SW) wheat samples were milled on a Buhler mill (AACC 26-21A, 26-31) to create straight grade flour, bran and shorts. Water sorption behaviors of bran samples were characterized after equilibrating the samples at water activity levels of 0.11, 0.33, 0.59, 0.75 and 0.97 using saturated salt solutions. There was no significant difference in sorption isotherms of HRS and SW bran for all water activity levels except for the level 0.75. Both bran fractions were added to each of flours resulting in: HRS bran + HRS flour; HRS bran + SW flour; SW bran + HRS flour; SW bran + SW flour at 0%, 5% and 10% levels. Water absorption rate, mixing tolerance index, mixing peak time of the dough systems were studied using the Farinograph and Mixograph. Initial studies were done on HRS bran + HRS flour and SW bran + HRS flour. Wheat bran inclusion produced significant effects on dough water absorption and mixing tolerance index. Increasing the bran percentage (0–10%) in the dough systems increased dough water absorption rate from 63.7%–65.2% for HRS bran and 63.7%–66.5% for SW bran whereas its mixing tolerance index decreased from 29 FU – 24 FU for HRS bran and increased from 29 FU – 32 FU for SW bran in HRS flour. Mixing peak time increased from 2.28–2.97 min for HRS bran and from 2.28–3.13 min for SW bran with the increase of bran percentage (0–10%) in HRS flour. From above results, SW bran inclusions resulted in higher water absorption rate and mixing times as compared to HRS bran in HRS flour.

The interactions of bran with gluten proteins during dough development using x-ray microtomography

H. GAJULA (1), J. Faubion (1), H. Dogan (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A42

Phytochemicals and nutrients associated with the non-endosperm (bran and germ) 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. The nature and extent of bran interactions with the gluten protein matrix play a dominant role in processing and end-quality of whole grain baked goods. The objective was to study the development of gas cells during proofing and the resulting crumb texture of the baked product of optimally developed dough with different bran contents using X-ray microtomography, a non-destructive imaging technique. The microstructure of dough systems with 0, 5 and 10% bran inclusions at 0, 30 and 60 min proof time were studied. Doughs were prepared according to AACC method 10-10B. Unproofed, underproofed and optimally proofed dough pieces were frozen at –80°C prior to scanning with a high resolution X-ray micro-CT system. Shadow images obtained at 1.35° scan steps through 180° of rotation were reconstructed to create cross-sectional images using CTAn software. 3-D analysis of the specimens indicated that the void fractions changes dramatically during proofing. Higher mean gas cell size values were observed in bran containing dough samples due to weakening effect of bran on gluten network causing gas cell coalescence. Void volume increased from 7.6–9.1% to 61.8–72.2% during proofing. As % bran addition increased the mean cell size increased from 0.015–0.016 mm to 0.256–0.726 mm, as compared to control dough. Gas cells retained in the control dough (no bran) were dispersed over a narrower range than those in the bran containing dough indicating a better stability during proofing. Overall results support the view that dough consistency affects the evolution of gas cells, and their number and size distribution.

Replacing wheat flour with lower GI ingredients in white wheat bread

E. Gallagher (1), P. Burton (1), A. PATRAS (1)
(1) Teagasc, Dublin, IRELAND
Cereal Foods World 54:A42

The regular consumption of foods exhibiting a high glycaemic index (GI) is associated with the development of diseases such as type 2 diabetes, certain cancers and increased risk of cardiovascular disease. White wheat bread is consumed worldwide. However, the starch present in most white breads is rapidly digested and absorbed in the small intestine, producing undesirably high blood glucose and insulin responses. In the present study, ingredients which are known to have a lower GI than white wheat flour (rice bran, maize flour, novelose resistant starch, chickpea flour) were incorporated into a bread formulation, to replace the wheat flour at levels up to 20%. The resulting dough properties (development time, stability, gaseous release), baking characteristics (loaf specific volume, crust/crumb colour, digital image analysis, staling properties) and sensory aspects of the baked breads were assessed. Water absorption and development times of the doughs were not significantly affected following the replacement of wheat flour with lower GI ingredients. The introduction of maize flour reduced loaf volume ($P < 0.05$) and increased the CIE b* value (yellow hue) of the crumb ($P < 0.05$). Novelose, when used at a 5% replacement level, resulted in a crumb structure that had an increased number of cells/mm^2 when compared with the wheat control ($P < 0.05$), indicating a fine crumb structure. Sensory panellists rated all of the test breads as acceptable on a hedonic scale. A novel in vitro method has now been established for analysing the estimated glycaemic index of cereal products such as breads. This method and results from trials will be discussed in an oral presentation.

Effect of flaxseed addition on proximal composition and digestibility of corn tortilla

F. GARCÍA-SUAREZ (1), G. Pacheco-Vargas (1), F. Gutierrez-Meraz (1)
(1) CEPROBI-IPN, Yautepec, MEXICO
Cereal Foods World 54:A42

The objective of this study was to supplement nixtamalized corn flour (NCF) with ground flaxseed to evaluate total dietary fiber (TDF), starch digestibility and proximal composition. TDF, ash, protein, and fat were analyzed according to AOAC and AACC Methods: 985.29, 08-01, 46-13, and 30-25, respectively. Total starch (TS) and *in vitro* rate of hydrolysis were measured using enzymatic hydrolysis. Flaxseed was added at three levels (10, 15 and 20%, w/w) and the flours were hydrated to obtain masa. Ash contents varied from 1.54 – 1.64%, and non-significant differences ($p > 0.05$) between control tortillas and those containing flaxseed flour. An increase in the protein content (10.87–12.95%) was observed with respect to the level of flaxseed added to the tortilla. This increase in flaxseed-added tortilla might be important to increase the essential amino acid level that is deficient in corn. The amount of lipids (8.23–12.00%), in the flaxseed-added tortilla increased approximately between 100% and 200%. The total carbohydrate content decreased (85.32 – 73.43) when the flaxseed level rose in the composite tortilla. However, more important was the increased level of non-starch polysaccharides (calculated as total carbohydrate–total starch), a fraction consisting of cellulose, hemicellulose and lignin from flaxseeds and included in the insoluble dietary fiber. Furthermore, a significant increase ($p < 0.001$) in TDF content was also obtained with the flaxseed-flour addition (approximately between 20% and 50%). TS values in tortilla decreased when the flaxseed flour level rose. The reduced enzymatic starch hydrolysis rate indicated slow digestion features. Today, flaxseed is used as a good source of soluble and insoluble fiber to reduce blood cholesterol and promote laxation. Flaxseed-added tortilla can be considered as a nutraceutical food.

Nixtamalized corn flour obtained by ohmic heating

M. GAYTÁN-MARTÍNEZ (1), E. Morales-Sánchez (2), J. Figueroa (1), H. Martínez-Flores (3), P. Vázquez Landaverde (4), M. Reyes Vega (2)
(1) CINVESTAV Unidad Queretaro, Queretaro, Qro., MEXICO; (2) CICATA IPN Unidad Querétaro, Mexico; (3) Facultad de Químico Farmacobiología, Universidad Michoacana de San Nicolás de Hidalgo; (4) CICATA INP Unidad Querétaro, Querétaro Mexico
Cereal Foods World 54:A42

Nixtamalization, also known as alkaline cooking, is an old method to process corn into tortillas. The method consists in cooking whole corn in a boiling water-lime solution (1 to 2% by weight of $Ca(OH)_2$) by a short time (20–45 minutes) and steeping in this solution, as it cools, for all night long (12 to 18 hours). The cooking liquor, called nejayote, is discarded and the corn grains are washed to remove excess of lime. The cooked whole corn or nixtamal is

ground with a stone mill to produce corn dough (masa). Ohmic heating is a conduction heating technique by which rapid internal resistive heating occurs by passing the AC electrical current through a product. The objective of the present work was to use the ohmic heating technique for the elaboration of nixtamalized corn flour. Results shown that is possible making corn flour to elaborate tortillas applying ohmic heating method. The tortilla yields obtained were 1.7 to 1.9 kg of tortilla/kg of flour, which were higher than those obtained by the traditional process, in addition the rheological and sensory quality was also superior. Besides that, other important advantages of using the ohmic heating were the elimination of liquid waste, shorter processing time from hours to minutes, and homogeneous cooking temperature that improved the heating quality.

Nutrient composition of retail samples of sorghum, millet, and whole wheat flour

S. E. GEBHARDT (1), R. G. Thomas (1)
(1) USDA ARS BHNRC, Beltsville, MD, U.S.A.
Cereal Foods World 54:A43

More than 2 million people in the United States have celiac disease, or about 1 in 133 individuals. People who have this disease cannot tolerate gluten, a protein in wheat, rye, and barley. The only treatment for celiac disease is a gluten-free diet. Nutrient profiles were lacking in the USDA National Nutrient Database for Standard Reference (SR) for sorghum and millet flour, both of which can be used in gluten-free diets. Three different brands of each type of flour were purchased from retail suppliers. Whole wheat flour samples were also obtained to update the existing nutrient profile. Samples were prepared at the Food Analysis Laboratory Control Center at Virginia Polytechnic Institute and State University and shipped by overnight delivery to analytical laboratories with appropriate analytical quality control and reference materials. These laboratories had previously been qualified to perform analyses of nutrients through the National Food and Nutrient Analysis Program. Samples were analyzed for proximate components, vitamins, minerals, fatty acids, and amino acids. Whole wheat flour is highest in protein content at 13.7% versus 10.8% for millet, and 7.7% for sorghum flour. Millet is the highest in total fat content at 4.9% versus sorghum at 3.5% and wheat at 1.9%. Wheat flour is significantly higher ($p < .05$) in iron, phosphorus, potassium, copper and manganese compared to sorghum flour and significantly higher ($p < .01$) in phosphorus, potassium and manganese compared to millet flour. For health professionals who advise clients on food choices as well as for people who are trying to follow a gluten-free diet, having data for millet and sorghum flours in the SR provides an easily accessible and reliable source of nutrient information (www.ars.usda.gov/nutrientdata).

Rapid product development for multi-component cereal-based foods using TD-NMR technology

S. GHOSH (1), X. Tombokan (1)
(1) Bruker Corporation, The Woodlands, TX, U.S.A.
Cereal Foods World 54:A43

The interaction of ingredient molecules become a dictating factor during the prodcut development process of complex food systems, with multi-components with widely difefreing physicochemical characteristics. A fast non-invasive technique to quantify this interaction becomes very useful in accelerating product development and decision making process. TD-NMR (time-domain nuclear magnetic resonance) technique can be implemented very easily using a small bench-top or hand-held instrument to precisely measure the mobility of molecules in a sample in a non-invasive way. Automated data acquision to look at dynamic system can also easily be implemented. The TD-NMR technology is based on extracting the signal from nuclear spins in the sample and mathematical calculation on the signal to rapidly obtain physicochemical information on the sample at molecular level. The principles of TD-NMR will be described in the talk. Experimental details and results of successful application of this technology to cereal-based multi-component foods will be elaborated. Future research direction and other TD-NMr applications to cereal products will also be touched upon.

Making fundamental sense of the Alveogram: Application of computer simulations to inversely identify rheological parameters from the Alveograph

A. GOH (1)
(1) Curtin University of Technology Sarawak, Miri, MALAYSIA
Cereal Foods World 54:A43

The Alveograph is a test device that has been routinely used to assess the breadmaking quality of flour. The test is normally considered to be empirical since the recordings are expressed in terms of bubble pressure versus time rather than in terms of any particular rheological parameters. Although it is possible to convert the Alveogram into biaxial extensional properties, the analysis requires rather tedious measurements of the shape of the bubble. Furthermore, the variation of strain rate during the bubble inflation means that the viscoelastic properties need also to be considered in the analysis. In the current work, an inverse method based on the Levenberg-Marquardt algorithm and the finite element method has been applied to identify viscoelastic constitutive properties from the bubble pressure–piston displacement relationship. The strain dependent behaviour was characterised by a two-parameter Mooney Rivlin hyperelastic model while the time dependent behaviour was characterised by the Prony series. The inverse method was evaluated using numerical experiments and it was found that good estimates of the viscoelastic properties could be obtained using only one set of bubble pressure–piston displacement data. The results suggest that data from the Alveograph can be used to provide information about the fundamental large strain viscoelastic properties of test samples.

Effects of the emulsifier sodium stearoyl lactylate (SSL) and of the enzyme maltogenic amylase on the quality of sandwich bread during storage

C. R. GOMES-RUFFI (1), R. H. Cunha (2), Y. K. Chang (3), C. J. Steel (4)
(1) ITAL Inst de Tecnologia de Alimentos, Campinas, SP, BRAZIL; (2) rhpardal@ig.com.br; (3) UNICAMP - Universidade Estadual de Campinas, Cidade Universitária Zeferino Vaz, Distrito de Barão Geraldo, Campinas - SP, BRASIL, Caixa Postal : 6101, CEP 13081-970; (4) State University of Campinas, Campinas, Sao Paulo, Brazil
Cereal Foods World 54:A43

Emulsifiers and enzymes are used as anti-staling agents in bakery products, providing increased shelf life, which is especially interesting for industrialized breads, such as the traditional sandwich bread. The objective of this study was to evaluate the effects of the emulsifier sodium stearoyl lactylate (SSL) and of the enzyme maltogenic amylase on the quality of sandwich bread during storage. The Response Surface Methodology (RSM) was used to evaluate the influence of the addition of SSL (0.0 to 0.5%, flour basis) and maltogenic amylase (0.00 to 0.04%, flour basis) on bread quality parameters. The responses evaluated from the 2^2 complete factorial experimental design were specific volume on day 1 and instrumental firmness on days 1, 6 and 10. The addition of SSL and maltogenic amylase showed positive effects on specific volume, which ranged from 5,65 to 6,53 mL/g for breads with added emulsifier and/or enzyme (compared to 5,80 mL/g for the control, without the addition of emulsifier or enzyme) and on texture. Experimental firmness varied from 80,09 to 134,76 g.f. on day 1 for breads with added emulsifier and/or enzyme (compared to 123,84 g.f. for the control); from 126,42 to 222,52 g.f. on day 6 for breads with added emulsifier and/or enzyme (compared to 241,42 g.f. for the control) and from 130,94 to 267,65 g.f. on day 10 for breads with added emulsifier and/or enzyme (compared to 282,64 g.f. for the control). Response surfaces and mathematical models were obtained for all the responses studied, showing the positive effect of the addition of SSL and maltogenic amylase on the increase of bread volume and the reduction of firmness, especially on day 10.

Effect of partial replacement of wheat flour for fiber and protein of soy and technological changes in the properties of dough

C. R. GOMES-RUFFI (1), F. P. Collares-Queiroz (2), S. H. Biondi (1), F. M. Montenegro (1), M. X. Paz (1), A. C. Dalmora (1)
(1) ITAL Inst de Tecnologia de Alimentos, Campinas, SP, BRAZIL; (2) State University of Campinas, Campinas, Sao Paulo, Brazil
Cereal Foods World 54:A43

The soybean and its derivatives have great potential in the functional foods market due to the presence of bioactive compounds (isoflavones), being also excellent to protein enrichment, mainly as a source of essential amino acids (lysine) and dietetic fiber (soluble and insoluble), translating into benefits for health and adding value to the product. However, the partial substitution of gluten (wheat flour) by soy protein and fiber can lead to impairment of the technological performance of the dough. The objective of this study was to evaluate the rheological behavior of mixtures of wheat flour and different proportions of derivatives of soy (protein and fiber) and technological changes in the properties of dough. Therefore, 3 samples of wheat flour with partial replacement of 6%, 10% and 14% of soy derivatives (mix with 52% fiber and 30% protein) and 1 control sample (without additions) were analized. The samples were evaluated on the physical (color) properties and rheological farinography, extensography, gluten content and falling number, in triplicate. The extensographic results of elasticity (R, Rm) showed similar behavior to the control flour. However, this elasticity is not effective since the dough showed a different behavior: no retraction after modeling in the cylinder. There was decrease in extensibility (easy rupture when stretched) due to interference by fiber and soy protein exerted on the viscoelastic properties, as confirmed by the results of farinography where values of water absorption, time of arrival, time of stability, development time increased compared to control. The addition of soy derivatives increased the gluten content of flour and the color tended to light beige, however, not affecting the value of falling number (over 400).

Sensory and rheological properties of noodles enrichment with *Jatropha curcas* flours

N. GUEMES VERA (1), G. Flores-Miranda (1), E. Gomez-Montes (1), S. Soto-Simental (1), E. Perez Soto (1), J. Martinez-Herrera (2), J. Chavez-Hernandez (3), R. Gomez-Ramirez (1)
(1) Instituto de Ciencias Agropecuarias Universidad Autonoma del Estado de Hidalgo, Tulancingo, Hidalgo, MEXICO; (2) Centro de Productos Bioticos del IPN Yautepec Morelos Mexico; (3) Ciencias Veterinarias y Agronomicas del Instituto Tecnologico de Sonora, Cd. Obregón Sonora Mexico
Cereal Foods World 54:A44

Pasta made from semolina is a good source of complex carbohydrates. Pasta contains relatively high amounts of resistant starch and is low in fat and protein, an alternative to compensate these deficiencies is the use of oilseeds such as *Jatropha curcas*. It was prepared from semolina enrichment with 5, 10, 15, 20 and 25% of *Jatropha curcas* flour. The protein content showed 13.62% (compared with 11% for commercial pasta) for noodles with 10% of *Jatropha curcas* flour and a lysine content of 6.5% (compared with 2.3% for control). Sensory analysis of enriched noodles with 10% of *Jatropha curcas* flour was accepted by the judges. The extensibility of noodles presented with 10% of *Jatropha curcas* flour was 35.3 cm, the R max was 38.9. These results were similars to the noodles control. The firmness from noodles with 10% of *Jatropha curcas* flour (0.55 Kf) was similar to the noodles control (0.51 Kf). The b* value decreased when percentage of oilseed flour was increased. The best treatment was when 10% of *Jatropha curcas* flour was used.

Baking characteristics of Tollocan, Saturno and Salamanca wheat flour using extensibility, adhesives and texture profile analysis

N. GUEMES VERA (1), E. I. Mera García (2), M. M. López- Rodríguez (2), S. Flores-Mera (2), A. Santos-Escamilla (2), S. Soto-Simental (1), J. F. Hernandez-Chavez (3)
(1) Instituto de Ciencias Agropecuarias de la Universidad Autonoma del Estado de Hidalgo Tulancingo Hidalgo MEXICO; (2) Instituto Tecnológico Superior del Occidente del Estado de Hidalgo Mexico; (3) Ciencias Veterinarias y Agronómicas del Instituto Tecnológico de Sonora Cd. Obregon Sonora
Cereal Foods World 54:A44

The selection of new varieties of grains of wheat to cover the needs increasingly demanding of the industry of bakery needs some standards for the improvement of the products of bakery. The objective was evaluating dough quality of three wheat flour using extensibility, adhesiveness and texture profile analysis as indicators. Three wheat flour obtained from Tollocan, Saturno and Salamanca varieties of wheat grains growed in Mixquiahuala, Hidalgo, México. Dough extensibility, adhesiveness and texture profile analysis were measured in a TAXHD texture analyzer. Results obtained for extensibiliby were 36.8, 19.6 and 44.3 cm to Salamanca, Tollocan and Saturno, respectively. Adhesion averages of dough were 19.6, 30.4 and 42.3 kgf to Salamanca, Tollocan and Saturno, respectively. Texture Profile Analysis parameters for doughs were 0.26, 0.25 and 0.15 kgf for firmness to Salamanca, Saturno and Tollocan flours, respectively. It was concluded that Salamanca flour has the best quality to prepare dough.

Effect of storage of flour-blasted brown rice on lipolysis, peroxide value, texture, water absorption and pasting properties of their flours

H. GURAYA (1), J. Patindol (1), E. Champagne (1)
(1) USDA-ARS-SRRC, New Orleans, LA, U.S.A.
Cereal Foods World 54:A44

Brown rice was blasted with flour rather than sand in a sand blaster to make tiny little nicks and cuts so that water can easily enter into the brown rice endosperm and can cook the brown rice in a shorter time. The flour-blasted American Basmati, long grain and parboiled rice samples were stored in Ziploc® bags and vacuum packs, and were periodically tested for changes in % water absorption (WA) during cooking, free fatty acids (FFA), peroxide value (POV), viscosity changes of flour using Rapid Visco Analyzer (RVA) and texture of whole cooked kernal using Texture Analyzer during storage for 300 days. Flour-blasted rice absorbs less water but needed less cooking time than non-floublasted counterpart. Parboiled rice was more resistant to increase in FFA after flourblasting as compared to other flourblasted non-parboiled rice due to inactivation of lipases during heat moisture treatment used to manufacture parboiled rice. The ANOVA showing the *F* values were significant for all four factors, i.e., the type of rice, blasting treatment, type of packaging and time of storage at $p < 0.05$ for FFA, POV, peak viscosity (PK), final viscosity (FV), breakdown viscosity (BD) and setback viscosity (SB), hardness, gumminess and % WA but packaging alone did not significantly affect FFA, BD, gumminess and %WA. An increase in FFA, POV, PV, FV, BD and SB during storage of flourblasted brown rice for 300 days but no change was observed in texture (hardness, gumminess) and % WA. The combined (includes all types of rice) coefficient of correlation were 0.86 between FFA and FV, 0.90 between FFA and SB is 0.90 at $p < 0.0001$. Other correlations also occur in the data, which could be used to model rancidity and develop standard methods, which could then be used by the rice industry to monitor rancidity.

Effects of drying conditions on endogenous enzyme activity and starch properties of corn

J. GUTESA (1), S. Harjadi (1), A. P. Burgers (1), C. R. Hurburgh (1), J. Jane (1)
(1) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A44

Objectives of this study were to understand how drying conditions affect quality of corn and its endogenous enzyme activity, attributes that are of importance for the utilization of corn. For 2007 crops, an increase in starch gelatinization temperature and no significant changes in the endogenous enzyme activity were observed in corn dried up to 65°C comparing with the control dried at 25°C. Corn dried at 85°C showed less enzyme activity (17.1% decrease in reducing sugar yield after 20 h incubation time), higher starch gelatinization temperature (T_0, T_p, T_c) and enthalpy change (2.5°C, 1.5°C, 1.6°C, and 1 J/g increase, respectively), and less starch swelling power and % solubility than the control. The increase in the gelatinization temperature and enthalpy change suggested that during the drying at 65°C and 85°C starch lost some weak crystalline structure, which gelatinized bellow the respective temperatures. Corn kernels dried at 10°C also showed a higher gelatinization temperature of starch than the control. This could be attributed to that the drying temperature of 10°C was close to the optimal temperature for starch crystallization (4–5°C) and thus, enhanced starch crystallinity. Starch isolated from kernels dried at ambient temperature (25°C and 45°C) was hydrolyzed faster than that dried at temperatures of 10°C, 65°C and 85°C using a raw-starch hydrolyzing enzyme. For 2008 crops, the endogenous enzyme activity was not affected by increasing the drying temperature up to 85°C. Kernels dried at 105°C and 125°C, however, showed less endogenous enzyme activity (13.5% and 31.4% decline in the reducing sugar yield, respectively, after 20 h incubation time) than the control. The results obtained from this study provide useful information for animal feed and ethanol production to optimize drying conditions of corn and obtain the best quality and yield of products.

Technological properties of extruded flour and tortillas from transgenic maize (*Zea mays* L.) expressing amarantin

R. GUTIERREZ-DORADO (1), J. Milan-Carrillo (2), S. Mora-Rochin (3), J. Lopez-Valenzuela (3), A. Valdez-Ortiz (3), C. Reyes-Moreno (3)
(1) robe399@hotmail.com; (2) Univ Autonoma de Sinaloa, Culiacan, Sinaloa, MEXICO; (3) creyes@uas.uasnet.mx
Cereal Foods World 54:A44

The maize kernel contains 7–13% protein (dry basis, db), but the quality of its proteins is poor because they are deficient in the essential amino acids lysine and tryptophan. Through biotechnological approaches was successfully expressed the main seed storage protein of amaranth (named amarantin) in the kernel of common maize; this transgenic maize showed a significant increment in total protein (+32%) and the essential amino acids lysine (+18%), isoleucine (+36%) and tryptophan (+22%), also is not an important allergenicity inducer. Nevertheless, additional evaluations of this transgenic maize and its products are required to determine its potential use and impact on human nutrition. In this work, technological properties of extruded flour from transgenic maize (genetically modified maize containing the cDNA encoding amarantin) were compared to those of commercial nixtamalized maize flour (CNMF). Extruded transgenic maize flour (ETMF) showed higher protein (13.1 vs 8.98%, db) and crude fiber (2.2 vs 1.5%, db) contents, total color (14.95 vs 12.13) and pH (6.89 vs 6.61) values, and water solubility index (7.51 vs 3.97 g solids/g original solids, db), and lower lipid (4.8 vs 5.1%, db) and ash (1.73 vs 1.75%, db) contents, Hunter *L* value (87.6 vs 89.91), and water absorption index (3.20 vs 3.39 g gel/g solids, db) than CNMF. Tortillas from ETMF had higher protein and crude fiber contents and pH values, and lower lipid and ash contents than tortillas from CNMF, differences similar to those exhibited by their flours. However, the tortillas from ETMF had a higher whiteness (higher Hunter *L* value and lower total color difference) than those from CNMF. Tortillas from both ETMF and CNMF showed similar sensory properties (rollability, puffing and acceptability). The use of transgenic maize for flour and tortilla preparation may have a positive impact on the nutritional status of people from countries where maize is the basic staple food.

The effects of extruded lentil flours on white pan dough and bread characteristics

C. HALL (1), M. Tulbek (2)
(1) North Dakota State University, Fargo, ND; (2) Northern Crops Institute, Fargo, ND, U.S.A.
Cereal Foods World 54:A44

The effect of extruded lentil flours on dough and bread characteristics was studied. The level of lentil flour addition appears to affect dough and bread

characteristic more than the type of lentil flour, i.e. lentil extruded at 350, 400 or 450 rpm and then made into flour. However, extrusion of lentils at 350 rpm had the least impact on dough properties and white pan bread characteristics. The water absorption values of the wheat increased with increasing concentration of extruded lentil flours, indicating that more water should be added to flours containing higher levels of lentil flours to produce a dough similar to flours with lower values of lentil flour. Regardless of the level of lentil flour added, the trend of increasing water absorptions existed with increasing rate of extrusion. For example, the white flour blended with lentil flour obtained from the 450 rpm extrusion conditions had the highest water absorption. Bread made with up to 10% extruded lentil flour using the water absorption of 62% were not substantially different from breads made without lentil flour. The best lentil-fortified breads were made with 5% of the 350 rpm extruded lentil flour. However, an acceptable loaf, as measure by analytical instruments, also could be produced using 10% extruded (350 rpm) lentil flour. The data suggests that that increasing the level of lentil flour in the bread increased the rate of crumb firmness. The type of extruded lentil flour slightly affected the crumb firmness. An important observation was that the percentage increase in bread firmness over 5 days was higher for bread made with raw lentil flour than with processed lentil flour. This observation supports the need for processing of the lentil flour before addition to bread.

Measurement of amino acid content of whole-kernel corn with near infrared spectroscopy

C. L. HARDY (1), C. R. Hurburgh (1), G. R. Rippke (1), W. Goldstein (2)
(1) Iowa State University, Ames, IA, U.S.A.; (2) Michael Fields Ag Institute, East Troy, WI, U.S.A.
Cereal Foods World 54:A45

In food and feed products, near infrared spectroscopy (NIRS) is used to measure an increasing number of chemical parameters that have traditionally been measured by analytical chemistry. Rapid measurement of amino acids in raw and processed grain is becoming increasingly important in balancing livestock rations. National Organic Program standards are expected to change in 2010 to disallow synthetic amino acid supplements in organic feeds. The ability to rapidly measure amino acids enhances plant breeding and livestock ration balancing. NIRS measurement of amino acids in corn has been hampered by the high correlation between the total protein content and the typical amino acid level. When average corn is used to calibrate NIRS analyzers, the calibration estimates the typical amounts of amino acids for the protein level. The organic corn breeding program coordinated by Michael Fields Agricultural Institute is developing organic lines of corn with increased levels of methionine, lysine, and cysteine, deliberately manipulated to break the correlation with total protein. Calibrations were developed for two whole-seed NIRS transmission analyzers (Bruins OmegAnalyzer G and Foss Infratec™ 1241 Grain Analyzer). Samples from 2006 and 2007 crops were used for calibration; samples from 2008 crop were used as validation. Lysine and methionine calibrations had R^2 of 0.73 – 0.84, significantly higher than the correlation of each amino acid to the total protein. These calibrations are suitable for genetic screening in corn breeding programs (high vs. low genetic evaluations). Cysteine was only reflective of protein but this amino acid is less important in ration formulation than lysine and methionine. A standard protocol was also developed to evaluate NIRS calibrations for factors that are correlated with other properties already known to be measureable with NIRS.

Effects of glutenin loci allelic diversity and rye translocations on dough properties within U.S. Hard Winter Wheat breeding programs

S. E. HARMER (1), B. W. Seabourn (1)
(1) USDA-ARS-GMPRC, Manhattan, KS, U.S.A.
Cereal Foods World 54:A45

Allelic variation at the *Glu-1* and *Glu-3* loci is known to contribute to end-use qualities in wheat (*Triticum aestivum* L.). The *Glu-1* loci, which encodes high molecular weight glutenin subunits (HMW-GS), and the *Glu-3* loci, which encodes low molecular weight glutenin subunits (LMW-GS), are polymorphic and therefore multiple alleles exist in different breeding programs. However, the effect of different glutenin alleles at all six loci on dough and bread-making properties is poorly characterised, particularly in U.S. breeding programs. In this study, a set of advanced breeding lines and cultivars from the USDA-ARS Regional Performance Nursery (RPN), consisting of hard winter wheat from breeding programs across the U.S. Great Plains growing region, were used to determine HMW-GS and LMW-GS allelic composition using SDS-PAGE and lab-on-a-chip® technologies. Three, eight and four alleles were detected at the HMW-GS encoding loci for *Glu-A1, Glu-B1* and *Glu-D1*, respectively. The LMW-GS loci were diverse, with six alleles each detected at *Glu-A3* and *Glu-D3* loci and nine alleles detected at the highly polymorphic *Glu-B3* locus. Estimates of glutenin allele effects on dough mixing properties were analysed using mixograph mix-time data (adjusted for protein content) from the RPN crop years 1995–2007. The degree of association of glutenin alleles to mixograph mix time was determined using ANOVA. These results showed that the *Glu-D1* locus had a significant effect ($p < 0.0005$) on mixograph mix time. Generally, *Glu-D1d*, *Glu-B3d* and *Glu-A1a* were associated with higher mixograph mix times, whilst *Glu-A1c*, *GluB1f, Glu-D1a* were associated with lower mixograph mix times.

Investigation of soba noodles prepared with tartary, green and common buckwheat

D. W. HATCHER (1), M. Izydorczyk (1), J. E. Dexter (1), G. G. Bellido (1), C. Campbell (2)
(1) Canadian Grain Commission, Winnipeg, MB, CANADA; (2) Kade Research, Morden, MB, Canada
Cereal Foods World 54:A45

Buckwheat flour has many beneficial nutraceutical compounds capable of improving human health in addition to proteins with a unique amino acid composition. Buckwheat or soba noodles are made from a blend of common wheat flour and buckwheat flour and are consumed both hot and cold throughout Asia. This study compared the texture of soba noodles prepared from a brown tartary, a green testa buckwheat and two common buckwheat varieties. The buckwheat flours were combined (80:20) with a high protein Canada Western Red Spring flour (13.0% protein) as well as with a lower protein (11.5%), but stronger dough strength, Canada Prairie Spring (Red) flour. All soba noodles exhibited significant ($p < 0.0001$) reductions in cooked noodle thickness compared to either common wheat control noodles. Empirical mechanical tests on the cooked noodles; maximum cutting stress (MCS), resistance to compression (RTC) and recovery (REC) as well as a new uniaxial stress relaxation technique; SR20 (stress relaxation at 20 s), K1 (initial rate of relaxation), K2 (extent of relaxation) and elasticity index (EI), highlighted differences in noodle texture. MCS, RTC and REC values of the soba noodles were at least a third lower ($p = 0.05$) than those in either of the control common wheat noodles. Tartary soba noodles however displayed the highest MCS, RTC and REC values of the soba noodles, indicating that they had superior texture than all other buckwheat blends. Uniaxial stress relaxation parameters showed that soba noodles had significantly lower elastic-like behaviour than their corresponding common wheat control noodles, with viscoelastic behaviour varying in soba noodles depending on buckwheat flour source. This study indicates that differences in buckwheat starch content were primarily responsible for the observed rheological behaviour of tartary, green, and common buckwheat soba noodles.

***WiSci Finder*: An innovative approach to communication in grain science**

D. A. HAUGE (1), D. Vukson-Van Beek (1), D. Gallaher (2), L. Marquart (1)
(1) Grains for Health Foundation, St. Paul, MN, U.S.A.; (2) University of Minnesota
Cereal Foods World 54:A45

Today's complex scientific issues require communication, collaboration and action among a diverse group of scientists from around the globe. This establishes a need for a systematic approach that allows scientists to locate collaborative expertise, state of the art technology and techniques to successfully conduct interdisciplinary research. The purpose of this project was to develop and pilot test a comprehensive and searchable database (*WiSci Finder*) of experts in the areas of whole grains, dietary fiber and related bioactive compounds. The *WiSci Finder* includes information about experts/researchers including location, laboratory capabilities (equipment, standard compounds, methodologies, techniques), publications, and grants. A qualitative survey extended to a sample of users during the pilot period examined usability, relevance of categories, and expected outcomes when using *WiSci Finder*. This data will be used to optimize *WiSci Finder's* design to enhance functionality and usefulness to the researcher. *WiSci Finder* profiles are continually updated and maintained by the Grains for Health Foundation to remain relevant and accurate. *WiSci Finder* offers a place to track collaborative efforts and to assess outcomes for future reference. The long-term outcome of this project is to enhance connectivity among grains researchers in order to focus, prioritize, and leverage research related to whole grains, dietary fiber and grain components.

***WiSci Method*: An innovative approach to communication in grain science**

D. A. HAUGE (1), D. Vukson-Van Beek (1), D. Gallaher (2), L. Marquart (1)
(1) Grains for Health Foundation, St. Paul, MN, U.S.A.; (2) University of Minnesota
Cereal Foods World 54:A45

Today's complex public health issues require grain scientists to deal with large amounts of detailed information in overwhelming quantities. The next generation of research involves communication and collaboration by organizing world experts in grain science and technology. Currently, no organized discipline exists to connect and synchronize scientific outcomes from various experts, labs, methods, and techniques. Through the *WiSci Finder*, experts are virtually housed together, giving opportunity to focus,

prioritize, and leverage research to impact public health. The purpose of this project was to pilot test the *WiSci Method*. The *WiSci Method* is a process to define and frame a research problem within a prearranged context. The *Method* steps include: identify a topic, search *WiSci Finder*, gather experts, chat and discuss, define focus, conduct a webinar or conference, generate action steps, award grants/perform research. Experts were identified to present "Cereal Grain Components: Analysis and Bioavailability," a symposium at AACCI's annual meeting. During the course of a four month period presenters communicated by conference call and virtual meetings to frame the scope of the symposium. Their presentations focused the panel discussion through which next steps for research related to measurement of grain compounds and bioavailability will be generated. This *Method* will be evaluated through individual interviews with scientific and communication experts to examine opportunities pertaining to the use of technology, scientific context, and communication efforts in the *WiSci Method*. This input will be used to enhance the *Method* to accurately reflect researchers' needs today and in the future. In this way, gaps in the grain supply chain can be addressed by targeting grant development, policy and regulatory recommendations, or major research initiatives that benefit both the grain industry and public health.

Changes in anthocyanins and antioxidant capacity during the elaboration of tesgüino, a traditional Mexican corn beer

H. HERNANDEZ-SANCHEZ (1), D. Nava-Arenas (1), A. R. Jimenez-Aparicio (2)
(1) Escuela Nacional de Ciencias Biologicas - IPN, Mexico DF, MEXICO; (2) CeProBi-IPN, Mexico, DF, Mexico
Cereal Foods World 54:A46

Tesgüino is a traditional beer-like beverage from Northern Mexico obtained from sprouted white or yellow corn. Blue corn has a higher anthocyanin content and antioxidant activity than other types of corn, so the objective of this study was to elaborate and evaluate a blue tesgüino as a functional product. Germination conditions were 24 h steeping time, a ratio of 200 ml of water / 100 g of grain and a 96 h germination time at 25°C. The sprouts were milled and cooked at 94°C with water (4.3 L / kg of sprouts) for 8 h. This wort was divided in two batches. The first batch was allowed to cool and inoculated with *Saccharomyces cerevisiae* and *Lactobacillus plantarum* (a probiotic strain) cultures and fermented for 24 h at 30°C. The two batches were now mixed and allowed to ferment for 32 h and analyzed for moisture, anthocyanins, phenolic compounds and antioxidant activity. Moisture content increased from 10% (grains) to 40% (germinated grains) to 86% (wort) to 88% (tesgüino). Anthocyanins (expressed as cyanidin-3-glucoside) increased from 50 to 88 mg / 100 g dry solids due to the germination process to decrease to only 8 after the cooking and fermentation. Constant stirring at high temperature for 8 h could be responsible for this. Phenolic compounds (expressed as gallic acid) showed an important increase (25%) after the germination process only to fall 47% after the cooking process and remain constant after that. Antioxidant activity remained constant during the germination process but decreased in 40% after the preparation of the wort and increased slightly (1%) during the fermentation. The final value was 19% DPPH inhibition. The final product was sensorially acceptable. It was red, sour (pH 3.2) and with 1.8% alcohol. These results indicate that the blue tesgüino can be considered as a functional food with a good antioxidant activity and probiotic lactobacilli.

A comparative evaluation of antioxidant properties of commercial brands of regular- and whole-wheat spaghetti

R. Hirawan (1), W. Ser (1), S. Arntfield (1), T. BETA (1)
(1) University of Manitoba, Winnipeg, MB, CANADA
Cereal Foods World 54:A46

Whole grains contain more vitamins, minerals, natural antioxidants and dietary fibre than regular, refined grain products. Therefore, consumption of whole grain products is associated with beneficial health effects. The present investigation evaluated the antioxidant properties of ten samples of regular- and whole- wheat spaghetti that are commercially available. The methods employed were total phenolic content (TPC), 2,2-diphenyl-1-picryhydrazyl free radical (DPPH) scavenging activity, oxygen radical absorbance capacity (ORAC) and ferulic acid content by HPLC analysis. The effects of cooking on the antioxidant properties of spaghetti were also studied. Whole wheat spaghetti exhibited significantly higher levels of total phenolic content (1389 µg/g) than regular wheat spaghetti (865 µg/g); however, TPC in both regular and whole wheat spaghetti was 48–78% of the original content after cooking. There were no significant differences in ORAC values (34.3 to 100.4 µmol Trolox equivalent/g) or DPPH scavenging activity (1.0 to 2.3 µmol Trolox equivalent) among whole wheat and regular spaghetti. Whole wheat spaghetti (234 µg/g) had significantly higher ferulic acid than regular spaghetti ($p < 0.05$). TPC and ferulic acid content were found to be good indicators of the antioxidant capacity of spaghetti with both indices demonstrating the superiority of whole wheat over regular pasta products. The current findings on spaghetti add to the mounting evidence on the potential health benefits to be derived from consuming whole grain products.

Effect of genotype and environment on starch and protein content in, and the physicochemical properties of starch from, field pea and fababean

S. HOOD-NIEFER (1), R. Tyler (2)
(1) Parrheim Foods, Saskatoon, SK, CANADA; (2) bob.tyler@usask.ca
Cereal Foods World 54:A46

The effects of genotype and environment and their interaction on the concentrations of starch and protein in pea and fababean and amylose concentration and thermal and pasting characteristics of starch from pea and fababean were investigated. Genotypic differences in the concentrations of starch and protein in pea and fababean were observed. On a dry weight basis, pea and fababean contained 44.1–46.2% and 41.1–47.5% starch and 24.2–27.5% and 27.5–32.4% protein, respectively. CDC Striker and CDC Tucker contained the highest protein concentrations of the genotypes tested at 27.5 and 27.1% (dry basis), respectively. Gloria had the highest protein concentration at 32.4% (dry basis). CDC Fatima, NPZ4-7540 and SSNS-1 contained 30.7, 29.7 and 30.2% protein (dry basis), respectively. Genotypic differences in the onset temperature (To) and peak temperature of gelatinization of fababean starch. Additionally, genotypic differences were observed in the pasting, trough, cooling and final viscosities of pea starch and fababean starch. Significant two-way interactions (location × genotype) were observed for the concentration of starch in fababean. Significant two-way interactions were also observed for the amylose concentration in fababean starch, and the To, endothermic enthalpy of gelatinization and trough viscosity of fababean starch. Significant three-way interactions (location × year × genotype) were observed for the concentration of starch in pea and the pasting, trough, cooling and final viscosities of pea starch. The effect of genotype on the concentrations of starch and protein in pea and fababean was sufficient to be of practical significance to end-users. However, the significant interactions detected may complicate the manipulation through breeding of the concentrations of protein and starch in pea and fababean.

Comparison of NIR and BioFoss (FTIR) for analysis of Ethanol, Lactic & Acetic acid, Glycerol and Sugar composition for ethanol fermentation

M. HOST (1), R. Pradon (2), J. Persson (2)
(1) Foss North America, USA; (2) FOSS Analytical AB, Sweden
Cereal Foods World 54:A46

Advances within spectroscopy and chemometrics in combination with the high attention the Biofuel area is getting from manufacturers of spectroscopic analyzers pave the way to improved analytical solutions. Near Infrared (NIR) technologies has for a long time been the method of choice when it comes to rapid analysis of ingredients or rapid control of production processes. Although NIR is an excellent technique it still has its limitations. This will be demonstrated with an example from the rapidly expanding biofuel industry. Near Infrared (NIR) has, for a long period been the preferred method for analyzing whole grain at intake or in grain trading for parameters such as moisture, starch, ethanol yield and test-weight. The same technology has, in recent years, migrated into the ethanol process (e.g. fermentation). However, the relatively limited analytical performance achieved by NIR for fermentation monitoring has so far not lead to a wide spread use of the technology. Our studies have shown that the use of NIR for fermentation monitoring in normal situations can produce quite acceptable results but this is mainly an effect from the natural correlations between the components in a normal fermentation process. If the unexpected happens in the process, these natural correlations fall apart and NIR calibrations fail. In such situations a new simple instrument – BioFOSS based on FTIR technology has been found to outperform NIR instruments. The operating principles of this instrument will be presented and its performance will be exemplified with a comparison vs NIR technology for a range of critical fermentation control parameters such as Ethanol, Lactic acid, Acetic acid, Glycerol and Sugar composition.

Phytoglycogen, a dendritic polysaccharide nanoparticle, has unique hydrolysis pattern with amyloglucosidase

L. HUANG (1), Y. Yao (1)
(1) Purdue University, West Lafayette, IN, U.S.A.
Cereal Foods World 54:A46

Phytoglycogen (PG) is a dendritic alpha-D-glucan generated in the *su1*-containing mutant corns. In these mutants, the lack of isoamylase-like starch debranching enzyme leads to the generation of highly branched PG nanoparticles replacing starch granules. In an early study, we found that the susceptibility of PG to alpha-amylase and amyloglucosidase (AMG) is lower than that of starch, probably due to the high branch density of PG molecules. In the current study, our goal is to examine the proceeding of AMG-catalyzed hydrolysis of PG in comparison with amylopectin (AP) of waxy corn starch. The enzymatic reaction was conducted in 10 mL NaAc buffer containing 10 units of AMG and 0.25 to 5.0% of PG or AP, at pH4.5 and 55°C. The reaction

was monitored by measuring the glucose release at 0.5, 1, 2, 10 min, and thereafter every 10 min for 1 hr. The results showed distinct hydrolysis pattern for PG and AP, which is affected by the concentration of substrates. For substrate concentration of 1.0% and higher, in the initial stage (stage-1) of hydrolysis (less than 10 minutes), the amount of glucose release from PG was greater than that of AP, suggesting a higher availability of non-reducing ends from the PG outer layer to AMG enzyme. In the next stage (stage-2), the amount of glucose release from PG was surpassed by that of AP, suggesting the inhibitory effect of exposed alpha-1,6 linkages on glucose release. Interestingly, when the concentration of substrates was less than 1.0%, the existence of stage-1 was not observed. This may be attributed to the saturated enzyme binding and maximized hydrolysis at the surface of individual PG molecules, and this effect may remove the 1,4 linkages at the outer layer in less than 0.5 min. The information obtained from this work allows us to gain more insight on the structure uniqueness of PG and its applications as a carbohydrate food ingredient and functional nanocarrier.

Characteristics of starch fine structure and pasting properties of waxy rice during storage

Y. HUANG (1), H. Lai (1)
(1) National Taiwan University, Taipei, TAIWAN
Cereal Foods World 54:A47

Waxy rice was the major rice variety used for making snacks in Asian. It had been realized that the physicochemical properties of waxy rice affected by variety and storage condition after harvesting. The objectives of this study was to investigate the starch fine structure and pasting properties of two domestic waxy rice varieties, TNW1 (*Japonica* type) and TCSW1 (*Indica* type) during storage. The milled rice were stored at 4 and 17°C and the paddy rice were stored at room temperature (25 ± 5°C) for 15 months. The chain length of amylopectin (AP) were determined by using HPAEC-PAD and pasting properties of rice flour and rice starch suspensions were determined by using RVA. Principle component analysis (PCA) was employed to identify the correlations between RVA and AP chain-length data of waxy rice. The amount of short chains (DP＝6-15) of AP increased but that of the long chains (DP＞15) decreased when TNW 1 was stored for 7 months at all three storage conditions. The changes in chain length of TCSW 1 AP during storage were smaller than those of TNW 1. After 15 months of storage, the peak viscosity (PV) of waxy rice starches determined in both H_2O and in 2.5 mM $AgNO_3$ solution increased and the increments were larger in TNW 1 than TCSW 1. There were no significant changes in viscogram's patterns of TCSW 1 rice flour both in H_2O and in 2.5 mM $AgNO_3$ solution when they were stored at 4 and 17°C. While, significant increases of PV were found in TNW 1 rice flour in H_2O and slight increases in 2.5 mM $AgNO_3$ solution when they were stored at 4 and 17°C. The first two components of PCA explained 66% of overall variation of the total variation in the measurements. PCA indicated that the pasting properties of waxy rice flour were mainly affected by the changes in the chain length of AP during storage, which resulted from the reactions of endogenous amylase in rice during storage and/or heating stage of RVA measurements.

Bread making performance after partial substitution of wheat flour with corn processing by-products

A. R. ISLAS-RUBIO (1), T. L. Maldonado-Parra (1), M. C. Granados-Nevarez (1), F. Vasquez-Lara (1), L. R. Lorence-Rubio (2)
(1) Centro de Investigación en Alimentación y Desarrollo, A.C., Hermosillo, Sonora, MEXICO; (2) Industrias CENTLI, S.A. de C.V., Los Mochis, Sinaloa, Mexico
Cereal Foods World 54:A47

The benefits of dietary fiber (DF) in human health are well documented. Health conscious consumers demand foods with higher DF content. The objective of this study was to determine the maximum substitution level of wheat flour (WF) by fine (FF) or coarse (CF) fiber, and germ-rich fraction (GF) in bread manufacturing. Breads were made following the direct dough procedure, maintaining a constant amount of ingredients, except for water, flour and the amount of each of the by-products. Bread making performance was evaluated by measuring specific volume, crumb and overall appearance. In addition, bread firmness and water activity were evaluated during storage (up to 7 days) at 25°C. Significant differences on specific volume, bread firmness and water activity between the control bread (0% substitution) and the composite flour breads were observed. Wheat flour substitution level of 10% FF and 20% CF or GF provided the best results. It is possible to include this type of by-products in bread manufacturing without significantly affecting bread quality.

Confocal laser scanning microscopy as a tool in the analysis of cereal products

M. JEKLE (1), T. Becker (1)
(1) Technische Universität München, Freising, GERMANY
Cereal Foods World 54:A47

The effects of different ingredients and production parameters on dough and baked products are evaluated in a lot of studies. Nevertheless the microstructure of proteins and starch in dough and baked goods is still of special interest. Therefore a confocal laser scanning microscope (CLSM) was used to examine the protein and starch distribution. One of the main advantages of the relatively new technique is the slight extend of sample preparation that is required. The images were acquired with a Nikon Ti-E microscope in combination with an e-C1plus confocal system. An excitation wavelength of 543 nm of a green HeNe laser was utilized to detect the protein phase dyed with Rhodamin B. Nile Blue was used to examine the protein phase and simultaneously starch granules in dough and crumb samples (red HeNe laser, 637 nm). Optical sections were taken every 0,15 µm through the sample and three-dimensional images were produced by digital processing. The study shows the advanced possibilities of the use of CLSM within the scope of different raw materials (wheat and rye flour), protein cross-linking due to Transglutaminase in rye dough, and the variation of the properties of protein and starch during baking and as a central objective the investigation of the changes in the microstructure of wheat dough due to different dough yields. In wheat dough the composition and the spatial orientation of the gluten protein are of particular importance for its rheological and textural properties. For the correlation of the visible results of the CLSM with these aspects the effect of the varied water content was examined with frequency sweep test, creep recovery test and stickiness of the dough and the specific volume of the wheat bread. The results submit an innovative new view on the phase distribution of the protein network in dough which varies significantly with different water content.

Dosage effect of high-amylose modifier (HAM) gene on physicochemical properties of maize amylose-extender (*ae*) starch

H. JIANG (1), M. Campbell (2), J. Jane (1)
(1) Iowa State University, Ames, IA, U.S.A.; (2) Truman State University, Kirksville, MO, U.S.A.
Cereal Foods World 54:A47

GEMS-0067, with a pedigree of GUAT209:S13×(OH43*ae*×H99*ae*), is an inbred maize homozygous for the recessive *ae (sbe2b)* allele and a HAM gene containing *sbeI* allele. GEMS-0067 produces starch with ~25% more resistant-starch (RS) content than maize with the *ae* mutation alone. The objective of this study was to understand how the HAM gene dosage affected the RS formation in the maize *ae*-mutant starch. Starches isolated from triploid endosperm of GEMS-0067 (3 doses of HAM gene), GEMS-0067×H99*ae* (2 doses), H99*ae*×GEMS-0067 (1 dose), and H99*ae* (0 dose) were used in this study. The content of amylose/intermediate component (IC) increased from 68.9% to 88.2% upon increasing the dosage of HAM gene. As HAM gene doses decreased from 3 to 2, 1, and 0, RS contents determined using the AOAC Method 991.43 for total dietary fiber were 35.0%, 28.1%, 12.9%, and 15.7%, respectively. Two gelatinization thermal-transition peaks were observed on the differential-scanning-calorimetry (DSC) thermogram for most starches. The first peak (~82.6°C), corresponding to the melting of the crystallites of amylopectin/IC, showed as a shoulder for GEMS-0067 but increased with the decrease in the HAM gene dosage, whereas the second peak (~99.1°C), resulting from the melting of the amylose crystallites and the amylose-lipid complex, decreased with the decrease in the HAM gene dosage. These results suggested that the increased dosage of HAM gene was responsible for the increase in amylose/IC content of the maize *ae*-mutant starch and, in turn, the formation of the amylose crystallites and amylose-lipid complex. Two doses of HAM gene substantially increased the RS content, but one dose of HAM gene had little effect on the RS content. The results of this study provided information for plant breeders to develop high yielding corn with large RS contents by selectively crossing lines with HAM and *ae*-null genes.

Hydrothermal characteristics of pearl millet (*Pennisetum glaucum*) flour during cooking into 'Fura'

V. A. JIDEANI (1), D. J. Scott (1)
(1) Department of Food Technology, Cape Peninsula University of Technology, Cape Town 8000, SOUTH AFRICA
Cereal Foods World 54:A47

The effects of hydration times [HT] (1, 3.5, and 6 hours) and cooking times [CT] (20, 40, and 60 minutes) on the thermal characteristics of cooked pearl millet flour [CPMF] was investigated. The DSC thermograms depicted two separate endothermic transitions, identified as starch gelatinisation (29°C–30°C) and disruption of the starch-lipid complexes (90°C–120°C). The onset (T_o), peak (Tp) and conclusion temperature (Tc) of uncooked pearl millet flour [UPMF) were 50.6, 72.2 and 80.2°C respectively; that for the hydrated and CPMF ranged from 28.3–49.1°C, 47.9–79.7°C and 51.3–86.9°C respectively. The gelatinisation temperature range (DTr) for the UPMF was 29.6°C and that of the treated flour ranged from 3.2–37.7°C. HT and CT significantly ($P < 0.05$) affected the gelatinisation properties of the millet flour. HT gradually decreased the degree of gelatinisation, whereas CT drastically increased the

degree of gelatinisation. Hydrating millet flour for 1 h and cooking for 40 min was sufficient to achieve 100% gelatinised flour. Starch-lipid complex formed after gelatinisation at hydration time (3.5 h) and cooking for 40 min. HT (3.5 min) and CT (40 min) significantly decreased the *T*o, *T*p, *T*c temperatures and uniformity of gelatinisation (PHI). Melting range (D*T*r) and melting enthalpy (D*H* melting), for the UPMF is 34.63°C and 1026.94 J/g respectively; 28.16 to 35.49°C, and 751.61 to 1072.44 J/g respectively for the CPMF. Increasing both the HT and CT reduced the amount of energy required to break the starch-lipid complex formed during the cooking of millet flour. The UPMF showed a typical A-type X-ray diffraction pattern, which was altered by the hydrothermal treatments (1 h hydration and 20 min cooking) resulting in a transformation into the V-hydrate form evidence of starch-lipid complex formation. The formation of this complex possibly explains why millet flour remains intact during cooking into fura.

In-vitro starch digestibility and glycemic property of Acha (*Digitaria exilis*) porridge

V. A. JIDEANI (1), S. C. Podgorski (1)
(1) Department of Food Technology, Cape Peninsula University of Technology, Cape Town 8000, SOUTH AFRICA
Cereal Foods World 54:A48

The in-vitro starch digestibility of acha flour and glycemic property of acha porridge was investigated for two acha cultivars *(Digitaria exilis,* white and *Digitaria iburua,* brown) compared to maize porridge. The total starch (TS) for maize, white and brown acha flours were 45.3, 42.6 and 41.5% respectively. The resistant starch (RS) was 2.9, 2.1, and 1.2 respectively for maize, white and brown acha flours. The digestible starch (DS) was 43.7, 41.4 and 40.0% respectively for maize, white and brown acha flours. There was no significant difference between the maize flour and the two acha cultivars in TS and DS. However, brown acha differed significantly from white and maize flours in RS content. Both time and porridge type significantly ($P < 0.05$) affected the amount of hydrolysed starch. Within 180 min, a significantly higher amount of starch in maize porridge (32.8%) was hydrolysed compared to 18.6 and 15.5% respectively for white and brown acha porridge. The rapidly digestible starch (RDS) and slowly digestible starch (SDS) 31.2 and 40% respectively for maize porridge were significantly higher than those of white (13.7, 24.1%) and brown (16.3, 18.5%) acha porridge. The brown and white acha porridge had low estimated GI values (40). Acha grain may have a potential as a low GI food. However, further work is on going to establish effect of different processing methods on this grain.

Effects of resistant starch on the physical, sensory and textural properties of wheat flour tortillas

T. O. JONDIKO (1), N. J. Alviola (1), L. W. Rooney (1), J. M. Awika (1)
(1) Texas A&M University, College Station, TX, U.S.A.
Cereal Foods World 54:A48

Wheat flour tortillas are the fastest growing and most popular bread consumed in North America. As this market grows, demand for healthier high dietary fiber alternatives increases. Less than 10% of Americans consume the 25–38 g recommended daily intake (RDI) of fiber. This is partially due to the dislike of whole grain product texture, color and flavor. This study characterized the effects of resistant starch (RS) on the physical, sensory, acceptability and textural properties of wheat flour tortillas. Tortillas were baked from whole wheat and refined wheat flour substituted with 0, 5, 10 and 15% commercially produced wheat-based RS. Objective and subjective evaluations done were consumer sensory tests, tortilla diameter, color, opacity, work to rupture (Texture Analyzer™ TA-XT2) and flexibility over 16 days. Tortillas were consistently round, puffed, white/opaque except whole wheat tortilla which was brown. Tortilla diameter significantly increased from 0 to 15% RS. Whole wheat tortilla diameter at 161 mm was the smallest followed by 164, 169, 177 and 175 mm for 0, 5, 10 and 15% RS respectively. Work to rupture was for 10 and 15% RS (20 N.mm) was significantly lower than for whole wheat, 0, and 5% RS which had 29, 35 and 31 N.mm respectively. Tortilla flexibility was similar for whole wheat, 0, 5 and 10% RS, but significantly decreased for 15% RS substitution level after 12 days. Sensory evaluations (9-point scale) indicated that tortillas with 0 to 15% RS had similar flavor (6.9) and appearance (7.2), and were significantly more acceptable than whole wheat tortilla flavor (5.5) and appearance (5.4). Texture acceptability was lowest (5.2) for whole wheat compared (6.4) for 10% and (7.5) for 15% RS. Use of 15% resistant starch can increase the dietary fiber intake (RDI) to 3.5 g/40 g tortilla without affecting the wheat flour tortillas consumer acceptability.

Influence on cholesterol by diets containing garbanzo, Bengal gram, lentils, soy isolate, salmon hydrolysate and casein in hamsters

T. S. KAHLON (1), R. J. Avena-Bustillos (2), M. M. Chiu (3)
(1) USDA ARS WRRC, Albany, CA; (2) University of California, Davis, CA; (3) WRRC, USDA-ARS, Albany, CA, U.S.A.
Cereal Foods World 54:A48

Cholesterol-lowering potential of diets with 20% protein from garbanzo, Bengal gram, lentils, soy isolate, salmon hydrolysate or casein (control) was evaluated in a three week hamster feeding study. Initial and final animal weights, feed intakes and plasma triglycerides values were similar among all the treatments. Garbanzo containing diet significantly lowered total cholesterol and LDL- cholesterol compared with casein control. However, total cholesterol, VLDL-cholesterol and LDL-cholesterol were significantly elevated with salmon hydrolysate diet compared with casein control as well as all the other treatment diets. Salmon hydrolysate diet resulted in significantly higher liver weight, liver lipid, total and free liver cholesterol compared with all other treatments. Fish oil has been known to elevate cholesterol levels in hamsters. Plasma and liver cholesterol elevating effects of salmon hydrolysate need to be further explored in this animal model. Plasma cholesterol lowering potential of garbanzo is encouraging as it supports previously reported observations of higher in vitro bile acid binding by garbanzo.

Differences in rheological properties of various corn bran arabinoxylans

M. KALE (1), D. Pai (1), H. Chang (1), B. Hamaker (1), O. Campanella (1)
(1) Purdue University, West Lafayette, IN, U.S.A.
Cereal Foods World 54:A48

Dietary fiber consumption levels in the United States are much below the recommended daily allowances. One way to increase the fiber consumption among the general population is the fortification of commonly consumed foods with dietary fiber. Cereal brans are an abundant and cheaply available source of dietary fiber for fortification. However, incorporation of these fibers into food systems is associated with a major technological challenge of preserving its texture and organoleptic properties. Alkali treatment is used to modify these fibers and improve their rheological properties. The objective of this study was to determine the rheological properties of corn fiber fractions obtained by different alkali treatments. Four different alkali treated corn bran fibers were tested for their structural and rheological characteristics. The rheological characterization included lubricated squeezing flow rheometry, for extensional viscosity as a function of strain and strain rate, solution shear rheology, for shear viscosity; and capillary rheometry to evaluate the melt rheology in a simulation of the extrusion system. The rheology results were correlated with molecular weight and hydrodynamic radius data obtained using size exclusion chromatography and multi-angle laser light scattering (SEC-MALLS). The lower molecular weight arabinoxylan had lower extensional and shear viscosities. The study is a step towards the understanding of structure-function relationships of these polymeric fibers, with a view to evaluating the potential for their incorporation into food systems. The tested fibers showed good functional properties to this end.

Comparison of two rheological methods for measuring gluten visco-elasticity with added lecithin

P. KALYANARAMAN (1), P. Rayas-Duarte (1), S. Mulvaney (2)
(1) Oklahoma State University, Stillwater, OK; (2) Cornell University
Cereal Foods World 54:A48

Small deformation (creep recovery) and large deformation (tensile test) rheological methods were compared in order to determine the effect of lecithin on gluten viscoelasticity. Freshly prepared wet gluten samples (not defatted) from a commercial hard red winter wheat sample were analyzed. Glutens were prepared with 0, 0.5 and 1.0% lecithin addition. The tensile test imparted a strain of 500% at a rate of 1 mm/s using a TA-XT2 texture measuring instrument. Viscoelastic properties were also characterized using a creep recovery test (100s of creep followed by 100s of recovery at 40 Pa stress) which gave near-equilibrium recoverable strain results. Baking performance and Farinograph mixing properties were also determined. Work of extension (tensile test) decreased 46.7% with 1% lecithin, while the degree of elasticity (ratio of recoverable work to work of extension) and set (percentage increase in sample after extension and recovery) of the gluten samples did not change significantly with the addition of lecithin. Recoverable shear strain of gluten was similar in all samples (mean 81.6%) suggesting that the differences in gluten viscoelasticity were not detected by the creep recovery test at this level of lecithin addition. Dough stability time increased significantly (1.8 to 2.7 times) ($p < 0.002$) as the lecithin level increased and the specific volume of the loaves decreased significantly (10.2% decrease) ($p < 0.016$) with 1% lecithin. Loaf bread volume was not affected with 0.5% lecithin and showed a trend to decreasing values with 1% lecithin ($p < 0.068$). The tensile test (large deformation) was more successful in detecting differences in the viscoelastic properties of gluten with lecithin addition compared to the creep recovery test. The results suggest that lecithin affects primarily long range elastic structures in gluten, while creep-recovery probes shorter range elastic properties.

Optimization of amylase hydrolysis of starch in whole grain meal

A. KANDIL (1), T. Vasanthan (1), D. Bressler (1), J. Li (1)
(1) University of Alberta, Dept. AFNS, Edmonton, AB, CANADA
Cereal Foods World 54:A49

The effects of pre-washing using different solvents (water, hexane, 100% Ethanol and 50% ethanol) on the chemical composition and the amylolysis of four whole grain flours (Xena barley, Canadian corn, CPS-wheat and Pronghorn triticale) were studied. The particle size distribution of untreated flours ranged from 0–500 µm in diameter. When grains were passed through a 0.5 mm sieve, barely flour had the greatest proportion of fine particles, with 95–98% smaller than 150 µm. Pre-washing using 50% ethanol resulted in the highest amount of solid loss in the flours, and significantly decreased protein, phytic acid, and total phenolics contents by 10–37%, 23–56%, and 84–87%, respectively, in four flours, while generally increased starch and pentosans contents. Water pre-wash significantly reduced β-glucan content in barley by 98%, while hexane reduced lipid content by 97%, 83%, 73%, and 82% in corn, barley, wheat and triticale flours, respectively. The effects of pre-washing before α-amylase or amyloglucosidase hydrolysis treatments were either positive or negative depending on flour source. The greatest increases and extent of hydrolysis of starch compared to unwashed controls was achieved when pre-washing was combined with a dual treatment of both α-amylase and amyloglucosidase enzymes. This synergistic enzyme action was best demonstrated with 50% ethanol or water pre-washes, resulting in starch hydrolysis ranges of 96–97% and 86–94%, respectively, for all four flours. Mitigating the negative effects of non-starch grain components on starch hydrolysis, such as protein, lipids, pentosans, phytic acid, and β-glucan, using pre-washing strategies, may be an opportunity for the recovery of valuable components, while optimizing starch hydrolysis from grain sources for the bio-ethanol industry.

Development of the ready mix formulation for 'Missi Roti' a traditional Indian flat bread

A. KAUR (1)
(1) Punjab Agricultural University, Ludhiana, U.S.A.
Cereal Foods World 54:A49

Study was carried out to prepare a Ready Mix Formulation with wheat 'atta', bengal gram flour and functional ingredients for "Missi Roti". Chemical composition of each ingredient was studied. To find out the optimum level of incorporation of ingredients, each ingredient was individually incorporated into the optimized proportion of wheat 'atta' and bengal gram flour and evaluated for 'Chapatti' making quality and sensory properties by panel of semi trained judges. Best selected levels were bengal gram flour-50 per cent, fenugreek powder-5 per cent, onion powder-10 per cent, ginger powder-1 per cent, green chilli powder-0.25 per cent, red chilli powder-0.25 per cent, fat-2 per cent, salt-1.5 per cent, GMS and SSL-0.25 per cent. Two formulations were prepared after incorporating all the ingredients with fat i.e. Formulation I and without fat i.e. Formulation II. Both the formulations were packed in different packaging materials i.e. zip pouch, aluminium laminate and high density poly ethylene. Packed formulations were stored at ambient and refrigeration temperatures and changes in the proximate composition, water activity, free fatty acid, peroxide value and texture of 'Chapattis' were assessed periodically for the period of four months. Formulation I and II packed in aluminium laminates and stored under ambient and refrigeration conditions were found better as compared to those packed in high density polyethylene and zip pouches.

Semolina granulation and pasta quality

N. KAZENNOVA (1), I. Moiseev (2)
(1) Moscow State University of Technology and Management, Moscow, Russia; (2) Harrisburg, PA, U.S.A.
Cereal Foods World 54:A49

Effect of unadjusted semolina (450 mm – 0.5%; 300 mm – 33.0%; 250 mm – 22.5%; 200 mm – 12.5%; 180 mm –10.0%; 132 mm – 8.0%; pan – 13.5%) and adjusted semolina by particle size (450 mm – 2.0%; 300 mm - 76.0%; 250 mm – 16.0%; 200 mm – 5.0%; 180 mm – 2.5%; 132 mm – 2.0%; pan – 1.0%) on pasta quality was investigated. The unadjusted semolina had lower gluten quality and color characteristics, but higher content of reducing sugars. The rheological properties of unadjusted semolina dough had higher farinograph and mixograph water-absorption capacity of 60% and longer dough formation period of 6.5 min than adjusted semolina of 57% and 4.5 min, accordingly. According to extensograph rheological properties of dough made from adjusted semolina produced dough of higher plasticity-elasticity than unadjusted semolina, which negatively effected on elastic-plastic properties of pasta formation. Both semolina types mixing and drying parameters were optimized. Dough relaxation period of unadjusted semolina had greater correlation with dough mixing time (R_2 = 0.51) and dough moisture content (R_2 = 0.37), than for adjusted semolina (R_2 = 0.41) and (R_2 = 0.25), accordingly. Yellow color intensity (b*) of pasta made from adjusted or unadjusted semolina highly correlated with drying cabinet relative air humidity (R_2 = 0.88). Slightly negative correlation was observed between drying cabinet temperature (R_2 = –0.3) and yellow color intensity.

Development of healthful non-wheat breads fortified with antioxidant

Y. KIM (1), D. Shin (1), G. Lee (1)
(1) Korea University, Seoul
Cereal Foods World 54:A49

The soybean is a well-known source of phytochemicals as well as plant proteins. Besides its prominent health benefits, the soybean has desirable functional properties such as water-holding and foaming capacities, which are highly favorable for bread-making. Regular wheat bread has a high glycemic index-this has been the reason for a negative change in consumer's perception of bread. In this study, in an effort to improve the health benefits of bread, we developed a formulation for a 100% soybean bread which is both low in carbohydrates and high in protein. The soybean bread was prepared by adding 5% HPMC as an additional soluble fiber, using a modified formula for rice bread. In order to remove its beany flavor, the soybean flour was roasted for 30 min at 145°C. The quality of the dough was assessed by pH and volume, while the quality of the bread was evaluated by physical properties (loaf volume, color, water absorption, and texture) as well as by health properties (isoflavones, *in vitro* protein digestibility). The soybean bread developed in this study contained approximately 13% protein, twice that of regular bread. The incorporation of 5% of HPMC induced a decrease in loaf volume, but an increase in water absorption, and also delayed changes in the firmness of the bread over storage time. The total isoflavones of the bread prepared from the roasted flour increased after roasting as compared to that of the bread prepared using raw flour. Additionally, the IVPD of the bread did not vary with the incorporation or non-incorporation of HPMC. These results demonstrate that the development of a 100% soybean bread that is low in carbohydrates and high in protein is possible without a beany flavor, although the loaf volume of this bread is decreased slightly. We expect that such a soybean bread may eventually be introduced to consumers, and may help to fulfill their increasing demand for healthy products.

***In vitro* fermentation of high, medium, and low molecular weight β-glucan with human fecal flora**

H. KIM (1), P. J. White (1)
(1) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A49

Fermentation of undigested dietary fiber by colonic microflora provides many health benefits. Oats are an excellent source of the soluble dietary fiber, β-glucan. β-Glucan amount, structure, and molecular weight (MW) may affect the health benefits of β-glucan. The impact of β-glucan MW on viscosity and *in vitro* fermentation with human fecal flora were evaluated. Experimental oat line 'N979' (6.8% β-glucan), developed at Iowa State University, was used to yield high (6.87×10^5 g/mol), medium (3.71×10^5 g/mol), and low (1.56×10^5 g/mol) MW fractions of water-extracted β-glucan (65% β-glucan) by treating with lichenase (1,3-1,4-β-D-glucanase). Viscosity of the β-glucan solutions was measured by using a Rapid Visco Analyzer. High, medium, and low MW β-glucans were fermented by *in vitro* batch fermentation with human feces under anaerobic conditions for 24 hr. Fermentation progress was monitored by measuring pH, total gas and short-chain fatty acid (SCFA) production by GC. Viscosity of the β-glucan solutions increased greatly with greater MW ($p < 0.05$). Significant effects of high, medium, and low MW β-glucans on the formation of gas and total SCFA were observed compared to blank without substrate ($p < 0.05$). No differences occurred in pH changes and total gas production among high, medium, and low MW β-glucans, and lactulose, which was completely metabolized by colonic microflora ($p>0.05$). The lower the MW of β-glucan, the greater the SCFA production. Among the major SCFA (acetate, propionate, butyrate), more propionate tended to produce from extracted β-glucans than from lactulose. The MW of β-glucan greatly impacts solution viscosity and biological function. *In vitro* fermentation of extracted β-glucan with different MW lowered pH and produced SCFA potentially providing favorable environmental conditions for the colon. These findings will help to develop oat-based food products with desirable health benefits.

Quality improvement of the rice noodles with added semolina

B. KIM (1), J. Ahn (1), J. Park (2), G. Zu (3)
(1) Dankook University, Chonan-si, SOUTH KOREA; (2) Department of Food and Nutrition, Yongin-si, South Korea; (3) Department of Food Engineering, Cheonan-si, South Korea
Cereal Foods World 54:A49

Attempts to improve the chewy texture, the firm bite, and the resistance to overcooking of the rice noodles were made by introducing wheat semolina into rice flour. Raw mixtures were prepared by mixing 0 (control), 5, 10, 15, and 20% of semolina with wet-milled rice flour at a final moisture contents of

40% (w/w). Wheat glutens were equally added to the flour mixtures at 4% (w/w) levels along with salt (2%, w/w) to form pliable strands of the wet noodles. Textures measurements of the products were conducted using a Texture Analyzer. Extensibility of the uncooked noodles deceased by 19% while that of the cooked (boiling for 7 min) noodles increased by 44% at 10% semolina levels. In TPA tests, the cooked noodles showed positive correlations of hardness, chewiness, gumminess, and adhesiveness up to 15% of the semolina while springiness and cohesiveness have remained almost consistent. The overall decreases in Hunter colorimetric a- and increases in b values were observed as semolina increased while L values were almost unaffected. Boiling of the wet noodles for 7 min resulted in the decrease of the extractable soluble solids (°Bx) in the cooked water down to 1/3 of the control at 10% semolina while it increased afterward at 15%. In contrast, turbidity of the cooked water was almost consistent up to 10% while it increased again at 15% semolina. No significant variations in water absorptions among the weight of the cooked noodles were observed regardless of the semolina levels. Pasting of flours as measured by a Rapid Visco Analyser (RVA) resulted in a wide decrease in peak viscosity from 446.0 (control) to 371.67 RVU at 15% semolina while pasting temperature were consistent at 64.7~64.8°C. This indicates the easier mixing of the rice flours with added semolina for the preparation of wet noodle. It was finally concluded that optimum level of the semolina in the rice noodles was 10% for the best result of this research.

Impact of A- and B-type granule ratio on swelling, gelatinization, and pasting properties of hydroxypropylated wheat starch

H. KIM (1), K. C. Huber (1)
(1) University of Idaho, Moscow, ID, U.S.A.
Cereal Foods World 54:A50

The proportion of A- and B-type granules within wheat starch alters both starch composition and properties. This study investigated the influence of wheat starch A/B-type granule ratios on reactivity and modified starch properties in hydroxypropylation reactions. Waxy and normal wheat starches were fractionated into their respective A- and B-type granule populations, and the purified granule fractions were reconstituted according to defined mixing ratios (100:0, 75:25, 50:50, 25:75, 0:100). Reconstituted starches were substituted with propylene oxide (PO; 20%, dry starch weight basis) to achieve molar substitution (MS) levels comparable to 0.1; modified starch products were assessed with respect to MS, as well as swelling, gelatinization and pasting properties. Regardless of genotype, starch derivative MS values did not significantly differ across A/B-type granule ratios. Hydroxypropylation enhanced starch granule swelling capacities, and reduced gelatinization temperatures and enthalpies for all modified starch granule mixtures relative to their respective unmodified starch controls. Within a genotype, trends and differences in swelling and gelatinization properties across the various hydroxypropylated A/B-type granule mixtures followed those of their unmodified starch controls. However, the range of waxy starch pasting attribute differences (e.g., peak and breakdown viscosities) across hydroxypropylated granule mixtures increased compared to those of the unmodified starch controls. For normal starch, hydroxypropylation reduced the range of differences in trough, final and setback viscosities across modified A/B-type granule mixtures, relative to those of unmodified starch controls. Consequently, hydroxypropylation did not completely eradicate differences in intrinsic properties noted among unmodified wheat starch granule mixtures of differing A/B-type granule ratios.

Food composition database: For safety assessment of genetically modified crops as foods and feeds

K. KITTA (1), M. Ebihara (1), T. Kurashima (1), T. Iiduka (2), Y. Hirata (3), A. Hino (1), K. Isshiki (4), S. Kawamoto (1)
(1) National Food Research Institute, Tsukuba, JAPAN; (2) Japan Inspection Association of Food and Food Industry Environment, Tokyo, Japan; (3) Japan Food Research Laboratories, Tokyo, Japan; (4) Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan
Cereal Foods World 54:A50

Genetically modified (GM) crops have increasingly entered the market in recent years. The most common genetic modifications in crops confer herbicide tolerance or insect resistance to the plant, while some genetically modified plants are also anticipated to have altered nutrient composition, functionality, and medicinal properties. In Japan, 97 GM crops have been authorized and considered marketable as of Dec., 2008. However, many concerns about incoming GM crops have been expressed by consumers, and the concerns are mainly focused on the safety of GM crops intended for human consumption. While the most important factor taken into account in safety assessments is the primary effect derived from newly introduced protein, possible unintended effects of the insertion of defined DNA sequences have to be carefully examined as well. However, foods are complex mixtures of compounds characterized by wide variation in composition and nutritional values. Food constituents are significantly affected by cultivars and environmental factors, and thus it becomes very difficult to detect any potential adverse effects. A comparative approach focusing on the determination of differences between the GM food and its conventional counterpart should elicit potential safety issues and is considered the most appropriate strategy for the safety assessment of GM foods. For the efficient safety assessment of GM foods, accumulation of food composition data of conventional foods with wide variation under usual cultivation conditions using standardized validated measurement methods is indispensable. To achieve this, we developed an Internet-accessible food composition database comprising macronutrients, micronutrients, anti-nutrients, and physiologically active substances of staple crops, such as rice and soybeans. The database is accessible at http://afdb.dc.affrc.go.jp/afdb/index_e.asp.

High-selenium wheat fractions for use as enrichment ingredients

P. KRISHNAN (1), K. Woo (2), K. Glover (1), W. Berzonsky (1), H. Woodard (1), R. Fanning (1)
(1) South Dakota State University, Brookings, SD, U.S.A.; (2) MGP Ingredients, Inc., Atchison, KS
Cereal Foods World 54:A50

Renewed interest in selenium biofortified wheat has prompted research into the distribution of the element within the kernel and of processing techniques for high-Se wheat fractions. A 3-year assessment of South Dakota wheat (HRS and HRW) grown in traditional growing regions revealed a wide range of Se (0.06 -3.12 ppm) in the kernel. Predictability of Se distribution in high, medium, and low Se wheat was investigated. Speciation of selected samples showed that close to one-half of the total kernel selenium occurred as selenomethionine. Fractionation of the wheat kernel by scarification, pearling and roller milling was explored. Depending on the bran abrading technique used, 70% to 85% of the grain Se was retained in the endosperm material. Strong correlations were determined between protein and Se concentrations in each of the abraded polishings. GPS-based grid sampling of selected farms in Kennebec and Lyman Counties west of the Missiouri River yielded wheat with significantly higher grain Se (2 to 37.5 ppm). Production of wheat protein concentrates using high-selenium wheat is being explored as a means of concentrating the element in a functional ingredient. Such an ingredient will enhance the quality of weak flours while providing a natural source of grain Se. We will report on the efficacy of Se-fortified wheat protein concentrates (WPC) and wheat protein isolates (WPI) in food formulations. High-Se WPI and WPC were also enriched with phosphorylated resistant wheat starches to produce unique bioactive and food-functional ingredients. South Dakota wheat grown in selected locations shows potential for use in selenium enrichment of food.

Preparation of polypseudorotaxane gels through supramolecular self-assembling between beta-cyclodextrin and polyalkylene glycols

W. KUO (1), H. Lai (1)
(1) National Taiwan University, Taipei, Taiwan
Cereal Foods World 54:A50

Cyclodextrins (CDs) are enzymatically modified starches with a wide range of applications such as food, pharmaceutical, and chemical engineering. The serial threading of several CDs onto one linear polymer chain results in a supramolecule, polypseudorotaxane (PPR). PPR segments between individual polymer chains could further align with each other and crystallize, leading to a physically crosslinked gel. The thixotropic property found in PPR gels renders them promising to be used as injectable gels for biomedical applications. In order to obtain proper conditions for the PPR gel formation, b-CD was mixed and allowed to reacted with different polyalkylene glycols under various reaction conditions. The polymer used include PEG and Pluronic® (PPG–PEG–PPG block copolymer), where PEG and PPG refer to polyethylene glycol and polypropylene glycol, respectively. The reactions were carried out in H_2O, 30 and 60% DMSO or citric acid solutions at 25 or 65°C followed by overnight storage at 6°C. Based on the outer appearances of the products, gels were formed under the following conditions: b-CD/PEG mixtures in DMSO solutions treated at 65°C, b-CD/Pluronic® mixtures in H_2O treated at 25 or 65°C, and in citric acid solution treated at 25°C. Study of wide angle X-ray diffraction on the gels revealed that only the gels made of Pluronic® contained channel type crystalline, identifying them as PPR gels. Scanning electron microscopy, confocal laser scanning microscopy and rheological characterizations also showed respectively the presence of networks, the higher homogeneity and thixotropy of the gels made of Pluronic®, as compared to those made of PEG. Among the gels made of Pluronic®, the one made in citric acid solution at 25°C had the most homogeneous networks and fine pores, which were correlated to its relatively high gel strength and thixotropy.

Exploration of functionality of low-glycemic-impact sugars and polyols using DSC, RVA, SRC, and cookie baking

M. KWEON (1), L. Slade (2), H. Levine (2)
(1) USDA ARS, Wooster, OH, U.S.A.; (2) Food Polymer Science Consultancy, Morris Plains, NJ, U.S.A.
Cereal Foods World 54:A51

Consumers' growing interest in healthy cookies includes expectations for prebiotic nutritional benefits and low glycemic impact. The anti-plasticizing action of the high sucrose concentration in a cookie formula inhibits gluten development during dough mixing and starch gelatinization/pasting during baking. The resulting absence of readily digestible starch allows production of healthier cookies, if sugars and polyols with lower glycemic impact are used to replace sucrose. In the current study, sucrose (as a reference) and potential sucrose-replacing sugars (tagatose, ribose) and polyols (maltitol, lactitol, xylitol, polydextrose) were used to explore the effects of sugar-replacer type on DSC, RVA, SRC and wire-cut cookie baking. DSC results showed retardation of starch gelatinization, and RVA results showed retardation of the onset of starch pasting, both in the order: water< ribose< tagatose< xylitol< sucrose£maltitol< lactitol< polydextrose. SRC results showed that ribose-water SRC was the highest, which indicated the greatest swelling of solvent-accessible arabinoxylans in ribose solution. Cookie-baking results showed that wire-cut cookies formulated with xylitol, tagatose, or ribose exhibited snap-back, diagnostic of gluten development during mixing. In contrast, cookies formulated with maltitol, lactitol, or especially polydextrose showed facilitated flow and elongation in the direction of dough sheeting. Among the potential sugar-replacers, maltitol, lactitol, and polydextrose exhibited the most or sufficiently similar baking responses to sucrose, as observed by time-lapse photography during baking. Those results suggested that these prebiotic polyols could be used most satisfactorily as sucrose substitutes, to produce traditional wire-cut cookies with lower glycemic impact.

Corn mash preparation for granular starch hydrolysis for bioethanol

B. LAMSAL (1), L. Johnson (1)
(1) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A51

Starch damage is one of the key parameters in enzyme hydrolysis of cold granular starch for ethanol production. A 2^3 full-factorial study was designed to study the effect of corn mash preparation (flaking and grinding) on starch damage and granular starch hydrolysis for ethanol production following POET's BPX™ process. This process does not require cooking of corn mash, as starch degrading enzymes work on raw granular starch. Three parameters and their levels studied were: moisture content (15% and 22%), flaker gap (0.02" and 0.04"), and grinding (no grinding, and hammer mill grinding in a Fitz mill, screen #40 with 0.04" openings). About 1500 g of a single variety yellow dent #2 corn were cracked in a Witt mill at 0.1" gap for all treatments prior to flaking and milling. Control corn ground at 15% moisture with no flaking had an average particle size D (0.5) of 119.5 mm. Corn at 15% moisture when flaked at roller gaps of 0.04 and 0.02" produced flakes of D (0.5) 2.14 and 1.67 mm, respectively. Grinding of these flakes produced corn mash of D (0.5) 119 and 125 mm, respectively, which was not significant. Higher moisture content (22%) played a role in producing bigger sized flakes (2.91 mm at flaker gap of 0.04" as compared to 2.19 mm at 0.02" gap). However, corn mash particle sizes of ground flakes at higher moisture, were between 119 and 129 mm, not different from corn prepared at lower moisture. Damaged starch in ground mash was highest for drier corn (15% moisture) that was flaked through smaller roller gap. In general, ground corn mash had approximately twice (~2% as compared to 1%) the amount of damaged starch compared to flaked-only preparations. Starch digestibility, and ethanol yields are expected to follow the similar trend in cold starch hydrolysis for ethanol.

The ways of increasing safety of baked goods' components and also of functionally-technological characteristics of the complete product

A. LAZUTKIN (1), A. I. Moiseeva (1), N. M. Shlenskaya (1), A. Lazutkin (1)
(1) Moscow State University of Technology and Management, Moscow, Russia
Cereal Foods World 54:A51

Safety and functional properties of bread from wheat were improved with the help of colloidal silver in grain wetting period, discovering the optimal composition with and without using yeasts, including wholly-grinded grain and the biologically-active substance of colloidal-gel form with herbal extract into the formula. The content of mesophyllic aerobic microorganisms (KMAFAnM) at the surface of wheat grain before and after wetting is over, on an average of 50 samples, increased from $2{,}9*10^4$ to $3{,}7*10^4$, mycelial funguses from 25 to 35 KOE/g. The amount of mycelial fungus, yeast and spore-forming bacteria increased at 10–12%. Presence of silver in amount of 1000 mgr/l in growth environment resulted decreasing of grain seeding by microorganisms at 60–96%. Rheological properties of dough (that includes extra class flour, composition of wholly-grinded grain and the biologically-active substance): water absorption ability and dough stability decreased from 63,4 to 9,1–9,2% and from 16,5 to 4,0 in minutes; dough liquefaction increased from 35 to 105 E.F.; bread volume yield (cm^3/100 g of flour) and stability of shape decreased; porosity is fine, even, with no holes; crust colour is varying from brown to sunny brown. Inclusion of wholly-grinded grain and the biologically-active substance into the formula allows to increase functional properties and food value of baked goods. There were worked out standards of commodity research characteristics for the new baked goods from wholly-grinded grain and also using it in composition from yeasty and non-yeasty dough, also in compositions with the biologically-active substance.

Production of slowly digestible starch with dual enzyme treatments

B. LEE (1), B. R. Hamaker (1), S. Yoo (2)
(1) Department of Food Science, Whistler Center for Carbohydrate Research, Purdue University, West Lafayette, IN, U.S.A; (2) Department of Food Science & Technology and Carbohydrate Bioproduct Research Center, Sejong University, Seoul, Korea
Cereal Foods World 54:A51

Starch amylopectin contains α-1,4 linked linear chains of different lengths with α-1,6 branched linkages creating a range of structures with different digestion properties. Previous research showed that increased number of α-1,6 branched points and a lowering of α-1,4 chain length resulted in a slower digestion rate due to specific activities of amyloglucosidase on different structures. In this research, we modified waxy corn starch (WCS) structure using two types of enzymes, glycogen branching enzyme (GBE) for increasing α-1,6 linkages and β-amylase for decreasing α-1,4 chain length and by changing reaction sequence at optimal pH and temperature. We hypothesize that this biochemical process can be utilized to produce slowly digestible starch that have tailor-made α-(1,4)/(1,6)-linkage ratio. HPAEC and HPSEC-MALS-RI were used for analyzing structural changes of enzyme-modified starches. Enzyme-treated WCS showed different branching patterns and molecular weight depending on enzymes and sequence of enzymatic reactions. The Mw decreased from $1 \times 10^{8.5}$ to $5.0 \times 10^{5.5–6.0}$ depending on the enzyme reaction sequence. Also, branched chain length of WCS was decreased after second enzyme treatment. The digestibility of enzyme treated starches was studied using a modified *Englyst* method. Results indicate that the slow digestion and resistant starch products increased from 17% to almost 34% after enzyme treatments. GBE and β-amylase treatments produced modified WCS which has increased α-1,6 linkages points and less α-1,4 linkage. These enzyme-treated WCS's may have potential as slowly digestible starches with good functionality in processed starchy foods.

Effects of heat treatments on the milling and physicochemical properties of rough rice during storage

Y. LEE (1), Y. Wang (1)
(1) University of Arkansas, Fayetteville, AR, U.S.A.
Cereal Foods World 54:A51

The physicochemical properties of rice change during storage, which is termed aging. Some of the changes during aging such as pasting properties and texture are desirable for certain applications, but aging occurs slowly over time. This study investigated the effects of different heat treatments on 2 long-grain rice cultivars, Wells and XP723, in an attempt to accelerate rice aging. Three heat treatments, including UV irradiation, autoclaving (high moisture/high temperature), and high temperature (oven heating), with 2 or 3 conditions for each treatment and one control were included in this study. Treated rice samples were stored at ambient temperature and evaluated for head rice yield, and pasting and thermal properties every 45 days for 6 months. In general, the head rice yield of rice samples decreased slightly after the UV and high temperature treatments but increased after the autoclaving treatment. Most samples showed increased peak pasting viscosity as measured by a Rapid ViscoAnalyser after the heat treatments and during storage. The UV-treated samples reached steady peak pasting viscosity faster than other samples. Peak gelatinization temperature remained relatively unchanged after the heat treatments, except that the autoclaved samples had higher gelatinization temperatures. The gelatinization temperatures of treated samples generally decreased during storage. In conclusion, the UV irradiation seemed to be more effective in accelerating rice aging to reach stable pasting and thermal properties faster than the control and other heat treatments during storage.

Effects of salts on molecular conformation of waxy maize amylopectin in aqueous–DMSO solutions measured by light scattering detectors

J. LEE (1), S. Lim (1)
(1) Korea University, Seoul, KOREA
Cereal Foods World 54:A51

Effects of salts (0~0.2M NaCl and $CaCl_2$) on the molecular conformation of waxy maize amylopectin (WMA) in aqueous DMSO solutions (50 and 90%) were examined using multi-angle laser light scattering (MALLS) and dynamic

light scattering (DLS) detectors. The WMA had different molecular conformations and intermolecular interactions depending on the salt type and water content in DMSO. As the water content in DMSO increased, the solubility of WMA decreased (93.4~ 62.3%). The aggregated WMA molecules in 50% DMSO could not be fractionated by SEC resulting in larger values of M_w and R_g (radius of gyration) than those in 90%. From the distributions of R_h (hydrodynamic radius) in the aqueous DMSO, the amylopectin exhibited multimodal polydispersity including starch aggregates detected in 50% DMSO. Based on ρ (= R_g/R_h) value and SV_g (specific volume of gyration), the amylopectin existed in similar shapes in both 50 and 90% DMSO solutions, whereas the chain density was different. However, the presence of salts affected the chain conformation of amylopectin (ρ : 0.68~1.21) in aqueous DMSO. As salts bind water or amlylopectin depending on their ion strengths and concentrations, WMA either dissolves well or forms aggregates.

Soxtec extraction of cholesterol-lowering compounds from sorghum DDGS as influenced by temperature of the heating system

C. Leguizamon (1), C. L. WELLER (1), V. L. Schlegel (1), T. P. Carr (1)
(1) University of Nebraska, Lincoln, NE, U.S.A.
Cereal Foods World 54:A52

It is generally recognized that high plasma cholesterol levels lead to cardiovascular diseases, the number one cause of death in the U.S. in 2005. Plant sterol and policosanol compounds have been reported to have lowering-cholesterol properties. Hexane extracts from grain sorghum distillers dried grain with solubles (DDGS), a co-product of the ethanol production from sorghum, contain plant sterols and policosanols. Extraction methods and influence of operational parameters on the amount of plant sterols and policosanols extracted from sorghum DDGS need to be better understood. In this study, total lipid levels extracted from sorghum DDGS using a Soxtec method set at different heating system temperatures (80, 90, 103, 110, and 120°C) were determined. Additionally, plant sterol and policosanol composition of the lipid extracts were determined by a GC method. The amounts of lipids extracted as well as content of plant sterols and policosanols increased significantly ($p < 0.05$) as the temperature of the heating fluid increased. The temperature of the heating fluid had a significant linear effect ($p < 0.05$) on the lipid and total plant sterol yields. Total policosanol yields were also affected by the temperature of the heating fluid following a quadratic trend ($p < 0.05$).

Development of a USDA Vitamin D Data Set: Sampling and analytical issues for ready-to-eat cereals

L. E. LEMAR (1), K. Y. Patterson (1), K. M. Phillips (2), R. L. Horst (3)
(1) USDA/Nutrient Data Laboratory, Beltsville, MD, U.S.A.; (2) Virginia Tech, Blacksburg, VA, U.S.A.; (3) Heartland Assays, Inc, Ames, IA, U.S.A.
Cereal Foods World 54:A52

In September, 2009 the USDA Nutrient Data Laboratory is disseminating an expanded set of vitamin D values as part of the USDA National Nutrient Database for Standard Reference, SR22. It contains values for over 3,000 foods. This data set was developed to address the need to estimate dietary vitamin D intake, useful to an Institute of Medicine committee in its assessment, and possible revision, of the recommended intakes for vitamin D and calcium. The data release is the culmination of a multi-year project to select, process, and analyze the major sources of vitamin D in the US diet. Significant challenges to obtaining current and accurate analytical data for foods had to be resolved. Previously existing standard methods tended to be labor intensive and were developed for specific food matrices. Also, there was a lack of vitamin D certified reference materials. Probability-based sampling plans were developed for high priority fortified foods, including 12 high consumption vitamin D_3 fortified ready-to-eat (RTE) breakfast cereals. Twelve primary sample units were collected in 2006 from 12 locations nationwide and randomly assigned to one of four composite groups. Analytical samples along with blinded aliquots of a well-characterized cereal control composite (CC) are being analyzed at each of two laboratories using validated methodology (normal and reverse-phase HPLC with UV detection) after saponification and clean-up using normal and reverse phase chromatography. While the internal standard for many vitamin D determinations is vitamin D_2, one method was modified to use tritiated vitamin D_3 to allow quantification of any natural vitamin D_2 from the plant material as well as the added D_3. The careful attention to ongoing quality control and specific method development and the statistical sampling plan will result in reliable food composition data for RTE cereals.

Total anthocyanin content in blue corn cookies as affected by the various acids and oven types

J. LI (1), C. Walker (1), J. Faubion (1)
(1) Grain Science Dept., Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A52

Anthocyanins, a group of pink to purple water-soluble flavonoids, are natural occurring occurring pigments with numerous potential health benefits. However, anthocyanins are sensitive to degradation by pH, light, and temperature, etc. Blue corn is rich in anthocaynins. The majority are located in the pericarp. Its total anthocyanin content (TAC) is much higher than regular corn, wheat and other cereals grains. Citric acid, lactic acid, and GDL (glucono-delta-lactone) are weak acids commonly used in the food industry. It is not known if they can be used to lower the pH, thus increasing the TAC but maintaining final product quality. Reel, convection, and impingement ovens are commonly used in the baking industry. Difference in the operating principle of each type result in different optimum baking times and temperatures. Cookies might serve as a vehicle to deliver anti-oxidants. Each acid, significantly increased the TAC remaining either in the dough or final cookie at level of 1.5% (fwb) with minimum increase up to 6% addition. The interaction of three individual acids (1.5% fwb) with three different type of ovens at optimum baking time and temperature were tested to investigate the effect on system pH and the TAC remaining in the cookie. The largest cookie spread was obtained from the combination of citric acid and convection oven. The addition of GDL imparted larger spread in both impingement and reel ovens treatments compared to the other two acids; GDL/convection oven treatment resulted in slightly lower spread than citric acid/convection oven treatment. Cookies from impingement and convection ovens generally produced larger spread and retained more TAC than reel oven treatments due to higher heat transfer efficiency. All the acid treatment possesses the advantage of higher TAC in the cookies.

Effect of alcohol type on degradation of cellulose treated with hydrochloric acid in alcohols

J. LIN (1), Y. Chang (2), Y. Hsu (2)
(1) Department of Hospitality Management, MingDao University, Peetow 52345, TAIWAN; (2) Department of Food and Nutrition, Providence University, Shalu 43301, TAIWAN
Cereal Foods World 54:A52

Cotton cellulose was treated in alcohols (ethanol, 2-propanol and 1-butanol) containing 1.39% HCl at 65°C for 1 h to 7 days. The recovery and molecular size of acid-alcohol-treated cellulose were determined, and the effect of alcohol type on degradation of cellulose was investigated. The recovery of treated cellulose, ranging from 97.9~61.1%, decreased with increasing treatment time. The recovery of cellulose treated in 1-butanol was lower than that of cellulose treated in other alcohols for the same duration of treatment. The weight-average degree of polymerization (DP_w) of treated cellulose was lower than that of native cellulose. The DP_w of native cellulose was 2427 anhydrous glucose unit (AGU), and the DP_w of treated cellulose ranged from 1854~99 AGU. The DP_w of cellulose treated in ethanol and 2-propanol decreased with increasing treatment time within 3 days of treatment, and tended to lay-off after treated for more than 3 days. While, the DP_w of cellulose treated in 1-butanol was less than 200 AGU, and was unchanged or slightly decreased with increasing treatment time. Within 3 days of treatment, the DP_w of cellulose treated in different alcohols was in the order of ethanol > 2-propanol > 1-butanol. Results indicate that cellulose acid-treated in different alcohols showed distinct degradation extent, and that cellulose with DP_w less than 200 AGU, and higher than 90% recovery, could be prepared by acid-treated in 1-butanol for less than 1 h. This implies that the degradation of cellulose may be controllable by acid-treating in selected alcohols.

Grain Foods CRC Ltd - Australian Cooperative Grain Food Science

D. R. LIND (1)
(1) Grain Foods CRC LTD, North Ryde, NSW, AUSTRALIA
Cereal Foods World 54:A52

Grain Foods CRC Ltd is a research and commercialisation company established under the Australian Government's CRC Program. The company utilises a combination of grain genomics and application science to develop innovative grain food technologies. The scope of Grain Foods research portfolio will be described including the use of genomics to improve wheat quality output traits, biochemistry to enhance milling extraction rates and application technologies to produce new functional foods and processes. This poster will be of particular interest to those technologists keen to see strong linkages between research outcomes and market needs.

Effect of processing on pasting properties and *in vitro* bile acid binding of oat flours

Y. LIU (1), T. B. Bailey (2), P. J. White (1)
(1) Department of Food Science and Human Nutrition, Iowa State University, Ames, IA, U.S.A.; (2) Department of Statistics & Statistical Laboratory, Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A52

Beta-glucans in oats are known to reduce serum cholesterol in humans. The possible mechanism for the reduction may result from beta-glucan's ability to

increase the viscosity of intestinal contents. As a result of the increased viscosity, there is decreased re-absorption of bile acid (BA), thus increased BA excretion in the feces. Steaming and flaking, involving heat and moisture, may affect beta-glucan structure, consequently the pasting properties, and eventually the health benefits of oat-based food products. Four oat lines with high (7.1%), medium (5.8 and 4.7%), and low (3.8%) beta-glucan concentrations were evaluated for the impact of processing on pasting properties and *in vitro* BA binding of oat flours. The oats were dehulled, steamed, and rolled into flakes. Both oat groats (unflaked) and flakes were ground into flours. The viscosities of oat-flour slurries were evaluated by using a Rapid Visco Analyzer (RVA). The BA binding was measured by digesting oat flours via *in vitro* digestion with human digestion enzymes. Steaming and flaking did not affect beta-glucan concentration in oats ($P > 0.05$), but decreased final viscosity (FV) of oat-flour slurries ($P < 0.05$). These decreases might be explained by the changes of interactive effects between beta-glucan and other oat components to pasting properties. The percentage (%) of BA bound based on the total amount of BA increased after processing ($P = 0.0062$). Before processing, the beta-glucan concentration was highly correlated with FV ($r = 0.984$, $P = 0.016$) and bound BA % ($r = 0.999$, $P = 0.0013$); and FV was positively correlated with bound BA % ($r = 0.988$, $P = 0.0119$). After steaming and flaking, the beta-glucan concentration was less strongly correlated with FV ($r = 0.950$, $P = 0.0502$) and bound BA % ($r = 0.945$, $P = 0.0547$); and no linear correlation was found between FV and bound BA %. These findings will help food manufactures develop oat-based food products with enhanced health benefits.

Comparative evaluation of phytochemical profiles and identification of flavonoids in cereal grains

Q. Liu (1), Y. Qiu (2), A. Borgen (3), T. BETA (4)
(1) Department of Food Science, University of Manitoba, Winnipeg, MB, Canada R3T 2N2; (2) School of Food Science and Engineering, Nanjing University of Finance and Economics, Nanjing, Jiangsu, P. R. China, 210003; (3) Agrologica, Houvej 55, DK-9550 Mariager, Denmark; (4) University of Manitoba, Winnipeg, MB, CANADA
Cereal Foods World 54:A53

The phytochemicals including flavonoids and phenolic acids mainly contained in the outer layer of the kernels are key factors responsible for the biofunctionality of whole grains. The phytochemical profiles of twelve grain samples comprising 6 wheats, 3 barleys and 3 oats were studied for comparative evaluation of their antioxidant properties. Total phenolic content (TPC) and antioxidant activities (DPPH and ORAC) of the grain extracts were measured. The bound phenolic acids were identified and quantified using HPLC and mass spectrometry. The flavonoids in different grain were analyzed using HPLC and tandem mass spectrometric techniques. TPC in acidified methanol extracts ranged from 164 to 226, 264-391, and 308-331 mg/100 g for wheat, oats and barley, respectively. Similarly TPC in acetone extracts were 78 to 118, 223 to 351 and 367 to 433 mg/100 g. Acetone extracts had significantly ($p < 0.05$) higher TPC than acidified methanol extracts for barley samples. On the contrary, acidified methanol extracts from wheat and oats had higher TPC than their acetone extracts. The results showed that for both acetone and acidified methanol extracts, barley samples had significantly higher antioxidant activity than oats and wheat samples although even some of the oats had similar or even higher TPC compared to barley samples. Wheat extracts had low antioxidant activity assayed using both DPPH and ORAC assays. Oats had the highest levels of bound phenolic acids (431 to 656 mg/100 g) followed by wheat samples (91 to 153 mg/100 g). The bound phenolic acid contents of barley samples ranged from 81–105 mg/100 g. The major flavonoids in barley samples are dimers and trimers of proanthocyanidins, while flavone glucosides are the major flavonoids for wheat. The phytochemical including flavonoid profile may explain the antioxidant activity for different cereal grain rather than TPC.

Cardio healthy French bread: Characterization and health benefits

X. LOPEZ (1), C. Bugueño (1), R. Jeria (1), D. Piderit (1)
(1) Granotec Grupo America, Santiago, Chile
Cereal Foods World 54:A53

Now a day, due to high obesity and cardiovascular disease levels found in developed and developing countries, an increasing concern in formulating healthy and cardio-friendly food is present. In Chile, the main staple food is Marraqueta (MQ), which is a type of french bread. Owing to its high consumption levels (98 kg/hab/yr), the need to develop a low calorie, low salt and high fiber content MQ is of high priority. This product can be a very useful tool to reach the majority part of population in order to decrease one of the main cardiovascular risk factors, namely obesity and arterial hypertension. In the present research, a cardio- healthy marraqueta (CH-MQ) was developed. Since this project is aiming to improve the dietary quality of the most eaten bread in Chile, several relevant nutritional parameters has been quantified and compared to the common MQ. The proximal nutritional analysis of the CH-MQ indicate us that the CH-MQ has six times more fiber (12 gr/serving), 50% less sodium and 25% less calories that the common one. In order to assess the feasibility to introduce this product in the market, also physical features were evaluated. Specific volume and texture of the CH-MQ were slightly better than the unmodified MQ, whereby organoleptic characteristics were widely accepted among consumer. Given that one of the purposes of the CH-MQ is to achieve a bread with a reduced glycemic index (GI), relevant clinical trials were carried out. Healthy volunteers who met several criteria (age between 20 and 55, BMI<32, non smoking, non pregnant, non lactant) have been tested for glycemic index determination. Every subject, after a 12-hour overnight fast, ate one portion (80 gr) of MQ and CH-MQ, resting two days in between each bread type consumption. Pre- and postpandrial glycemia were measured every 30 minutes for 3 hours. The GI determination is made by calculating the percentage of the area under the glycemic curve of the CH-MQ in relation to the area of MQ for each individual since they act as their own control. The results indicated us that a lower GI is achieved in this high fiber content bread. In conclusion, a highly palatable bread with outstanding and proved health benefits has been developed.

Argentina, Chile, and Peru wheat Crop Report 2008/2009

X. LOPEZ (1), N. Via (1), V. Vaqueros (1)
(1) Grupo Granotec America, Santiago, Chile
Cereal Foods World 54:A53

The Grupo Granotec Amercia, altogether with other public and private entities, promotes in many countries the organization of the ICCT (Wheat Harvest Quality Reports). The objective is to count with significant data of the actual situation regarding the quality of the harvested wheats, and to contribute with concrete knowledge to every participant involved in the Wheat-Flour-Bread industry and translate it as an increment in the added value of the subproducts of this important cereal. The ICCT was implemented for the first time in Argentina during the campaign 1996/97 and it has achieved, not just to remain but also it has become stronger uninterruptedly until today. The knowledge and experience gotten are part of the current heritage with which the Granotec Grupo America has driven this practice to other countries, beginning with Chile, where this year the seventh consecutive report was published and the third for Peru. The ICCT collects sample information of each representative harvest in the wheat production, their main productive areas, and in some countries, it collects information about their cultivated varieties. All quality indicators summarized on the ICCT are performed according to international rules which are updated and accepted for every parameter. Among them: Commercial Grade, Hectolitre Weight, Proteins, Ashes, Gluten, Falling Number, Rheological indicators determined by the Consistogram and Alveogram. The report is complemented with productive data of every country and with results that emerge from studies on experimental bread making. Through the analysis performed for the ICCT, we can obtain valuable information and prediction of the flour behaviour that are going to be used by industries in the manufacture of different products.

Evaluation of rice pasta properties through new and conventional methods

M. LUCISANO (1), M. Mariotti (1), C. Cappa (1), S. Luoto (2)
(1) University of Milan, Milan, ITALY; (2) University of Helsinki, Helsinki, FINLAND
Cereal Foods World 54:A53

Quality of gluten-free pasta depends on raw materials composition and, to a greater extent, on the conditions adopted in the pasta making process aimed at forming a three-dimensional structure of gelatinized and retrograded starch. Samples of rice pasta (spaghetti) prepared following two different processes were considered in this study: sample A, obtained according to the technology adopted in the oriental countries that employs a wet-milled flour as raw material, and sample B, obtained using the conventional process used for wheat pasta production applied to a pre-gelatinized rice flour. Sample characterization included, beside chemical composition, both conventional parameters used for the evaluation of the cooking characteristics of traditional wheat pasta (cooking losses, weight increase, instrumental hardness and adhesiveness) and non-conventional approaches. In particular, bending test was used to evaluate the texture of dry sample, micro-viscoamylographic test to assess the extent of starch modification during pasta production, image analysis for monitoring geometrical changes during cooking, and creep test to evidence viscous-elastic behavior of cooked products. The different technological procedures strongly influenced gelatinization temperature (A = 82.0°C; B = 67.7°C) and the fracture properties of dry pasta (fracture force: A=1.83 N, B = 0.55 N; relative deformation at fracture: A = 2.38%, B = 0.63%). These results pointed out the different macromolecular organization between the two products that reflected upon their cooking characteristics. At their optimum cooking time (9 min for both samples), sample A presented lower cooking losses (3.2 g/100 g db vs. 5.6 g/100 g db), higher Young

Modulus (0.27 N/mm^2 vs. 0.36 N/mm^2), lower adhesiveness (0.67J*10^{-3} vs. 2.65J*10^{-3}) and a more elastic behavior.

Quality of baked products and pasta made with whole grain hulless barley flour

C. LUKIE (1), L. Malcolmson (1), T. Tweed (1)
(1) Canadian International Grains Institute, Winnipeg, MB, CANADA
Cereal Foods World 54:A54

Interest in using whole grain barley flour as a partial replacement for wheat flour has increased because of the reported health benefits associated with barley. Research has shown that barley beta-glucans can lower blood cholesterol levels and based on this evidence a heart health claim is permitted in the United States for foods containing barley. This research was undertaken to evaluate the quality of pan bread, bagels, tortillas and pasta made by partially substituting (25–50%) whole grain hulless barley flour for wheat flour. Two varieties of hulless barley were evaluated including CDC McGwire, a regular starch variety and CDC Fibar, a 100% amylopectin variety. In general, all baked products containing barley flour had higher water absorptions and required longer mixing times than the 100% wheat control samples. This was especially true for products made with CDC Fibar barley flour. For bread, product volume was similar between the CDC McGwire and the control, but the CDC Fibar bread had a much lower volume. Bagels made with barley flour had lower volumes compared to the control bagels. Crumb structure of barley substituted bread and bagels was more open compared to the control, but was still acceptable. Firmness of bread made from both barley varieties was lower than the control bread even after three days suggesting a softer crumb, possibly due to the higher moisture content. Tortillas made with barley flour were acceptable for both varieties on Day 1, but showed a decline in quality by Day 3. The addition of barley flour in pasta resulted in a product with higher cooking losses and a darker colour. Firmness of the pasta made from CDC McGwire was comparable to the control pasta, but the pasta made from CDC Fibar was softer. For most products, it was possible to achieve a high quality end-product with the required level of beta-glucans for the health claim.

An *in-vitro* method for the prediction of the glycemic index of food products

R. L. MAGALETTA (1)
(1) Kraft Foods Inc, East Hanover, NJ
Cereal Foods World 54:A54

Interest in the glycemic index (GI) of food products has significantly increased in recent years. The GI is an indicator of the relative human glycemic response to the dietary carbohydrates in a food product and allows foods to be ranked based on their effect on blood glucose levels. The GI of a food product is determined *in-vivo* by monitoring the blood glucose level of human subjects who have ingested the food product, and comparing the change in blood glucose to that induced by a reference material. Although the currently accepted gold standard, the *in-vivo* method is both costly and time-consuming, limiting its utility as a screening method for new product formulations. This presentation will describe an *in-vitro* analytical method that allows the accurate prediction of the GI of a food product. The method involves a digestion of the food product using HCl and enzymes followed by HPLC analysis of sugars and sugar alcohols. The data from the HPLC analysis is combined with the product's compositional information and then treated using an artificial neural network in order to produce a predicted value for the GI of the food product. GI values determined using this method show very high correlation with results obtained using the *in-vivo* test method. For the sample set examined, consisting of a broad variety of food types, n = 72, r^2 = 0.93 and RMSEC = 5 GI units. 20-fold cross-validation yields a cvr^2 = 0.89, indicating good predictive ability for samples outside the calibration set. The relative standard deviation of the method was found to be 6.6%. A single analyst is able to perform approximately 15 GI analyses per day using this method. Due to its rapid nature, accuracy and low cost relative to in-vivo testing, this method can be a very valuable screening tool for determining the relative effect of various food ingredients on the glycemic index of a food product.

Salt influence on the fluidity of wheat flour dough: A multi-technique study

S. P. MAK (1), S. E. Hill (2)
(1) Division of Food Sciences, University of Nottingham, UK; (2) University of Nottingham, Loughborough Leicestershire, UNITED KINGDOM
Cereal Foods World 54:A54

Food manufacturers are endeavouring to reduce sodium levels in cereal products, without loss of manufacturing efficiency and product quality. Reduction in salt levels is proving difficult as salt influences the product in many ways. It has been suggested that one of the actions of sodium chloride in wheat flour bread dough is to control the level and composition of "free liquor" in the mix. This could have an impact on the stability of gas cells and affect the rheological properties. In this study, doughs were prepared according to the Chorleywood Bread Process and contained levels of salt from 0 to 5% (flour base). The techniques of ultracentrifugation, differential scanning calorimetry (DSC) and low field time domain nuclear magnetic resonance (^{1}H NMR) were used to gain information on how salt affects the distribution of water between the phases of the dough. Improver type was found to affect the amount of liquor isolated and salt caused a linear increase of the dough liquor as measured by centrifugation. Addition of salt changed the starch gelatinisation temperature of the dough, but not the calculated freezable water. ^{1}H NMR showed a clear effect on the proton mobility of different amounts of added water to the dough. However, no effect of salt on the proton mobility was observed. This suggested that the release of liquor upon ultracentrifugation is a "drainage" phenomenon, and is not a consequence of changes in the amount of "free" water in the dough system.

Sodium nmr and measures in wheat flour doughs

S. P. MAK (1), B. MacNaughtan (1), S. E. Hill (2)
(1) Division of Food Sciences, University of Nottingham, UK; (2) University of Nottingham, Loughborough Leicestershire, UNITED KINGDOM
Cereal Foods World 54:A54

The average salt consumption in the western diet is 11 g/day with cereal products contributing about 35% of the dietary sodium intake. There is considerable drive to decrease the sodium levels in many processed foods, but a general lack of understanding of the multiple roles that sodium has in the system is limiting many manufactures' ability to process at the required standards at the lower salt levels. For example, large scale bakeries are finding it difficult to deliver further reductions of salt in breads as at lower salt levels plant waste increases due to sticky doughs, collapse of proved dough and open texture of the baked loaf. One question still not really answered is the location and behavior of sodium in systems with limited water. To monitor the mobility of the sodium ions in cereal systems a bench top Resonance Instruments Maran NMR spectrometer was fitted with the sodium probe. This was used to determine the mobility of sodium by using a simple relaxation decay method. A study using dough contained levels of salt from 0% to 5% (flour base) was conducted. Dough liquor and sediment phases were separated by ultracentrifugation and the levels of sodium associated with these fractions were also investigated. The amount of sodium in the different phases of dough was calculated using standard sodium chloride solutions. Findings showed that a large portion of the added sodium was dissolved in the aqueous phase. However, a portion of the sodium was not measurable and it is believed that this was bound to the large molecules in the sediment phase (i.e. starch and gluten). This method could be used to understand the role of salt in cereal products and thus provide strategies for its reduction.

Carotenoid pigment content in durum wheat kernels

F. A. MANTHEY (1), E. M. Elias (1)
(1) North Dakota State University, Fargo, ND, U.S.A.
Cereal Foods World 54:A54

Yellow color of pasta is primarily due to carotenoid pigments found in the endosperm of durum wheat (*Triticum turgidum* L. var. *durum*). Researchers have shown that genotype and environment affect the final carotenoid pigment content of durum wheat. Limited research has been conducted on deposition of carotenoid pigments during kernel development. An experiment was conducted to determine the effect of kernel development and location on the spike on the carotenoid pigment concentration in durum wheat kernels. Spikes were collected from durum grown in field plots established in Prosper, ND. A second experiment was conducted to determine the relationship between kernel vitreousness and carotenoid pigment concentration. Grain samples were collected from durum variety trials at Langdon and Williston, ND. Vitreous and nonvitreous kernels were separated from the same sample. Carotenoid pigment content was determined using Approved Method 14-50 (AACC International 2000). The interaction between kernel development and location on the spike was not significant for carotenoid pigment concentration per kernel. As grain development progressed from early post-anthesis to physiological maturity, kernel size and weight increased, while concentration of carotenoid pigments per kernel declined. Carotenoid pigment concentration per kernel was greater for kernels found in the middle or bottom of the spike than for kernels located at the top of the spike. Kernels from the bottom of the spike weighed more than kernels found in the middle or top of the spike. Experiment to determine the relationship between vitreousness and carotenoid pigment content found that kernel weight and carotenoid pigment concentration per kernel was greater for vitreous kernels than for nonvitreous kernels.

New approaches for semolina characterization

A. MARTI (1), G. Bottega (1), R. Caramanico (2), M. Pagani (1), K. Seetharaman (3)
(1) University of Milan, Milan, ITALY; (2) CRA-SCV, S. Angelo Lodigiano (LO) - Italy; (3) University of Guelph, Guelph, ON N1G 2W1, Canada
Cereal Foods World 54:A55

Semolina from durum wheat is considered the most suitable raw material for pasta-making. Protein quantity and quality are important factors affecting pasta properties, while the role of starch has received less attention. In this study two semolina samples (organic and conventional), different in protein and starch characteristics, were analyzed using both conventional and new approaches. Starch organization was studied by using DSC, MVA test, and X-ray diffraction. Rheological properties of dough during heating and cooling were investigated using Mixolab and Farinograph. Despite a lower protein and gluten content, the dough from organic semolina was stronger than conventional semolina. The organic semolina was characterized by a higher total starch content, with a higher pasting viscosity, larger gelatinization temperature range, and a higher ΔH value. Exposure of semolina to iodine vapour exhibited differences in the organization of the starch granules. Both the new approaches used to investigate dough behaviour under heating and cooling showed similar trends. More differences between the semolina samples appeared during the heating and cooling steps: the organic semolina showed a higher consistency than conventional semolina. These preliminary results suggest that there are differences in the starch properties between semolina that require further studies.

Measurement of total starch

B. V. MCCLEARY (1), A. Draga (1), I. Lazewska (1)
(1) Megazyme International Ireland Limited, Bray, County Wicklow, IRELAND
Cereal Foods World 54:A55

Several methods have been developed for the measurement of starch. In recent decades, enzyme based methods have been favoured. These generally involve solubilisation of starch in boiling water, hot DMSO or KOH, followed by liquifaction of the starch and subsequent hydrolysis of dextrins to D-glucose; with D-glucose measurement with the glucose oxidase/peroxidase system, or with hexokinase plus glucose 6-phosphate dehydrogenase. AACC Method 76.13 (AOAC Method 996.11), developed by Megazyme, involves hydrolysis of starch with thermostable alpha-amylase at pH 7, followed by hydrolysis of dextrins to D-glucose with amyloglucosidase (AMG) at pH 4.5. High amylose starch is pre-dissolved in hot DMSO. With the development of improved enzymes for industrial starch hydrolysis, it is now possible to obtain thermostable alpha-amylases that are stable and active at pH 5. This has allowed us to modify the starch assay procedure to allow both liquifaction and dextrinisation steps to be performed at the same pH (pH 5.0), which simplifies the assay and allows the use of inexpensive acetate buffer. The use of cold KOH and hot DMSO for the solubilisation of high amylose starches have been compared, and the incorporation of glucose mutarotase to accelerate the glucose determination step has been evaluated.

Measurementof beta-amylase and alpha-amylase in cereal flours and malt

B. V. MCCLEARY (1), I. Lazewska (1), A. Draga (1)
(1) Megazyme International Ireland Limited, Bray, County Wicklow, IRELAND
Cereal Foods World 54:A55

Most methods for the measurement of alpha-amylase and beta-amylase use ill-defined substrates. Several specific procedures have been developed for the measurement of alpha-amylase, such as those employing chromogenic and colourimetric substrates and viscometric assays. However, most assays for beta-amylase are non-specific. We have developed and supply several assay formats and substrates for alpha-amylase and beta-amylase. Of these, the only methods that employ well-defined substrates are the Ceralpha method for alpha-amylase and Betamyl method for beta-amylase. The Ceralpha method employs end-blocked p-nitrophenyl maltoheptaoside in the presence of thermostable alpha-glucosidase, and the Betamyl method employs p-nitrophenyl maltopentaose in the presence of yeast alpha-glucosidase. In recent years, p-NP-maltopentaose has become less available and expensive, so we needed to develop a new substrate and assay format for beta-amylase. In this paper, we will discuss the use of this new substrate, based on p-NP beta-maltotriose in the presence of thermostable beta-glucosidase, for the assay of beta-amylase and describe a single extraction format that can be employed to allow the measurement of both beta-amylase and alpha-amylase in malts.

Refinement of hulless barley fibre-rich fractions and their potential as functional ingredients in wheat bread

T. L. MCMILLAN (1), J. Kletke (1), N. M. Edwards (1), L. Dushnicky (1), S. Bazin (1), M. S. Izydorczyk (1)
(1) Canadian Grain Commission, Winnipeg, MB, CANADA
Cereal Foods World 54:A55

Roller milling can be used to fractionate barley into flour and a fiber-rich fraction (FRF). The FRF is highly enriched in β-glucan and therefore shows promise as a natural functional food ingredient. A waxy and high amylose (HA) hulless barley were roller milled to obtain FRFs. Further refinement (pin milling, sieving and an additional short duster passage) of the FRF was carried out to remove starch and obtain a FRF preparation enriched in β-glucan and other dietary fibre (DF) constituents. The objective of this study was to compare the composition of the original and enriched FRFs and to examine their potential as a functional ingredient in wheat bread. The additional refinement steps significantly increased the β-glucan and total DF contents of the FRF. The enriched FRF also contained higher amounts of Fe, Zn, Mg, and P. Compared to the whole grain both the original and enriched FRFs from the waxy barley contained higher amounts of vitamins B1, B2, B3 and B6 but only vitamin B3 increased with refinement. The additional refinement steps increased the brightness and reduced the particle size of the FRF as well as removed the majority of the entrapped starch granules. The potential of these FRFs as functional ingredients was assessed by baking bread using the Canadian short process (CPS). To obtain the FDA recommended dosage of 0.75 grams of β-glucan per two-slice serving it was determined, for the barley used in this study, that only 10–13% of white wheat flour needed to be replaced when the original FRF preparation was used and 6–8% when the enriched FRF was used. Bread supplemented with the enriched FRF had a loaf volume superior to that of 100% whole wheat and when compared to white flour bread the volume was reduced by only 6–8%. It was concluded that the enrichment of the FRF significantly improved the overall quality of the supplemented bread.

Rheological properties of waxy corn mutants as modified by isoamylase

M. MENDEZ-MONTEALVO (1), Y. Wang (1), M. Campbell (2)
(1) University of Arkansas, Fayetteville, AR, U.S.A.; (2) Truman State University, Kirksville, MO, U.S.A.
Cereal Foods World 54:A55

Starch swelling is a property of amylopectin, and amylose acts as a diluents. Previous works suggested that increased proportions of long B chains and longer average chain length in amylopectin may provide a stronger association of the amylopectin molecules with each other and with amylose, consequently increasing the resistance of the granule to gelatinization and swelling. The objective of this work was to correlate the changes in amylopectin structure of 2 waxy corn mutant starches (Hsyn73 wxwx and Hsyn73 duwx) with the changes in rheological and morphology properties after isoamylase treatment to various extents. Both wxwx and duwx mutants had a similar molecular weight, but wxwx had a more branched structure than duwx according to ratios of molecular weight and short chains to long chains, and z-averaged gyration radius. When subjected to isoamylase treatment, duwx was hydrolyzed to a greater extent than wxwx. All samples exhibited a shear thinning behavior with Hsyn73 wxwx having slightly higher values of pasting viscosity, flow behavior index and consistency index than Hsyn73 duwx. Significant decreases in molecular weight, z-averaged gyration radius, pasting viscosity, flow behavior index and consistency index were observed for both wxwx and duwx as debranching treatment progressed. The results suggest that z-averaged gyration radius may play a more important role in determining the rheological properties of waxy corn starch.

Gluten-free frozen doughs: Influence of freezing on proteins, dough properties and bread quality

S. Mezaize (1), S. Chevallier (1), C. Guyon (1), A. LE BAIL (1), M. de-Lamballerie (1)
(1) ENITIAA - Univ UNAM - UMR GEPEA CNRS 6144-Nantes-FRANCE
Cereal Foods World 54:A55

The freezing process at different steps of breadmaking is widely used to improve fresh bread availability for the consumer. The consequences of a freezing step on wheat dough and bread, and the way to reduce its negative impacts have been well studied for years. Nevertheless, few works report studies on gluten-free doughs and breads. This work investigates the effect of unfermented frozen process on the properties of gluten-free dough and the quality of the final product by comparison with conventional process. Gluten-free formulation contained rice, corn and buckwheat flours, corn and potato starches, guar gum, inulin, yeast, salt, oil and water. The bread quality parameters measured were specific volume, dry matter on bread, crust colour and crumb texture. The texture was characterized by the maximum force of a compression test and the distribution of gas cells in crumb. Rheological tests (frequency sweep and flow tests) were carried out on fresh (without freezing step) and thawed doughs. Proteins were extracted in solution of isopropanol / acetic acid at 0.3% (70/30, v/v) from the doughs and separated by RP-HPLC in a gradient of water / ACN with acetic acid (0.3%). Gluten-free breads obtained by unfermented frozen process had lower specific volume and harder crumb than conventional breads. Distribution of gas cells was more homogeneous and cells mean diameter was smaller with a freezing step. Other

bread quality parameters were not modified. Rheological tests showed likewise that viscoelastic properties were unchanged for fresh and thawed doughs. However, chromatograms showed different protein profiles, giving clues that could explain the differences of bread quality.

Resin embedding of whole groats for rapid evaluation of β-glucan distribution in oats

S. MILLER (1), B. G. Rossnagel (2)
(1) Agriculture & Agri-Food Canada, Ottawa, ON, CANADA; (2) University of Saskatchewan, College of Agriculture & Bioresources, Crop Development Centre, Saskatoon, SK, Canada
Cereal Foods World 54:A56

Mixed linkage (1-3),(1-4)-β-D-glucan, or β-glucan, is the soluble fibre component that is primarily responsible for the beneficial effects of oat consumption on carbohydrate and lipid metabolism. These health benefits have generated a demand for new varieties of oats with high β-glucan. Distribution of β-glucan within the groat and among varieties is not uniform. Such variation has implications for the end use of specific varieties, whether for the production of oat bran, or incorporation into products as whole groats. Thus, knowledge of β-glucan distribution in different varieties would be useful to breeders and processors. Traditional methods of embedding and sectioning to examine β-glucan distribution are time consuming, and permit only a limited number of grains to be examined. Availability of a rapid method to evaluate β-glucan distribution in a more representative population of oats would be valuable to both breeders and processors. Previously, Miller and Fulcher* embedded whole groats in resin blocks, which were cut by abrasion to expose grain cross sections, and β-glucan distribution was revealed using fluorescence microspectroscopy. In this poster, we demonstrate use of the whole groat block method in comparison with sections obtained using conventional fixation/ embedding/sectioning protocols to reveal β-glucan distribution in 7 varieties of oats using fluorescence microscopy. *Miller, S.S., and Fulcher, R.G. 1994. Cereal Chem. 71: 64-68.

Phase/state behavior of wheat kernels in relation to their milling performance

C. MILLER (1), J. Gwirtz (1), T. Pearson (2), H. Dogan (1)
(1) Kansas State University, Manhattan, KS, U.S.A.; (2) USDA-ARS GMPRC, Manhattan, KS, U.S.A.
Cereal Foods World 54:A56

The suitability of wheat grains for milling varies widely depending on a number of factors such as kernel morphology, endosperm texture and composition. Thermal and mechanical properties of grains can provide guides for processing and utilization of cereals including their milling behavior. The aim of this study was to develop phase/state diagrams for hard red spring (HRS) and soft white (SW) wheat and to understand the effect of tempering on the mechanical properties of wheat kernels in relation to their fracture behavior during milling. Wheat kernels and their components (bran, germ and endosperm) were equilibrated to Aw levels of 0.12, 0.28, 0.43, 0.64, 0.84 and 0.93 by placing them in desiccators over supersaturated salt solutions. Glass transition temperature (Tg) of equilibrated samples were determined using a differential scanning calorimeter (DSC). Scans were done between –20°C and 120°C at a heating rate of 5°C/min. State diagrams were developed by plotting Tgs against corresponding moisture contents which were used to determine state of each component prior to milling. Mechanical properties of wheat kernels were determined to quantify fracture stress (measure of hardness), elongation at fracture (measure of brittleness), modulus (measure of elasticity), fracture energy (measure of toughness) as a function of water activity. Stress-strain profiles obtained during uniaxial compression were compared with the SKCS crush profiles. Equilibrated (tempered) kernels were milled on the laboratory roll stand and sieve analysis was performed. Kernels at different Aw levels showed different modes of failure (i.e. fragile or ductile failure) leading to distinctly different disintegration behavior during milling. Depending on the failure mode, the spread of cracks in the endosperm observed to take place at substantially different rates that resulted in the formation of particles of different size and shape.

Utilization of a by-product from soybean processing for the cultivation of probiotic *Lactococcus lactis*

D. MITRA (1), A. L. Pometto (2), S. K. Khanal (3), J. V. Leeuwen (1)
(1) Iowa State University, Ames, IA, U.S.A.; (2) Clemson University, Clemson, SC, U.S.A.; (3) University of Hawaii, Manoa, Honolulu, HI, U.S.A.
Cereal Foods World 54:A56

Since most probiotic cultures are nutritionally fastidious, there is need to find suitable cheaper substrates for their cultivation and use in food and feed. In our study we have explored the potential of a food processing by-product for its ability to support lactococcal growth. Soy whey, a by-product stream generated during soy protein production is nutritionally rich but neglected substrate. Our research has shown that the probiotic culture *Lactococcus lactis* subsp. *lactis* could be cultivated with relative ease on soy whey. Lactic acid bacteria are known to be efficient probiotic cultures due to bacteriocin synthesis capacity. Nisin, the only FDA approved bacteriocin for use in foods was produced by *L. lactis* grown in soy whey. Lab tests indicated that lactococcal biomass levels of 2180 mg/L and nisin concentrations of 620 mg/L could be obtained from soy whey. The cell yields from soy whey were found to be higher than those from a complex synthetic medium, MRS. Through our research we envision to make a unique feed additive based on beneficial nisin producing lactic acid bacteria. This will improve the feed conversion for good weight gain in animals raised for dairy and meat production and also promote industrial waste recycling and value adding.

Evaluation of rheological and technological behavior of triticale flour, obtained from Embrapa's cultivars and their mixtures with wheat flour

F. M. MONTENEGRO (1), L. P. Dias (2), C. R. Gomes-Ruffi (1), A. Nascimento Junior (3), E. H. Nabeshima (1)
(1) ITAL - Institute of Food Technology, Campinas, SP, BRAZIL; (2) Faculty of Food Engineering - UNICAMP, Campinas, São Paulo, Brazil; (3) National Wheat Research Center - EMBRAPA, Passo Fundo, RS, Brazil
Cereal Foods World 54:A56

Triticale (hybrid of wheat and rye), in many cultivars, presents bigger and better nutritional quality and better environmental flexibility than other cereals, even when compared with wheat. Its flour, which can be partially replaced by wheat flour in bakery products, may reduce the demand for wheat by importers countries, reducing costs with importation. The objective of this study was evaluate the rheological and physico-chemical characteristics and technological performance of triticale flour and its mixtures with wheat flour in pan bread and pound cakes, obtained from cultivars Embrapa 53 and BRS Ulysses, both of Brazilian Agricultural Research Corporation - EMBRAPA. The Embrapa 53 cultivar's physico-chemical and rheological profile, obtained the best results when compared with BRS Ulysses, and we can detach the performance of 70% of wheat flour and 30% of triticale flour of this cultivar, that showed little changes when compared with pure wheat flour. Mixtures of 70% of wheat flour and 30% of triticale flour of both studied cultivars were applied in pan bread and pound cake. The results of the instrumental texture for pan breads and pound cakes, accompanied analytically over 21 and 30 days, respectively, confirmed the best physico-chemical and rheological performing of Embrapa 53 cultivar, when mixed with the wheat flour in the proportion above, resulting in pan bread and pound cakes with good internal characteristics and softer when compared with the standard (100% wheat flour). In a sensory evaluation, there were no significant difference (level of 5%) of the two cultivars samples when compared with the standards pan bread and pound cake.

Effect of nixtamalization and extrusion process on phenolic content and antioxidant activity of pigmented Mexican maize

S. MORA-ROCHIN (1), C. Reyes-Moreno (2), S. Serna-Saldivar (3), J. Gutierrez-Uribe (3), J. Milan-Carrillo (2)
(1) saraidmr_21@hotmail.com; (2) Universidad Autonoma de Sinaloa, Culiacan, Sinaloa, MEXICO; (3) Instituto Tecnologico Monterrey
Cereal Foods World 54:A56

Total phenolic content and their antioxidant activity in four pigmented Mexican maize phenotypes processed by nixtamalization and extrusion were studied. Total phenolic contents in raw pigmented maize ranged 133.0 to 173.8 mg of gallic acid equiv/100 g of dry wt. Among types of pigmented maize, the highest concentrations of total phenolics were observed in the white followed by red, blue and yellow counterpart. The nixtamalization and extrusion processes significantly ($p < 0.05$) reduced the total phenolics and antioxidant activities when compared to raw maize. The highest concentrations of total phenolic were observed in extruded pigmented maize flour (124.0 to 162.0 mg of gallic acid equiv/100 g of dry wt). The extruded yellow and red maize flour contained the biggest amount of antioxidant capacity.

Effects of parboiling conditions on the slowly digestible and resistant starch fractions in parboiled rice

J. NEWTON (1), Y. Wang (1)
(1) University of Arkansas, Fayetteville, AR, U.S.A.
Cereal Foods World 54:A56

Parboiling is a hydrothermal treatment applied to raw paddy rice, which involves soaking, steaming, and drying. It is known that parboiling treatment improves rice milling yield, nutritional profile and texture. Recent studies show that both cooking methods and rice cultivars influenced the amounts of rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS) in processed rice. This study investigated the effects of parboiling conditions on the RDS, SDS, and RS contents in parboiled rice. Rice was soaked (rough rice or brown rice at 65 degree C for 16 hrs or 90 min, respectively), steamed under pressure at 121 degree C for 20 or 40 min, dried

immediately at 50 degree C or stored at room temperature for 24 hr prior to drying, and then further processed into milled or brown rice. The longer parboiling duration was found to increase both SDS and RS contents in all treatments. Room temperature storage prior to drying increased SDS content, but there was no difference in SDS content for parboiled rice subjected to different parboiling durations. When steamed rice was dried immediately after cooking, the resultant milled rice consisted of a higher RS content but a lower SDS content than the resultant brown rice. When steamed rice was stored at room temperature for 24 hr after cooking, the resultant milled rice consisted of a significantly higher SDS content than the resultant brown rice. The results demonstrate that parboiling conditions have a significant impact on the SDS and RS contents of parboiled rice. Parboiled rice with different SDS and RS contents can be produced by varying the parboiling conditions.

The effect of Teff consumption on satiety and adult body composition

S. K. Ng (1), E. Derbyshire (1), V. STOJCESKA (1)
(1) The Manchester Metropolitan University, Manchester, United Kingdom
Cereal Foods World 54:A57

Teff (*Eragrostis tef*) is a cereal grain traditionally grown in Africa. It has a low glycaemic index and is relatively high in dietary fibre and calcium; both of which have been reported to help regulate body weight and composition. The aim of the present study was to investigate whether regular Teff consumption influenced satiety, or body composition. Nineteen, healthy females (mean age: 29 yrs and weight: 61 kg) took part in a 4-week intervention study. Students were recruited from Manchester Metropolitan University and randomly allocated to a control or intervention group (matched for age and body weight). The intervention group consumed three (50 g) slices of Teff bread daily for 4-weeks. The control group resumed their normal daily diet. Participants completed a 4-day food diary and Satiety Labelled Intensity Magnitude (SLIMS) scale during the 4-week study period. Body composition was measured using Air-displacement plethysmography (Bod Pod) at the start and end of the study. Mean percentage body fat reduced by 0.53% in the control group, compared with 1.10% in the intervention group but not to a level that was statistically significant (P = 0.37). Satiety scores were, however, statistically significantly higher in those consuming the Teff bread (28.7 and 47.7 in the control and intervention groups respectively; P = 0.026). The findings from this study indicate that daily consumption of Teff bread may promote satiety but do not appear to influence body composition. Further research is now needed to reinforce these preliminary findings.

Effect of protein molecular weight distribution on kernel and baking characteristics and intra-varietal variation in hard spring wheats

J. OHM (1), F. E. Dowell (2), G. Hareland (3), S. Senay (4), B. W. Seabourn (2), E. Maghirang (2)
(1) USDA ARS RRVARC NCSL, Fargo, ND; (2) USDA-ARS, GMPRC Manhattan, KS, U.S.A.; (3) USDA-ARS-RRVARC-NCSL Cereal Crops Research Unit, Wheat Quality, Fargo, ND, U.S.A.; (4) Dept. of Plant Sciences, North Dakota State University, Fargo, ND, U.S.A.
Cereal Foods World 54:A57

Specific wheat protein fractions are known to have distinct associations with wheat quality traits. Research was conducted on 10 hard spring wheat cultivars grown at two North Dakota locations to identify protein fractions that affected wheat kernel characteristics and breadmaking quality. SDS extractable and unextractable proteins were isolated from wheat kernels and separated by size exclusion HPLC. Individual absorbance areas (AA) at 0.01 min retention time were correlated with quality characteristics. Wheat kernel hardness index and percent vitreous kernel content were significantly correlated ($P < 0.05$) with AA values of protein fractions eluted at the front section of the main gliadin peak of extractable proteins, indicating that variations in gliadin composition were related to kernel hardness and vitreousness. Percent vitreous kernel content was significantly ($P < 0.05$) and positively correlated with AA values of high molecular weight polymeric fractions of unextractable proteins, which were also significantly correlated with farinograph and breadmaking characteristics. In a corresponding experiment, wheat kernels were separated into three fractions according to protein content using a Single Kernel NIR Sorter (Perten Instruments, Stockholm, Sweden). The individual kernel fractions were then analyzed for molecular weight distribution of proteins to evaluate uniformity of protein composition within a cultivar. Results indicated that high molecular weight polymeric and monomeric gliadin protein fractions showed greater quantitative variations than other protein fractions among kernel fractions. Intra-varietal variation of protein composition was not observed to differ among cultivars. Analysis of variance indicated that interaction effects of variety by kernel fraction was not significant ($P > 0.05$) for AA values of protein fractions in this sample set.

Effect of bisulfite on color properties of 3-deoxyanthocyanins at different pH levels

L. O. OJWANG (1), J. M. Awika (1)
(1) Texas A&M University, Cereal Quality Laboratory, College Station, TX, U.S.A.
Cereal Foods World 54:A57

3-Deoxyanthocyanins are a rare class of flavonoids found in sorghum. Their greater stability to color degradation compared to anthocyanins enhances their potential use in low acid foods. The color stability of 3-deoxyanthocyanin pigments (apigeninidin, luteolinidin, and their mono- and di- methoxylated derivatives) and crude black sorghum extracts were investigated in the presence and absence of SO_2, at different pH levels for 21 days at 27°C using a UV-Vis spectrophotometer. All pigments had better color stability in the absence of SO_2 at pH 3.2 compared to pH 2.0 and 5.0. In the presence of SO_2, all the pigments were completely bleached at all pH levels on day 0, but most regained their color after 21 days. At pH 2.0, 3-deoxyanthocyanin samples regained most of their color ($\geq$ 90% absorbance, relative to control) in the presence of SO_2; while they restored $\leq$ 60% and $\leq$ 74% of their color at pH 3.2 and 5.0, respectively, after 21 days. Non- and mono- methoxylated analogs had better color restoration at pH 2.0 and 5.0 in the presence of SO_2 after 21 days. This could be due to nucleophilic interactions between the pigment molecules and SO_2 that cause gradual structural modifications. Sorghum extracts lost only 65, 63 and 51% of their color on day 0 in the presence of SO_2, at pH 2.0, 3.2 and 5.0, respectively. However, after 21 days, sorghum extracts were more resistant to SO_2 bleaching, suggesting that unknown compounds enhanced color stability.

Effects of ascorbic acid on the formation of specks in wheat flour products

H. OKUSU (1)
(1) Nippon Flour Mills Co Ltd, Kanagawa, JAPAN
Cereal Foods World 54:A57

Ascorbic acid (AsA) is a widely used antioxidant in the food industry. The formation of specks in products made from wheat flour is mainly due to the enzyme-induced oxidation. In this study, AsA was evaluated for its effectiveness in reducing the specks in selected flour products. It was found that the addition of 0.5 - 1.0% of AsA can reduce the specks in the side of pancakes by 90% as measured 5 days after baking. The specks on the crêpe (very thin pancake) were reduced by 98% during two days of refrigeration after baking. The specks on the Udon (white salt noodles) were reduced by 50% after two days of storage at room temperature. The redness of dough, however, was increased with the incorporation of AsA. To reduce the redness of the dough, polyphosphates were added to the dough. The level of 0.1% was sufficient to correct the redness of dough and 1% or more of polyphosphates will soften the dough significantly. Results of this study demonstrated that the combination of AsA and the polyphosphate could reduce the specks not only in refrigerated baked products but also in noodles.

Effect of cyclodextrin glycosyltransferase (CGTase) on wheat bread staling

D. S. OLIVEIRA (1), T. S. Rocha (2), J. T. Romero (2), R. da Silva (2), C. M. Franco (2)
(1) Universidade Estadual Paulista, São José do Rio Preto, BRAZIL; (2) UNESP-University of Sao Paulo State, Sao Jose do Rio Preto, SP, Brazil
Cereal Foods World 54:A57

Bread staling occurs during storage, especially via water migration and the transformations that occur in starch during this period. Various negative effects such as crust hardening, higher firmness and lower elasticity of the crumb, moisture and aroma loss are observed. The aim of this research was to investigate the effect of cyclodextrin glycosyltransferase (CGTase) produced by *Bacillus clausii* E-16 on the bread's staling process. For this, control breads and breads with addition of the enzyme (15U and 30U of CGTase per 100 grams of wheat flour) were stored in polyethylene bags and maintained at 4°C for 10 days. Moisture, firmness and amylopectin retrogradation were analyzed by an infrared moisture analyzer, a texture analyzer, and a differential scanning calorimeter, respectively. Crumb moisture loss of the control and treated breads was more intense during the first five days. At the end of 10 days of storage the crumb of the bread with addition of 30U of CGTase contained 33.3% moisture while the control contained 32.2%. Bread crumb firmness was reduced 13.6% and 20% compared to the control by addition of 15U and 30U of CGTase, respectively. Regarding amylopectin retrogradation, the bread with 30U of CGTase had the lowest retrogradation enthalpy, followed by the bread with 15U of CGTase, and then by the control bread. The results obtained from the thermal analyses are correlated with those obtained for crumb firmness. Addition of (CGTase) reduced the staling rate of wheat breads, thus demonstrating the utility of this enzyme for increasing shelf life. Financial support: Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP.

Development of gluten-free cakes

M. B. Omary (1), T. GOTOH (1), O. Zawadi (1), K. Rosentrater (2), J. Brown (1), A. Razavi (1), K. Prado (1), C. Brenner (1), W. Dong (1), T. Faltens (1)
(1) Cal Poly Pomona University, Pomona, CA, U.S.A.; (2) United States Department of Agriculture, Agricultural Research Service, North Central Agricultural Research Laboratory, Brookings, SD, U.S.A.
Cereal Foods World 54:A58

Celiac (coeliac) disease, also known as celiac sprue and gluten–sensitive enteropathy, is one of the most frequent food intolerances in the world. It is an autoimmune disorder prevalent in 1:133 of the US population and 1:266 of the population worldwide. Celiac disease is characterized by the inflammation of the upper small intestine. When exposed to gluten, *villi*, tiny hair-like projections in the small intestine are damaged, leading to mal-absorption of essential nutrients such as iron, folic acid, calcium, and fat-soluble vitamins. Currently, the only treatment available for celiac disease is to adopt a gluten-free diet. Gluten is a complex composed of the proteins glutenin and gliadin, and can be found in wheat, barley, rye, triticale and possibly oat cereals. The immune response may actually be focused on a limited portion of the gliadin region. When hydrated and mixed or kneaded, gluten forms strands that facilitate texture development and provide structure to baked goods. Most previous research on gluten-free baked products has focused on breads. However, the development of other high-quality gluten-free baked goods with sensory and textural properties similar to those baked goods containing gluten remains a challenge. The goals of this study were to determine the consumer acceptance, and physical and chemical properties including texture, weight, volume and water activity of cakes formulated with soy flour and corn starch using standard laboratory methods. A response surface methodology was used to assist with formula optimization and data analysis. Preliminary results from this study will be presented. The data generated during this study will be useful to the gluten-free baked goods industry.

Low temperature low relative humidity drying of rough rice

G. O. ONDIER (1)
(1) University of Arkansas, Fayetteville, AR, U.S.A.
Cereal Foods World 54:A58

With the increase in harvesting capacity by rice farmers, coupled by the increase in drying costs, the rice industry must find more efficient and economical ways of drying rough rice without adversely affecting product quality. The potential of using air at low temperature (26–34°C) and low relative humidity (RH) (19 – 68%) to dry rough rice was investigated. Drying rates and durations of four rice cultivars were measured. Head rice yield (HRY) and color were used as indicators to determine the effects on product quality. Changes in RH were found to have greater influence on drying rates and durations at 26°C than at 30 and 34°C. Head rice yields and color of the dried samples were not significantly different from those of control samples. High peak and final viscosities were found for all the drying conditions.

Effect of spray drying conditions on the resistant starch content of unripe banana (*Musa* sp.) flour

R. S. ORMENESE (1), A. P. Biazzi (1), V. N. Silva (1), L. Armiliato (1), C. S. Almeida (1), A. A. Vitali (1), F. Collares-Queiroz (2)
(1) Instituto de Tecnologia de Alimentos, Campinas, BRAZIL; (2) Faculdade de Engenharia Química – FEQ/UNICAMP, Campinas, SP, Brasil
Cereal Foods World 54:A58

The pulp of unripe banana is rich in resistant starch (RS), which behaves in the body such as fiber. Brazil is one of the world largest producers of bananas; however, the loss of the fruit in the post-harvest phase is high. This project aimed to assess the technological feasibility of obtaining unripe banana flour in spray dryer. After peeled and treated with antioxidant agents, unripe bananas from cultivar *Nanicão Jangada* (RS between 55.6 and 65.0%) were crushed in blender with water in the proportion of 1:1½ (banana/water). The pulp was passed through a brush finisher and dried in the Mobile Minor Spray Dryer. The evaluation of process parameters was performed according to a 2^3 complete factorial design, with 18 experiments. The independent variables were the temperature of the drying air (from 140 to 180°C), the air pressure (from 4.0 to 5.6 kgf/cm^2) and the rotation of the feeding pump (from 11 to 17 rpm). The variables were the moisture and the resistant starch contents, the water activity and instrumental color. ANOVA indicated low percentages of explained variation and calculated F values were not significant, indicating that there was not a good fit of experimental values to the models. The low variability of responses indicates that the range of study used in the experimental design did not significantly change the variables. All the flours processed in spray dryer presented high levels of resistant starch (32.3 to 49.4%), indicating that this kind of process preserves the functional characteristics of unripe banana starch, possibly because of the low gelatinization rate. All treatments resulted in flours with moisture content (7.57 to 12.58%) and water activity (0.282 to 0.566) suitable for a farinaceous product storage, with clear color (L* between 74.3 and 80. 2) and with low intense red and yellow tones (a* between 3.7 and 6.9; b* between 14.1 and 17.9).

The effect of using Doum fruit on lipid profile in experimental rats and its effect on quality characteristics of some bakery products

N. A. OWISS (1)
(1) Helwan University, Cairo, EGYPT
Cereal Foods World 54:A58

Egyptian consumers may consume types of food despite the insufficient information about its chemicals composition or its beneficial effects against some diseases. Therefore, the present investigation was under taken to determine the beneficial effect of doum (D) (Hyphene thebaica) on lipid profile in rats and its effect on characteristics (objective and sensory) of some bakery products (BP). The study was divided into 2 parts: The 1st part was the biological study: carried on 30 male Sprague Dawly strain rats (weight 110 ± 10 g). Rats were divided into 5 groups 6/group; 3 of them fed on different % of (D) (5, 10 and 15%) for 4 weeks. After this period blood samples were collected for determination of lipid profile and liver function. The 2nd part of the study included the preparation of some (BP). Doum flour (DF) was used to fortify 2 types of the (BP) [chocolate cake (CC) and Anise biscuits (AB)] with different % (5, 10, and 15% of (DF) weight). Fortified products (FP) were subjected to different objective measurements. Sensory evaluation was carried on by panelist using score sheet. The biological results showed significant decrease (SD) ($P < 0.05$) in blood (cholesterol, TG, LDL, VLDL, AI I, AI II) of the groups fed on 10 and 15% (D). The results of objective characteristics of (FP) showed that (CC) with 15% of (DF) maintained significantly higher ($P < 0.05$) height, volume and index to volume as compared to (UF) product. Sensory evaluation results of (CC) indicated that, there was significant decrease in the score given for product fortified with 10% and 15%). It can be concluded that feeding diet contained (10 and 15%) (DF) had greater effects on rats' lipid parameters. However, products fortified with 5% (DF) maintained better characteristics. Flavor enhancers can be added to improved product odor and overall quality. Further study should be carried on to confirm the health benefits of doum over along period of consumption.

Carotenoids of biological importance in Brazilian corn cultivars

M. D. PAES (1), P. O. Guimarães (1), R. E. Schaffert (1)
(1) EMBRAPA Maize and Sorghum, Sete Lagoas, MG, BRAZIL
Cereal Foods World 54:A58

This present study aimed at characterize maize commercial cultivars produced in Brazil for carotenoids profile. Selected Brazilian maize hybrids and open pollinated varieties were selected based on both color of kernels and agronomic performance. The material was planted and harvested under controlled conditions and resulting samples were analyzed for total carotenoids, xanthophyls and carotenes using both spectrophotometric and chromatographic methods. Significant differences were found in carotenoids profiles among maize cultivars within each group (hybrids and OPVs) but not among groups. Total carotenoids in the Brazilian maize cultivars averaged 19.8 µg/g dwb and varied from 13.4 to 24.2 µg/g dwb. Zeaxanthin and lutein were identified as major carotenoids in maize. Total pro-vitamin A carotenoids content was found to be similar among commercial maize hybrids and averaged 4 µg/g dwb. However, the overall mean for total carotenes was significantly higher in the hybrids (4.2 µg/g) compared to OPVs (2.8 µg/g). Correlation coefficients were obtained for carotenoids profile data of all samples analyzed for carotenoids. Total carotenoids content was highly correlated to xanthophylls (0.906) and also to beta-cryptoxanthin (0.645) and carotenes (0.637), but carotenes were not well correlated to xanthophylls (0.314). Therefore, selection for high pro-vitamin A maize genetic resources cannot be based only on either total carotenoids or xanthophylls contents.

Characteristics of cous cous samples prepared with different semolina and processing parameters

M. PAGANI (1), G. Bottega (1), M. Mariotti (1), R. Caramanico (1), M. Lucisano (1), A. Marti (1)
(1) University of Milan, Milan, ITALY
Cereal Foods World 54:A58

The cous cous, one the most famous dishes of the Arabian cooking, is prepared by a long mixing of semolina and water in order to obtain agglomerates of 1–2 mm size. The artisan process requires considerable preparation time for its cooking, consisting of hydration and steam treatments. In the current industrial process, the pre-cooking of the agglomerates with a steam treatment allows to reduce the domestic cooking time to few minutes. The main disadvantage of the industrial process is related to a shorter shelf-life of the product as a consequence of rancidity development during shelf-life. The role of semolina particle size (3 granulations) and drying conditions on several characteristics of the pre-cooked products have been investigated. All samples dried with the low temperature (LT) diagram were more susceptible to rancidity than the corresponding high temperature (HT) dried

products, as exhibited by their peroxide value after only three months of storage. Moreover, cous cous dried with the HT diagram showed a denser structure and a lower water absorptions during cooking, especially in the case of the product prepared from coarse semolina. These results could be related to the macromolecular structures of starch induced by the process conditions, as highlighted by viscoamylographic parameters and susceptibility to α-amylase hydrolysis.

Grain hardness and fracture mechanics in wheat using the Brabender Hardness Analyser

J. PANOZZO (1), C. Walker (1)
(1) Department of Primary Industries, Horsham, Victoria, AUSTRALIA
Cereal Foods World 54:A59

Grain hardness in wheat can have a significant impact on the quality characteristics and can affect the rate of water uptake during tempering, milling and the resulting impact on starch granules and subsequent effects on water absorption, rheology and baking. There have been numerous methods published for characterizing wheat as either hard or soft and in the past decade the genetic basis for wheat hardness is beginning to be better understood using mapping populations. In this study the authors have evaluated the Brabender Hardness Analyser and compared the results to established methods such as the sieving method, the single kernel characterisation system. The results indicate that the Brabender Hardness Tester can accurately characterise wheat based on its endosperm hardness and in addition developments in the Brabender Hardness tester when coupled to the Farinograph-E have yielded additional information showing the fraction mechanics that occur during grinding which can be used when phenotyping mapping populations for grain hardness and other quality traits.

Recovering fractions of corn enriched in recombinant proteins

I. PARAMAN (1), N. Vignaux (1), L. Moeller (1), S. Fox (1), K. Wang (1), C. E. Glatz (1), L. A. Johnson (1)
(1) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A59

Pharmaceutical and industrial proteins are being produced in transgenic corn grains and are often expressed tissue-specific in germ or endosperm. The grain can be fractionated by dry- or wet-processes as a means of recovering fractions enriched in recombinant proteins. We have developed a simple dry-milling process that will separate corn into germ-, endosperm-, and bran-rich fractions, and typically recovers 70% of the germ in 20–25% of the corn mass. When applying our dry-milling process using grain containing recombinant dog gastric lipase recovered 89% of the total enzyme in an endosperm-rich fraction with the removal of 73% of the total germ. Separating the germ prior to extracting r-protein is beneficial to downstream processing otherwise oil and water-soluble germ proteins complicate r-protein purification. Wet milling is another approach capable of separating corn into starch, protein, fiber, oil, and water solubles. Grains containing collagen targeted for the germ or LTB protein (B subunit of E. coli heat labile enterotoxin, a subunit vaccine) targeted for the endosperm were wet-milled and about 65% of total r-collagen and 72% of total r-LTB were recovered in the germ-fiber- or fiber-rich fractions, respectively, representing 18–22% of the kernel mass. The starch was free of r-protein, which can be utilized to produce non-food bioproducts and biofuels. The quick-germ process is a wet-separation process designed to recover germ in dry-grind ethanol plants. We were able to recover β-glucuronidase or collagen-related r-proteins expressed in germ after modifying the process. About 85% of the total β-glucuronidase activity and 63% of the r-collagen were recovered in 8–10% of the corn mass. Selecting proper grain fractionation methods enhance the economics of recovering r-proteins by enriching r-proteins in a small fraction of grain to be extracted and enable better use of non-protein by-products.

Mobility as a key in sugar-snap cookie dough setting

B. PAREYT (1), J. A. Delcour (1)
(1) Laboratory of Food Chemistry and Biochemistry and Leuven Food Science and Nutrition Research Centre (LFoRCe), Katholieke Universiteit Leuven
Cereal Foods World 54:A59

Sucrose, the main sugar used in cookie making, delivers sweetness and influences the texture of the final product. It raises the starch gelatinisation temperature and impacts the dough liquor phase so that the gluten is not developed because of improper hydration. There currently is no agreement in literature how gluten behaves during sugar-snap cookie baking, and how its behaviour is influenced by sucrose levels. We here studied the impact of different sucrose levels on cookie dimensions and related this to the gluten cross-linking during sugar-snap cookie baking. Determination of the sodium dodecyl sulfate extractable protein levels with size-exclusion HPLC during baking showed an initial lag phase followed by an exponential decrease. This decrease occurred earlier (3 vs. 4 minutes) and was more pronounced (loss of 10.7% vs. 8.0% per minute) with lower (21.9%) than with higher sucrose levels (31.2%). This was related to an earlier setting (5.6 min) for low than for high sucrose recipes (7.6 min). Furthermore, cookie baking with equal sucrose-water solvent volume demonstrated that higher water levels lead to more extensive cross-linking and earlier setting because of higher system mobility. More gluten cross-linking and/or entanglement results in more resistance to collapse, and, at the same time, earlier setting during baking, and, hence, smaller cookie diameters.

Significance of the proportion and composition of albumins on *in vitro* protein digestibility of raw and cooked pea seeds

S. PARK (1), B. Baik (1)
(1) Washington State University, Pullman, WA, U.S.A.
Cereal Foods World 54:A59

Albumins of legume seeds, representing 15–25% of legume seed protein, are considered to negatively affect digestibility and consequently availability of seed protein in foods and feeds. This study was conducted to elucidate the relationship between proportion and composition of albumins, and protein digestibility of pea seeds. Eight pea varieties with a wide range of protein content (15.7–27.3%) were determined for quantitative and qualitative characteristics of seed proteins, including proportion of albumins and globulins, their composition using SDS-PAGE, and *in vitro* protein digestibility (IVPD) using a multi-enzyme (trypsin, chymotrypsin and peptidase) before and after heat treatment. The proportion of albumins based on total seed protein content decreased from 22.9 to 14.7% as seed protein content increased from 15.7 to 27.3%, while the proportion of globulins increased from 48.3 to 59.0%. The IVPDs of eight pea varieties were 79.9–83.5% before cooking, with significant varietal variations, and improved to 85.9–86.8% by cooking. IVPDs of pea seed before cooking showed positive relationships with seed protein content and proportion of globulins, and a negative relationship with proportion of albumins. IVPDs of cooked seeds exhibited a positive relationship only with seed protein content. SDS-PAGE bands of pea albumin 2 (PA2), lectins, and trypsin inhibitors were detected in albumins after digestion using proteases without heat treatment. With heat and protease treatments, bands of lipoxygenase and PA2 intensified, while bands of lectins and trypsin inhibitors became lighter. Globulins were mostly digested by protease after heat treatment.

Modification of corn distillers dried grains with solubles (DDGS) with probiotics

P. Pathirapong (1), B. LAMSAL (2), S. Rakshit (1)
(1) Asian Institute of Tech; (2) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A59

Corn distillers dried grains with solubles (DDGS) was fermented by three known probiotics: *L. plantarum*, *P. acidilactici* and *S. boulardii*. Four growth media were prepared: 1) unmodified control DDGS, 2) enzyme-modified DDGS (with a cocktail of cellulase and pectinase), 3) supplemented DDGS with starch and soy protein concentrate (20 and 10% w/w respectively) and enzyme hydrolyzed including α, and gluco-amylases, and 4) synthetic media MRS (for bacteria) or YEPD (for yeast). All the media was inoculated at 10^8 CFU/mL by either of microorganism and fermented for 72 h. The reducing sugars produced by enzymatic modification of DDGS were 0.25, 0.61, and 0.83 mg/mL for medium 1, 2, and 3 respectively. *S. boulardii* showed the highest specific growth rate (SGR) of 0.6 h^{-1} on control DDGS, whereas it was 0.54 and 0.51 h^{-1} in YEPD and enzyme-modified DDGS, respectively. *P. acidilactici* had SGR of 0.12 and 0.17 h^{-1} in MRS and control DDGS media respectively, with enzyme modification having no effect. *L. plantarum* had the lowest SGR of about 0.07 in all media. Although SGR lowest for *L. plantarum*, total cell count stood highest at 2.91×10^{11} CFU/mL in 48 h on unmodified DDGS. *S. boulardii* growth peaked at 12 h, though with cell counts of 1.5×10^9 CFU/mL on YEPD media, followed closely by enzyme modified DDGS. *P. acidilactici* peaked at 24 h at 1.16×10^{10} CFU/mL on MRS media compared to 1.11×10^{10} CFU/mL on enzyme-modified DDGS. The microbial population dropped by 72 h, for reasons not known yet, slightly for *L. plantarum* and by half for *S. boulardii*, whereas it remained steady for *P. acidilactici*. Protein in DDGS, which was highly digestible (about 97%) already, improved slightly further to 99% upon fermentation. We expect that modification of DDGS via probiotic fermentation will enhance its inclusion levels in monogastric animals and poultry.

Nutritionally-important starch fractions of rice cultivars grown in southern United States

J. PATINDOL (1), H. Guraya (1), E. Champagne (1), A. McClung (2)
(1) USDA ARS SRRC, New Orleans, LA; (2) USDA-ARS DBNRRC, Stuttgart, AR
Cereal Foods World 54:A59

Dietary starches can be classified into three major fractions according to *in vitro* digestibility: rapidly digestible (RDS), slowly digestible (SDS), and

resistant starch (RS). Literature indicates that SDS and RS have significant implications on human health, particularly on glucose metabolism, diabetes management, colon cancer prevention, mental performance, and satiety. In this work, cooked rice nutritionally-important starch fractions were assayed *in vitro*, making use of 16 cultivars grown in five southern U.S. rice growing areas (Arkansas, Louisiana, Mississippi, Missouri, and Texas). The relative amounts of RDS, SDS, and RS in cooked rice were affected by cultivar, location, and cultivar × location interaction. SDS ranged from 10.3 to 26.6%. Across locations, it was highest for Dixiebelle and lowest for Wells; and across cultivars, it was higher for the Louisiana samples compared with Texas. RS ranged from 1.2 to 9.0%. Across locations, it was highest for Bowman and lowest for HB-1; and across cultivars, it was higher for the samples from Texas than those from Arkansas, Louisiana, and Mississippi. Two cultivars (Dixiebelle and Tesanai-2) were relatively high in both RS and SDS, and the amounts were stable across locations (based on standard deviation values and Tukey's honestly significant differences test). However, SDS and RS were not linearly correlated ($n = 80$, $r = –0.18$, $p < 0.05$); it does not always follow that a cultivar high in SDS is also high in RS, and vice versa.

Correlations between head rice thermal properties and cooked rice nutritionally-important starch fractions

J. PATINDOL (1), H. Guraya (1), K. Daigle (1), E. Champagne (1)
(1) USDA ARS SRRC, New Orleans, LA
Cereal Foods World 54:A60

Available methods for *in vitro* determination of nutritionally-important starch fractions (rapidly digestible, slowly digestible, and resistant starch) in foods are usually complicated and time-consuming. Simple, fast, and accurate predictors will be a valuable innovation. This work evaluated the usefulness of differential scanning calorimetry (DSC) measurements as indicators of cooked rice starch digestibility. Head rice samples were cooked in a household-type rice cooker using a rice to water ratio of 1:2. Rapidly digestible (RS), slowly digestible (SDS), and resistant starch (RS) fractions were determined by enzymatic assay with a cocktail of amylases. Head rice-water mixtures (1:2 ratio) were used in obtaining the DSC thermograms. Apparent amylose and crude protein were analyzed by iodine colorimetry and combustion method, respectively. RS significantly correlated with onset ($n = 70$, $r = 0.36$ $p < 0.01$) and peak gelatinization temperature ($n = 70$, $r = 0.33$, $p < 0.01$), and apparent amylose ($n = 70$, $r = 0.53$; $p < 0.001$). None of the thermal and physicochemical properties analyzed significantly correlated with SDS. RDS and apparent amylose were inversely related ($n = 70$, $r = –0.28$, $p < 0.05$). Crude protein did not show significant correlation with any of the starch fractions. Present findings indicate that the usefulness of DSC measurements in predicting cooked rice starch digestibility may be limited to RS. The other starch fractions (RDS and SDS) did not show significant correlations with head rice thermal properties.

Rapid and low-cost system for detecting insect infested grain and estimating storability

T. PEARSON (1), P. Flinn (1), D. Brabec (1)
(1) USDA-ARS-GMPRC, Manhattan, KS, U.S.A.
Cereal Foods World 54:A60

A modified laboratory mill was tested for estimating insect fragments in flour from a 1000 g whole grain sample by monitoring electrical conductance through the grain as it is milled. This system can test a kilogram of wheat in less than 2 minutes and has been shown to detect ~70% of infested kernels. Wheat was infested with lesser grain borers and stored for 6 and 10 weeks at 24 C. The infestation populations were quantified with x-ray followed by conductance milling. It was found that a good correlation ($R^2 = 0.93$) exists between insect counts by the conductance mill and insect fragment counts from flour after the grain is milled. This indicates that the conductance mill could be a useful tool to asses grain quality related to insect damage. Additionally, insect colonization and storage models for the lesser grain borer were added to predict wheat storage risk.

Single kernel analysis of *Fusarium* head blight symptoms and mycotoxins in infected wheat heads

K. H. PEIRIS (1), M. O. Pumphrey (2), Y. Dong (3), F. E. Dowell (4)
(1) Agricultural and Biological Engineering, Kansas State University, Manhattan, KS, U.S.A.; (2) USDA, ARS, GMPRC Plant Science and Entomology Research Unit, Manhattan, KS, U.S.A.; (3) Department of Plant Pathology, University of Minnesota, St. Paul, MN, U.S.A.; (4) USDA, ARS, GMPRC Engineering & Wind Erosion Research Unit, Manhattan, KS, U.S.A.
Cereal Foods World 54:A60

Mycotoxin accumulation in *Fusarium* head blight (FHB) infected wheat depends on interactions among the host, fungal genotypes and environmental conditions. To study disease symptoms and mycotoxin accumulation among kernels in wheat heads relative to the point of infection, FHB symptoms and mycotoxin levels of single kernels were assessed using three inoculated heads each of two wheat lines, 'Wheaton' and 'PI69251'. The heads were inoculated at anthesis by injecting a single central floret with 10 µl macroconidia (1×10^5 ml^{-1}) of *F. graminearum* isolate Z-3639 (NRRL accession 29169) and covering with plastic bags for 48 h. Kernels in each spikelet were extracted from mature heads. Kernel weight, presence of visible *Fusarium* mycelia and scab symptoms were recorded for one randomly selected kernel per floret. DON and 15-Acetyl-DON levels were determined by GC-MS method. Mycotoxin accumulation among the kernels along the head was distinctly different for the two varieties. Higher mycotoxin levels were accumulated in scabby kernels above and below the point of inoculation in Wheaton heads. Mycotoxin accumulation in PI 69251 was limited to kernels below the point of inoculation whereas scabby kernels above the point of inoculation had non-detectable DON levels. Kernels close to the point of inoculation had the highest mycotoxin levels. Results showed that some asymptomatic kernels had significant mycotoxin levels while some scabby kernels had no detectable levels of mycotoxins. These results in part will explain the reasons for irregular correlations between FHB disease indexes and bulk kernel DON levels often reported in literature. Further studies using similar single kernel evaluation methodology for different types of FHB resistant varieties and *Fusarium* strains will provide valuable information about the complex relationship between FHB and DON accumulation in kernels.

Effect of oxidizing agents on the rheological properties of refined and whole-grain wheat flour doughs

E. P. Pereira (1), E. O. Amorim (1), H. C. Ambiel (1), Y. K. Chang (1), C. J. STEEL (1)
(1) University of Campinas (UNICAMP), Campinas, SP, BRAZIL
Cereal Foods World 54:A60

Gluten is the main responsible for permitting the production of several kinds of breads from wheat flour. Its strength can be evaluated through rheological analyses. Oxidizing additives act on gluten proteins forming disulfide bonds and strengthening the dough. In this work, the effect of different oxidizing agents on the rheological properties of refined and whole-grain wheat flour doughs was studied. The chemical oxidants ascorbic acid (AA), azodicarbonamide (ADA) and potassium bromate (BR) and the oxidizing enzyme glucose oxidase (GO), all at a concentration of 40 mg/kg, flour basis, were used. In the farinographic analyses, AA and BR did not alter the characteristics of refined flour; however, ADA reduced tolerance to mixing and stability of the dough. The enzyme GO increased stability and presented the lowest mixing tolerance index, that is, the best results. For whole-grain flour, a reduction of stability was observed with AA and ADA, and also an increase in the values of the mixing tolerance index. It was observed that whole-grain flour presented higher water absorption and dough development time than refined flour, fact related to the higher fiber content of the former. In the extensographic analyses, AA and ADA increased resistance to extension of refined and whole-grain flour doughs more significantly. The remaining additives did not present great variations, presenting more pronounced effects when added to refined flour. The results showed that AA and ADA had intermediate and rapid actions, respectively, which can be correlated to a better action during mixing and fermentation. BR did not present considerable effects on rheological parameters, in comparison to the control doughs. This was expected, as bromate is a slow reaction oxidizing agent, activated by temperature, and should act during baking.

New, cost efficient NIR diode array based analyzer for online applications from FOSS

J. PERSSON (1)
(1) Foss Analytical AB, Hoganas, SWEDEN
Cereal Foods World 54:A60

Processing industries has for years relied on laboratory methods to optimize the efficiency of the production lines. The use of rapid methods like Near Infrared Spectroscopy has had a great impact on the industry due to the increased speed with which analytical results could be fed back to the processing lines. Although a rapid analytical technique is used there still limitations in how well you can optimize a processing system One of the larger error sources being the routines used for sampling the process flow. The final result can never be more accurate than the validity of the sample analyzed. Production lines get bigger and bigger and there is a constant pressure to optimize quality and to reduce production costs. To reach these targets the analytical measurement must move out into the process line – accurate online sensors must be used. To meet these demands FOSS has developed a new Diode Array base online analyzer with dedicated sample interfaces for a range of processing industries. One example is found in the flour milling industry. By continuous measurement of main parameters like moisture, protein and ash in the first grade flour produced one can secure consistency in quality and also optimize the milling process to increase yields. The new FOSS online concept will be presented together with an example from an installation in the processing line in a flour mill.

Dietary fibers from cereals (barley fiber, oat bran and rye bran) replacing fat in sausages

K. PETERSSON (1), O. Godard (1), A. Eliasson (1), E. Tornberg (1)
(1) Department of Food Technology, Engineering and Nutrition, Lund, SWEDEN
Cereal Foods World 54:A61

The aim of this study was to investigate the effect of the addition of dietary fibers from cereals on the physicochemical and sensory properties of reduced-fat sausages. Fibers from barley fiber, oat bran and rye bran were added to low fat and low starch sausages. Rye bran was also treated in water at 50°C for four hours with three hydrolytic enzymes, with varying xylanase and endoglucanase activities, along with a sample with no added enzymes. Three references were made with no fiber added; one high in fat and starch, one low in fat and high in starch and one low in fat and starch. The water/protein ratio and the total amount of starch were constant (7.9 and 4%) in all batters. The total amount of added fibers was 1%, with varying ratios of soluble/insoluble fibers. The barley fiber is very high in soluble β-glucans and the rye fiber has only a very small part of soluble fiber. Process and frying losses were measured and the hardness of the cooked sausages was examined by a texture analyzer. Six attributes (color, crumbliness, off flavor, meat intensity, compactness and total impression) were assessed by a hedonic sensory test. Low starch and fat content resulted in high frying losses. The sensory panel preferred the sausages with oat fiber. These also had a lower cooking loss and higher values for the hardness compared to the others. The barley had a very low value of the hardness and was the least preferred. All the enzymes increased the hardness and lowered the frying losses of the rye sausages, but so did the rye that had been in water without any enzymes added. The endogenous enzymes of the rye bran together with the swelling of the rye starch prior the incorporation to the sausage batter could be the reason for this improvement. The proportion of soluble respectively insoluble fibers does not seem to have the largest impact on the outcome of the sausages.

Analysis of flavonoid compounds in commercial wild rice by HPLC-MS-MS

Y. QIU (1), Q. Liu (2), T. Beta (2)
(1) University of Manitoba, Winnipeg, MB, CANADA; (2) Department of Food Science, University of Manitoba, Winnipeg, MB, Canada
Cereal Foods World 54:A61

Wild rice is the only cereal native to North America. Although the antioxidant activity of wild rice has been studied, the antioxidant compounds have not been well characterized. Flavonoids as the major group of plant antioxidants were analyzed in different commercial wild rice samples. Eleven wild rice samples were extracted with acidic acetone solution and fractionated by a Sephadex LH-20 column. The DPPH scavenging activities of each fraction showed that fraction 2 (F2) and fraction 3 (F3) had the highest antioxidant activity, followed by fraction 5 (F5) and fraction 4 (F4). Fraction 1 (F1) had the lowest antioxidant activity. By applying tandem mass spectrometric techniques, the predominant flavonoid compounds detected in F2 and F3 were di-hexosyl apigenin, hexosyl-pentosyl apigenin, and di-pentosyl apigenin. These three flavone glycosides were abundantly occurring in all the wild rice samples. F4 and F5 were characterized by the presence of flavan-3-ols. Catechin, epicatechin and procyanidin dimers were commonly found in all the samples, whereas oligomeric procyanidins with $3 \leq DP \leq 5$ were only detected in some of them, thus consequently resulting in a wide range of procyanidin content ($1 \leq DP \leq 5$) from 7 to 239 µg/g catechin equivalents. The absence of flavonoids in F1 may explain its low antioxidant activity.

Effect of different sources of potential prebiotics on starch digestibility and pasting characteristics in a flour-water system

S. RAGAEE (1), L. Ashrafi (1), I. Guzar (1), K. Seetharaman (1)
(1) University of Guelph, Guelph, ON, CANADA
Cereal Foods World 54:A61

The benefits of soluble and insoluble fiber incorporation in the diet are well recognized. It is also well recognized that cereals contain complex non-starch polysaccharides (NSPS) that could be potential prebiotics. Some authors demonstrated that oligosaccharides produced from β-glucan acted as selective factors, favoring growth of some known probiotic bacteria strains. While most studies have focused on direct health benefits of these potential prebiotics, little is known about any possible interaction between these NSPS and starch within a baked product matrix. The objective of the present study was to investigate the effect of fiber type and level, and water availability on the matrix structure and the *in-vitro* starch digestibility following heating and cooling of the flour-water system. Pasting properties of the composite flours were also investigated. Hard wheat flour was replaced with whole meals from different cereals (wheat, rye, barley and oat) at different replacement levels. Scanning Electron Microscopy (SEM) and Confocal Laser Scanning Microscopy (CLSM) were used to examine the structure of the baked system. RVA of the flour-water composite system indicated differences in peak and final viscosities depending on the type of whole meal included in the system. SEM, CLSM and starch digestibility results indicated differences among the different composite systems depending on the type of the cereal whole meals incorporated. These observations suggest that further research is required to better understand the nature of interaction between flour components when evaluating the health benefits of different prebiotics.

Surface lipid content and color of individual milled rice kernels using Near-Infrared Reflectance Spectroscopy

J. RASH (1), M. Saleh (1), J. Meullenet (1)
(1) University of Arkansas, Fayetteville, AR, U.S.A.
Cereal Foods World 54:A61

The use of Near Infrared Reflectance Spectroscopy to predict surface lipid content (SLC) and color of individual rice kernels was evaluated. Twenty-five rice samples including medium- and long-grain cultivars, harvested from locations in Arkansas in 2007 were used in this study. SLC (%) and color parameters, response variables, of milled rice bulk were predicted by diode-array-analyzer (DA7200, Perten Instruments, Huddinge, Sweden) using prediction models developed by Saleh et al 2008. 100-individual milled rice kernels were scanned using the diode-array-analyzer fitted with single kernel adapter. Absorbance readings were collected over a near-infrared wavelength range of 950-1650 nm. Partial least squares regression was performed using Unscrambler software (Unscrambler, v.9.2, Camo, Oslo, Norway) to predict individual rice kernels SLC and color. Results showed that measured and predicted kernels SLC and L, a, and b color parameters had coefficient of determinations of 0.86, 0.86, 0.61, and 0.83, respectively. The correspondent root mean square errors of prediction were 0.06%, 0.79, 0.22 and 0.50, respectively. Distributions of SLC and color of individual kernels were further evaluated as indications of milled rice bulk SLC and color. SLC and color of individual kernels were normally distributed around means that are highly correlated with SLC and color of milled rice bulk. The use of Near Infrared Reflectance Spectroscopy showed satisfactory potential for predicting individual milled rice kernels quality parameters that can be adapted in various rice breeding programs where limited sample size often a drawback.

From grain to feed – process development of high protein fractions from grain and legume products for extruded fish feed pellets

H. RASMUSSEN (1)
(1) Danish Technological Institute, Sdr. Stenderup, DENMARK
Cereal Foods World 54:A61

The Danish project "Organic Aquaculture"- the link between sustainable production and superior products is examining relevant organically produced crops to be used as raw materials for fish feed where fish meal is the main source of protein. Fish from aquaculture make up around 35% of the total global amount of consumed fish. The global fish catch will not increase because of restrictive quotes. Consequently, the production of fishmeal to aquaculture will not increase, and the increasing demand on fish products needs to be covered by the aquaculture. This has resulted in increased marked prices of fishmeal which is a barrier for further development of aquaculture. Therefore, there is a large demand for developing sustainable protein sources as a substitute for fish meal. Protein from crops and legumes is an obvious solution. However, the crops and legumes need to be processed into fractions with higher protein contents in order to compete with fishmeal. These new products will secure the future development of aquaculture and the sustainability of our world fish stock. The process development was carried out at The Danish Technological Institute's Pilot Plant located in Sdr. Stenderup, Denmark. Sweet lupine seeds were processed, among other crops, and a dehulling process was developed. The protein content was concentrated from 34 to 43% protein, which is a large protein increase obtained just by dehulling, and gave good conditions for further processing. The dehulled lupines were ground and further processed by air classification. A protein fraction with 62% protein on dry matter and fat free basis was reached and used as substitution of fish meal in fish feed. The feed was extruded into pellets on a Werner Pfleider Continua 37 extruder and the feed was tested in following feeding trials.

Application of rapid visco-analysis to monitor starch retrogradation

W. S. RATNAYAKE (1), D. Rybak (1), D. S. Jackson (1)
(1) University of Nebraska, Lincoln, NE
Cereal Foods World 54:A61

A simple method was developed to analyze maize starch retrogradation using rapid visco-analysis (RVA). Regular maize starch, 2 g at 14% moisture, was mixed with 25 mL distilled water and subjected to standard-1 (1 min at 50°C, heat to 95°C at 12.16°C/min, maintain at 95°C for 2.5 min, cool from 95 to 50°C at 12.16°C/min rate, maintain at 50°C for 2 min with 160 rpm speed), and standard-2 (1 min at 50°C, heat to 95°C at 6°C/min rate, maintain at 95°C for 5.5 min, cool from 95 to 50°C at 6°C/min rate, maintain at 50°C for 2 min with 160 rpm speed) RVA profiles. Pasted samples were sealed and stored at

5 ± 1°C for 5, 10, and 20 days. Stored samples were equilibrated at room temperature (~25°C) for ~2 h and analyzed by RVA using standard-1 and standard-2 profiles after adding 2 mL dimethylsulfoxide (DMSO). Retrograded samples were reproducibly analyzed using modified standard-2 RVA profile, but not with standard-1 profile. The average pasting temperature of retrograded samples (50.7°C) did not change significantly ($p > 0.05$) between the three storage times tested, and this was significantly less ($p < 0.05$) than the average pasting temperature (87.9°C) of non-retrograded samples. The peak viscosity increased dramatically in retrograded samples, from an average of 790cP for non-retrograded samples to 1910cP for retrograded samples. This increase in peak viscosity was statistically the same between the three storage times. RVA is applicable to detect starch retrogradation, in the presence of DMSO, as a hydrogen bond breaker among retrograded starch polymers.

Heat transfer surface fouling: Implications on bioprocessing

K. D. RAUSCH (1), A. Arora (1), M. R. Wilkins (2), R. M. Agbisit (3), V. Singh (1), M. E. Tumbleson (1)
(1) University of Illinois, Urbana, IL, U.S.A.; (2) Oklahoma State University, Stillwater, OK, U.S.A.; (3) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A62

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. In the corn dry grind process, 6 to 7 L thin stillage are produced per 1 L ethanol. In corn wet milling, 1 to 2 L water per kg corn are needed for starch production; this water passes through steepwater evaporators. As emphasis on renewable fuels continues, cellulosic feedstocks are to be used to produce fuel ethanol. For cellulosic ethanol, it is anticipated that water use will increase 2 to 3 times over that required for conventional ethanol processes; a large percentage will need to be removed from ethanol and coproduct streams. Despite its importance in economic operation, heat transfer surface fouling is not well understood. A probe was used to quantify fouling tendencies of fluids passing over heated surfaces. Microfiltration reduced fouling tendencies of steepwater by 5 fold, although solids content was reduced by only 19%. Thin stillage from dry grind fouled more rapidly than thin stillage from wet milling. The observed effect of pH was counter to industry experience; flow rate (Reynolds number) affected fouling rate. Solids content alone did not explain decreased fouling tendencies in microfiltered stillage. Additional work is needed to understand causes of fouling and to determine constituents associated with accelerated fouling. This understanding could be used to avoid increased energy consumption and reduced process efficiencies.

Nutritional and sensory evaluation of corn tortilla using chia seed (*Salvia hispanica* L.)

R. RENDON-VILLALOBOS (1), G. Pacheco-Vargas (1), J. Islas-Hernández (1), N. Astilleros-Rosas (2)
(1) CEPROBI-IPN, Yautepec, Morelos, MEXICO; (2) Instituto Tecnologico de Zacatepec, Mexico
Cereal Foods World 54:A62

The objective of this work was to develop nutritionally enhanced tortillas by incorporating an ingredient with well-documented nutritional functionality (chia seed) in a corn tortilla formulation in the ratios 95:5, 90:10, 85:15 and 80:20 (w/w), in an attempt to create a low-glycemic index (GI) and fibre-rich product while preserving sensory acceptability and physicochemical properties. Total dietary fiber (TDF) (AOAC method 985.29), ash (08-01), fat (30-25) and protein content (46-13) were analyzed with AACC methods. Total starch, *in vitro* rate of hydrolysis and predicted GI (pGI) were evaluated. Fresh tortillas were evaluated in a sensory evaluation laboratory for color, flavor, taste, aroma intensity and general acceptability on a 3 point hedonic scale. A panel of seventeen judges (untrained but familiar with corn tortillas) was used. Ash contents varied from 1.29 – 1.76%, and non-significant differences ($p > 0.05$) between control tortillas and those containing chia seed flour. An increase in the protein content (9.41–12.48%) was observed with respect to the level of chia seed added to the tortilla. The amount of lipids in the chia seed-added tortilla increased approximately 76%. A significant increase ($p < 0.001$) in the TDF content was also obtained with the chia seed-flour addition (approximately 56%). The reduced enzymatic starch hydrolysis rate and pGI recorded for the chia seed-added tortilla indicated slow digestion features. Sensory evaluation did not show significant ($p > 0.05$) differences in the organoleptic among tortillas. Owing to increase in the TDF, lower digestion and pGI values, chia seed-added tortilla can be considered as a nutraceutical food. Therefore, the newly developed tortilla supplemented with chia seed flour, could represent a valuable staple in improving the nutritional value of the original food product.

Characterization of Peruvian carrot starch and effect of annealing on its semi-crystalline structure

T. S. ROCHA (1), J. Jane (2), C. M. Franco (1)
(1) UNESP - University of Sao Paulo State, Sao Jose do Rio Preto, SP, BRAZIL; (2) Iowa State University, Ames, IA, U.S.A.
Cereal Foods World 54:A62

Objectives of this study were to determine the structural characteristics of native and annealed Peruvian carrot starches, and to compare them with that of cassava and potato starches. The Peruvian carrot starch showed round and irregular shaped granules with an average diameter of 20 µm, as shown by scanning electron micrograph. Like potato starch, the Peruvian carrot starch displayed a B-type X-ray pattern and the amylopectin contained a large proportion of long branch-chains (DP>37) determined using high performance anion exchange chromatograph equipped with a pulsed amperometric detector. The Peruvian carrot starch also showed a large proportion of short branch-chains (DP 6-12), which could contribute to its low onset gelatinization temperature (T_0 = 57°C). This starch had the little apparent amylose content (20%) and great susceptibility to acid hydrolysis (2.2 M HCl, 35°C). After annealing for 24 hr at 3°C below the onset gelatinization temperature (54°C, 56°C and 59°C for Peruvian carrot, cassava and potato starches, respectively), the gelatinization temperature of all starches increased, but the enthalpy change increased only for the Peruvian carrot and potato starches. The X-ray pattern of Peruvian carrot starch did not change after annealing, but the relative crystallinity increased. These results demonstrated that Peruvian carrot starch had different structural characteristics from cassava and potato starches. The annealing affected the semi-crystalline structure of the Peruvian carrot starch, enhancing starch crystallinity more than for cassava and potato starches.

Whole-grain corn snacks elaborated with an ecological nixtamalization process

L. RODRÍGUEZ-VÁSQUEZ (1), J. Figueroa (2), J. Véles-Medina (2), F. Loarca Piña (1)
(1) PROPAC, Facultad de Química, Universidad Autónoma de Querétaro, Centro Universitario s/n Querétaro, Qro. C.P. 76010 Querétaro, México; (2) CINVESTAV Unidad Querétaro, Libramiento Norponiente 2000, Fracc. Real de Juriquilla, Querétaro, Mexico
Cereal Foods World 54:A62

Overweight and obesity have been implicated as risk factors for many chronic diseases. Replacing high-energy dense food with lower-calorie and, fiber-rich may be a strategy to control weight, reduce obesity, and reduce risk for certain diseases. To overcome the lack of fiber and other nutrients in the diet a new whole-grain corn snack was developed to take advantage of the corn pericarp. The objective of this study was to evaluate the chemical composition and of whole-grain corn snacks (WGS) obtained from the ecological method of nixtamalization and compare with those values obtained from traditional commercial snacks (TCS). The WGS obtained with the ecological process using calcium salts presented significant lower fat content 15.8% compared to the 20% fat presented by the TCS elaborated with the traditional process. The dietary fiber in maize sample did not have difference compared to WGS; however, there were significant differences ($P < 0.05$) compared to TCS because WGS were prepared with the ecological method of nixtamalization, in which the pericarp (insoluble fiber) of the grain remains after boiling. The WGS showed 19.8% of insoluble fiber and 15.4% for the TCS. Regarding the texture and color the WGS showed excellent quality with L value of 56.1 compared to 50.4 of the TCS but the texture did not show differences. On the basis of the results, there was demonstrated that the nutritional benefits and quality of the WGS obtained with the ecological method of nixtamalization, improves substantially the dietary fiber and reduces the fat content; and also, the resultant liquid waste (nejayote) of this process is less harmful to the environment. That fact is important since WGS do not reduce the important nutrients for growing but also was compatible with the demands of the market for preventing obesity.

Physico-chemical and sensory evaluation of cookies enriched with fiber from wheat milling by-products

A. ROMERO-BARANZINI (1), M. Salazar (1), F. Reyes-Pérez (1), P. Rayas-Duarte (2), R. Alfaro-Rodriguez (3)
(1) Universidad de Sonora, Hermosillo Sonora, MEXICO; (2) Robert M. Kerr Food & Agricultural Products Center, Oklahoma State University; (3) Universidad Autonoma del Estado de Hidalgo, Tulancingo, Hidalgo, Mexico
Cereal Foods World 54:A62

The health benefits of increasing the fiber consumption are recognized. Sweet good products and in particular cookies could be attractive product choices to improve the consumption of soluble and insoluble dietary fiber in Western diets. The objective of this study was to evaluate the effect of bran, shorts and germ in the physico-chemical and sensory attributes of cookies. Cookies were prepared from a blend of wheat flour and each by-product at 70:30 ratio, w/w.

Control cookies were made from 100% white wheat flour. Cookies were evaluated for chemical composition, soluble and insoluble total dietary fiber, color, diameter, thickness, D/G ratio, texture, and consumer preference test. Protein, ash, fat, soluble, insoluble and total fiber content increased significantly ($p < 0.05$) in the cookies containing bran, shorts and germ. Cookies containing 30% bran showed the highest increase in insoluble fiber (3.0 to 9.8%), total fiber (5.7 to 15.4%), improvement in color, smaller D/G expansion ratio, and received similar consumer preference score as the control. Alternative healthier cookie products can be produced, i.e., enriched fiber, 3.3 folds more insoluble fiber and 2.3 folds more total fiber, compared to white flour products by substituting 30% wheat milling by-products for flour.

A simple method for the determination of xylanase activity on insoluble substrates

D. ROSE (1), G. Inglett (1)
(1) USDA, Peoria, IL, U.S.A.
Cereal Foods World 54:A63

The propensity for a xylanase to convert insoluble (arabino)xylan into soluble oligosaccharides is an important parameter in the baking, pulp and paper, prebiotics, and biofuel industries. Current methods for determining xylanase activity on insoluble substrates are labor intensive, non-specific, or utilize artificial substrates which may provide much different results from native substrates. Therefore, a new, rapid method for the determination of xylanase activity on native substrates was developed. This method involves incubation of the enzyme preparation with a material containing insoluble (arabino)xylan under the proper conditions. Following the reaction, total (arabino)xylan released is quantified as total pentose sugars in solution spectrophotometrically using a modification of the phloroglucinol method of Douglas (Food Chemistry 1981, 7, 139-145). This method was tested using two commercial xylanase preparations and four insoluble arabinoxylan-containing substrates. Proper buffer, reaction time, and stopping procedure were determined. Acetate and citrate buffers were suitable for the reaction; phosphate buffer substantially interfered with quantification of reaction products by reducing chromagen formation. The reaction was linear for at least 5 min under all conditions tested, after which the reaction was stopped by boiling for 2 min. Stopping the reaction by pH adjustment resulted in a significant increase in the absorbance of the blank. Relative standard deviations were below 5% on samples assayed on different days. Enzyme activity on different insoluble arabinoxylan-containing substrates differed by up to 100-fold, emphasizing the need for the use of application-specific substrates to obtain accurate estimations of xylanase activity.

Extrusion of aquafeeds containing DDGS with navy and pinto bean flours

K. A. Rosentrater (1), M. TULBEK (2)
(1) USDA-ARS, Brookings, SD, U.S.A.; (2) Northern Crops Institute, Fargo, ND, U.S.A.
Cereal Foods World 54:A63

As the global population continues to grow, there is an increasing need to produce food. Aquaculture is a rapidly growing segment of agriculture, and is helping to meet some of this growing demand. The majority of protein for aquafeeds is fish meal. But due to growing costs and potential scarcity of fish meal supplies in coming years, there is an impending need to find alternative protein sources. DDGS, a coproduct of the fuel ethanol industry, may be suitable for this purpose. The objective of this study was to examine the effect of extrusion processing conditions on feed blends containing DDGS and other ingredients. Two aquafeeds were formulated using 20% DDGS, 14.75% soybean meal, 14.0% corn flour, 0.75% vitamin and mineral mix, and either 50% navy bean or 50% pinto bean flour. The blends were processed in a pilot-scale twin-screw extruder at speeds between 357 and 477 rpm, using a 3-mm circular die. The resulting extrudates were subjected to extensive physical property analysis, which included moisture content, unit density, bulk density, expansion ratio, sinking velocity, color (Hunter L, a, and b) and pellet durability index (PDI). 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. All process settings produced viable extrudates which floated for more than 24 h. Extrudate bulk density ranged from 0.25 to 0.33 g/cm^3; compressive strength ranged from 0.22 to 1.56 MPa, and PDI ranged from 85.8 to 92.6%. This study highlights the importance of experimentally quantifying the effects of feed ingredients and process variables when developing aquafeeds with novel materials.

The development of a sorghum-based master mix

S. RUAN (1)
(1) Kansas State University, Manhattan, KS
Cereal Foods World 54:A63

Sorghum is the fifth most produced cereal in the world. However, it has not been used extensively in human food in the U.S. This study was conducted to develop a sorghum based, gluten-free, master mix similar in application to Bisquick® for celiac disease sufferers and certain health-concerned populations. Sorghum variety Fontella 1000 (a white grain sorghum, grown in 2007, KS) was decorticated when milled to flour fineness. The formula amounts of functional ingredients (sugar, shortening, xanthan gum, guar gum, and emulsifiers were varied systematically to assess their ability to improve the resulting product. The products tested in all cases were chemically leavened biscuits. The biscuits made from Bisquick® were used as control samples. Quality attributes, baking loss, specific volume, crumb firmness, crumb visual texture, and color were assessed. The sugar content and gum type and the content affected the quality of biscuits more significantly than did changes to other ingredients. The best biscuits were produced from a formula containing 20% sugar, 1% xanthan gum and 1% guar gum. The simple modifications of sorghum flour including pre-gelatinization, heat-moisture treatment, and oxidation were, also tested to improve this sorghum-based master mix. In this case, formulas for different baked foods such as cookies, waffles, pancakes, and coffee cakes were developed and tested.

Alkali-extractable arabinoxylan xylanase-hydrolyzates from corn, wheat and rice brans and their *in vitro* fermentation by human fecal microbiota

P. RUMPAGAPORN (1), B. R. Hamaker (1)
(1) Food Science Department, Purdue University, West Lafayette, IN
Cereal Foods World 54:A63

Arabinoxylans, the non-starch polysaccharides in cereal grains, can be fermented by bacteria in the colon which provide health benefits to humans. Production of short chain fatty acids (SCFA) and decrease in colonic pH are two beneficial consequences of their fermentation. Arabinoxylans with varying structures can cause dissimilar fermentation profiles and might result in variable advantages. The objective of this study was to investigate the effect of molecular weight and branching of alkaline-extractable arabinoxylans (AE-AX) from corn, wheat and rice brans and their fractions on fermentation properties. *In vitro* fermentation by human fecal microbiota and hydrolysis of AE-AX by xylanase were used in this study. After hydrolysis with xylanase and precipitation with ethanol, the arabinose to xylose (A/X) ratio of AE-AX fractions from corn, wheat and rice brans were 0.48, 0.74 and 0.97, respectively. The slowest rate of fermentation was found in AE-AX hydrolyzate from wheat bran, whereas fructooligosaccharide, which was used as the control, showed the highest rate of fermentation. At the first 4 h of fermentation, AE-AX hydrolyzate from rice bran was fermented at a higher rate than AE-AX hydrolyzates from wheat and corn brans, as indicated by gas and SCFA production. AE-AX and AE-AX hydrolyzate from corn bran were fermented at the same slower rate than that of fructooligosaccharide from 0–12 h of fermentation, though total fermentation product was the same from 12 to 24 h. Corn AE-AXs produced the highest level of propionate after 12 h. Fructooligosaccharide produced the highest butyrate level. Wheat and rice AE-AXs overall produced less SCFAs. Native and hydrolyzed AE-AXs from corn bran are sources of soluble dietary fiber with high fermentation, but relatively slow rate.

Growth of selected *Bifidobacterium* strains on resistant starches with different residual susceptibilities to digestion

D. SAIBENE (1), R. F. Roberts (1), D. B. Thompson (1)
(1) Penn State University, State College, PA, U.S.A.
Cereal Foods World 54:A63

The portion of starch not hydrolyzed by pancreatic α-amylase and absorbed in the small intestine is termed resistant starch (RS). Depending on its form, RS may be further hydrolyzed in the colon by the autochthonous microflora. The objective of this study was to compare growth of selected *Bifidobacterium* spp. when RS samples having different residual susceptibilities to pancreatic α-amylase digestion were used as the main source of carbohydrate. The initial RS-containing starches were high-amylose maize starch (HAMS), a heat-moisture treated HAMS (HMT), and a dispersed and debranched HAMS (DD). The proportion of RS was determined for each starch by AOAC method 2002.02, modified to monitor the digestion time course. We employed a double-exponential equation to model digestion kinetics. The RS was recovered (RS-HAMS, RS-HMT, and RS-DD) and used as the main carbohydrate source in MRS medium for three species of *Bifidobacterium* (*B. choerinum* ATCC 27686, *B. infantis* ATCC 15697, and *B. pseudolongum* ATCC 25526). By the double-exponential equation model, the RS value corresponded to the limit of digestion only for RS-HMT, meaning that both RS-HAMS and RS-DD were further digested by extending the digestion time beyond the stipulated 16 h. When grown on any of the RS samples, all three *Bifidobacterium* species tested had higher populations at 12 h than a no-carbohydrate-added control. By 24 h for *B. choerinum*, and by 48 h for *B. pseudolongum*, the population in the RS-HMT containing MRS was less than the control, but for RS-HAMS and RS-DD the population continued to remain higher than the control. *B. infantis* similarly distinguished RS-HMT from the other types of RS by 72 h. This outcome suggests that susceptibility to pancreatic α-amylase digestion is related to growth differences on the RS samples.

Effects of a palm stearin and canola oil mixed on the rheology parameters of the wheat dough and bread

M. G. SALAZAR-GARCIA (1), A. Pavlovich-Abril (1), F. J. Cinco-Moroyoqui (1), R. Ortega-Ramirez (1), N. Gamez-Meza (1)
(1) Universidad de Sonora, Hermosillo, Sonora, MEXICO
Cereal Foods World 54:A64

The effects of the substitution of the commercial shortening for palm stearin and canola oil mixed on the rheological properties of a wheat dough and bread were studied. Were carried out correlation (r = 0.82) ($p < 0.05$) between Alveograph deformation work (W) and water absorption (WA) on the Farinograph, and the WA and the specific volume (r = –0.55), the W and specific volume (r = –0.54). The data show that the addition of fat decrease W, and the resisted to stretching (P), WA, and increased the stability and devolved time. Ass well were carried out correlation between loaf volume and compression force (Texture) (r = –0.74) in the bread. The palm stearin and canola oil mixed was have a greater level of polyunsaturated fatty acid than commercial shortening, with out the present of *trans* fatty acid, the mixed provides similar rheological properties, with out show differences in loaf volume and bread texture. This study reveals that the fat elaborated whit the palm stearin and canola oil it's a viable alternative to replace the conventional commercial shortening.

Effect of xanthan gum and retort time on the quality of canned pasta containing nontraditional ingredients

G. K. SANDHU (1)
(1) North Dakota State University, Fargo, ND, U.S.A.
Cereal Foods World 54:A64

The aim of this experiment was to determine the effect of xanthan gum and retort time on the quality of the canned pasta containing nontraditional ingredients. All ingredients were obtained from commercial sources. Spaghetti was made with semolina fortified with either soy, oat, or flaxseed flours (15% w/w) and without and with xanthan gum (2% w/w). Spaghetti was dried using a high temperature drying cycle (70°C). Dried spaghetti was retorted for 15, 30, 45 and 60 min. Cooking loss, cooked weight, and cooked firmness of the canned spaghetti were determined. Results indicated that xanthan gum increased cooked firmness of spaghetti containing only semolina and semolina with oat flour, reduced cooked firmness with spaghetti containing soy flour and had no effect on the cooked firmness with spaghetti containing flaxseed flour. Increased cooked firmness by xanthan gum was only observed at 15 min and not at 30, 45 or 60 min of retorting. Xanthan gum reduced the cooking loss but did not affect cooked weight of the spaghetti. Spaghetti containing soy flour had the greatest cooking loss and cooked weight. Retorting reduced cooked firmness. Cooked firmness was greatest at 15 min, intermediate at 30 min and least at 45 and 60 min of retorting. Cooked weight increased with retort time. Cooking loss increased from 15 to 30 min of retort but did not significantly increase after 30 min.

Characteristics of biofilms from pea starch (*Pisum sativum*) in association with xanthan gum and glycerol

S. B. SARMENTO (1), M. D. Matta (1), C. I. Sarantópoulos (2), L. M. Oliveira (2), S. S. Zocchi (1)
(1) Universidade de São Paulo/ESALQ, Piracicaba, São Paulo, BRAZIL; (2) Instituto de Tecnologia de Alimentos/CETEA, Campinas, São Paulo, Brazil
Cereal Foods World 54:A64

Hydrocolloids have been used in starch-based products to control rheological properties. A full factorial design was adopted to study the effect of xanthan gum and glycerol on the properties of films from pea starch. The starch was extracted from peas, cv. Utrillo, containing 61% of amylose. Pea starch (3, 4 and 5% w/w), xanthan (0, 0.05 and 0.1% w/w) and glycerol (glycerol/starch ratio 1:5) were used to obtain filmogenic solution. These levels were determined according pre-tests to obtain good thickness and flexibility. The films were prepared by casting. The filmogenic solution was obtained by boiling (5 min) and autoclaving (120°C/1 h). The solution (21 g) was poured onto the plate (15 cm) and allowed to dry at 35°C/3 h in a convection oven and at room temperature (2 h). Experimental data were analyzed to fit polynomial models to response variables by SAS RSREF procedure and stepwise procedure to simplify the models. The film thickness ranged from 0.055 to 0.098 mm. The water solubility ranged from 3.0 to 18.4%. The increase in starch concentrations led to increases in thickness, puncture force and solubility and to decreases in the transparency of films. The water vapor transmission rate (23°C/75% RU) ranged from 258 to 968 g water/(m^2.d) and decreased with increasing starch amounts. The oxygen transmission rate (23°C/1 atm) ranged from 5.5 to 17.9 mL (CNTP)/(m^2.d) and to this variable, the lack of fit was significant for any model. The addition of glycerol decreased the tensile strength and increased elongation. The addition of gum increased the chroma a* and transparency and reduced the hue angle. ANOVA indicated the need of additional assays with gum levels for a best adjustment of water vapour and oxygen permeability models. Glycerol influenced the film characteristics because it establishes hydrogen bonds with the starch matrix, increasing flexibility, decreasing tensile and increasing water mobility. Acknowledgments: FAPESP.

Effect of acid and enzymatic hydrolysis on the process to obtain resistant starch from chick-pea starch

S. B. SARMENTO (1), L. F. Polesi (2)
(1) Universidade de São Paulo, Piracicaba, BRAZIL; (2) Universidade de São Paulo/ESALQ, Piracicaba, São Paulo, Brazil
Cereal Foods World 54:A64

The process for the production of resistant starch (RS) from chick-pea (*Cicer arietinum*) starch using hydrothermal treatment and agents for reducing molecular weight were evaluated. Starch in native and gelatinized forms were or were not submitted to acid (HCl 2M for 2.5 h) or enzymatic hydrolysis (pululanase, 40 U/g for 10 h), autoclaved (121°C/ 30 min.), stored (4°C/ 24 h) and lyophilized. The natural starch showed amylose content of 29.2% and an amount of 31.9% of RS, the latter being reduced after hydrothermal process and cooling to 16.4%. This is because the heat processing destroys most of the RS type 2 in the starch samples due to natural loss of granular structure, but produces RS type 3 due to retrogradation. The previous starch hydrolysis increased the RS levels to values between 19.8 and 32.3%, and the enzymatic treatment with gelatinized starch was the most efficient. RS showed increases in the water absorption and water solubility rates due to the hydrolytic and thermal process. The process for the RS production altered the starch crystallinity pattern from C to B and the relative crystallinity from 42% to values between 29.1 and 45.6%. Comparing RS submitted to hydrolysis with that not submitted to it (control RS), an increase in crystallinity was observed due to the greater retrogradation caused by the reduction of molecular weight. The control RS presented an initial viscosity greater than natural starch because it is a pre-gelatinized starch and also due to its greater tendency to breakdown and retrogradation. RS obtained from hydrolysates showed a reduction in viscosity, indicating the breakdown of molecules. The viscosity showed to be inversely proportional to the RS level in the sample. The gelatinized starch hydrolyzed by the debranching enzyme showed to be the most interesting to obtain RS. Acknowledgments: FAPESP.

The effect of bubbles on dough relexation

M. G. SCANLON (1), Y. Fan (1), J. H. Page (1)
(1) University of Manitoba, Winnipeg, MB, CANADA
Cereal Foods World 54:A64

Dough is a rheologically complex material, as its viscoelasticity leads to a strain-history dependence for its measured rheological properties. This complexity affects the measured rheological properties of dough subsamples either in the lab or on the process line. This study used ultrasound to examine the role of bubbles in relaxation of dough. An ultrasonic wavelength was chosen that allows characterization of contributions from both bubbles and dough matrix to the overall measured properties of the dough. Lean formula doughs were mechanically developed using a hard red spring wheat flour. Doughs were mixed at atmospheric pressure or under vacuum (0.06 atm) for 5.5 minutes (optimal mix time for the air-mixed dough). Mixing under vacuum substantially reduced the number of bubbles in the dough. The time-dependent changes in the transit time and amplitude of ultrasonic pulses propagating in dough samples that were subjected to a series of compressive and tensile stresses were recorded. In air-mixed doughs, the patterns of change in both ultrasonic parameters strongly depended on the compressive strain that the dough was subject to. Since the patterns of change in transit time and amplitude were markedly different in air-mixed doughs to those that had been mixed under vacuum, bubbles appear to have a substantial effect on the short-time (less than 30 minutes) relaxation behaviour of air-mixed dough samples. Longer-time relaxation behaviour was evident in both air and vacuum-mixed doughs, but again, contrasting patterns were observed for doughs created under the two headspace pressures. These results imply that compressive loading analyses of dough relaxation that focus exclusively on the behaviour of gluten polymers may be incomplete if the effect of bubble compression is overlooked.

Adiabatic compressibility measurements on gliadin solutions

M. SCANLON (1), Z. Zhang (1)
(1) University of Manitoba, Winnipeg, MB, CANADA
Cereal Foods World 54:A64

The gliadins, which comprise about 50% of the gluten proteins, are associated with some of the functional properties of dough made from flour. The objective of this study was to characterize the physical properties of dilute solutions of wheat gliadins to ascertain the effects of solvent on the compressibility of the gliadin molecules with a view to gaining insights into gliadin molecular structure. Crude gliadin fractions were extracted from hard red spring wheat flour using 70% (v/v) aqueous ethanol. Solvent was removed by aspiration and lyophilisation so that serial dilution solutions of the crude gliadins of known concentration could be prepared in 62.65% (w/w) aqueous

ethanol or dilute aqueous acetic acid. High-precision density and ultrasonic velocity measurements were performed at 20°C to characterize the volumetric and compressional properties of the fractionated protein solutions. Good linear relations between solution density and concentration, and between ultrasonic velocity and concentration, were observed. From these relations, the partial specific adiabatic compressibility of the gliadins in each solvent could be calculated. The gliadins had a small value for this coefficient in both aqueous ethanol and aqueous acetic acid. Differences in the values of the coefficient of partial specific adiabatic compressibility of the gliadins in the two solvents suggested that the gliadin molecules had looser structures in the aqueous acetic acid than in the aqueous ethanol. A possible reason might be the difference in interaction between hydrated gliadin molecules and the solvent molecules. The significance of the results is that precise density and ultrasonic measurements can indicate the nature of wheat gluten protein interactions.

The anti-oxidation effect of polylysine in emulsions containing poly-unsaturated fatty acids

S. Scheffler (1), X. WANG (1), F. San Martin (1), Y. Yao (1)
(1) Purdue University, West Lafayette, IN, U.S.A.
Cereal Foods World 54:A65

In this presentation we will report a novel finding of polylysine in terms of its anti-oxidation properties in food emulsions. Polylysine (ε-Poly-L-lysine) is a polypeptide of L-lysine and is produced by the fermentation of *Streptomyces albulus*. It has been used as a food-grade (GRAS) antibacterial polypeptide, as well as a dietary agent to suppress fat absorption. However, the function of polylysine to reduce the lipid oxidation in oil-in-water emulsions has not been reported. In our study, the anti-oxidation effect was examined for emulsions in which polylysine was added before or after emulsification. Firstly, we prepared phytoglycogen octenyl succinate (PG-OSA) and waxy corn starch octenyl succinate (WX-OSA) with different degree of substitution (DS) (around 0.015 and 0.048). Thereafter, the emulsions were formed using 2.5% fish oil and 5% PG-OSA, WX-OSA, or gum arabic, or 0.5% of Tween20. Polylysine was added before or after the homogenization (Nano DeBee, two cycles at 5000 psi). Emulsions without polylysine were prepared as references. All emulsions were stored at 55°C, and the extent of oxidation was measured at 0, 2, 4, 6 and 8 days of storage. The results indicated that the addition of polylysine before emulsification resulted in a substantially improved anti-oxidation effect compared with the groups without polylysine or with polylysine added after emulsification. We consider that the polylysine absorbed at the oil-water interface may form a positively charged barrier. This barrier reduces the permeation of pro-oxidative factors, such as metal ions, from the water phase to the oil phase, thus reducing the oxidation of lipophilic compounds in oil. This study would allow us to broaden the application of polylysine as a food ingredient, and to seek new strategies to improve the qualities of foods containing polyunsaturated fatty acids.

Effect of isolated rye pentosans on some properties of gluten-free breads

J. Schmidt (1), K. Hanz (1), E. Brenner (1), S. Theiß (1), E. BERGHOFER (1)
(1) University of Natural Resources and Applied Life Sciences, Division Food Technology, Vienna, AUSTRIA
Cereal Foods World 54:A65

Rising incidence of celiac disease is mirrored in an increasing demand for gluten free bread. Gluten free bread nowadays available lags behind in terms of taste, texture and appearance. Hence, this work was aimed at applying soluble and enzymatically degraded rye arabinoxylans as a "natural" bread improver for gluten free amaranth-, maize-, rice- and, in particular, gluten-free wheat starch-bread. Soluble arabinoxylans isolated out of rye flour in semi-industrial scale (hereby achieving a purity of 75%) were employed for sour-dough baking trials with (combinations of) above mentioned raw materials aimed at testing arabinoxylan addition of up to 15%. Experiments were supervised by determination of dough characteristics such as viscosity (Rapid ViscoAnalyzer), elasticity and stickiness (TA.XT2i, Stable Micro Systems, SMS/Chen-Hoseney Dough Stickiness Rig) and following bread characteristics: bread volume (rapeseed volumimeter), crust appearance and crumb pore size (image analysis, Olympus SZ-CTV, Japan), hardness, elasticity and chewiness (TA.XT2i, Stable Micro Systems, compression test with relaxation), brightness (Micro Color Dr. Lange, L*a*b*-system) and sensory attributes. Indeed, for some receipts, a remarkable improvement in bread volume, crust appearance and crumb pore size could be reached by pentosan addition of 5% only. Surprisingly, 5% pentosan addition was even able to replace a commercially available emulgator (DATEM) regarding its effect to increase bread volume. Furthermore, pentosan enriched bread showed significant reduction in hardness and brightness compared to control.

Effect of Capsicum powder on breadmaking properties

M. SEGUCHI (1)
(1) Kobe Women's University, Suma-Ku Kobe, JAPAN
Cereal Foods World 54:A65

Fruits of Capsicum species such as Paprika (*Capsicum annuum cv*.), Tomapi (*Capsicum annuum subsup. annuum var pomiferum*), Pimento (*Capsicum annuum* var. *angulosum*), and Cayenne (*Capsicum annuum L*.) were crushed, freeze-dried and blended with wheat flour for breadmaking. It is known that breadmaking properties such as bread height (mm) and specific volume (cm^3/g) are increased by the addition (8%) of every mature fruit of the Capsicum species. Among Capsicum species, different growth to maturity stages of Paprika was used for breadmaking. Breadmaking properties increased with increasing growth period. Bread height and specific volume baked with green Paprika/flour were lower than those of controls. When the green Paprika was heated in an autoclave (127°C, 100 min), the breadmaking properties with the heated green Paprika matched those of controls, which suggested that the decrease of breadmaking properties by green Paprika was due to protease. Size-exclusion high performance liquid chromatography (SE-HPLC) profiles of flour proteins extracted from wheat flours mixed with unheated and heated Paprika also suggested the presence of protease in green Paprika. When red Paprika (carotenoids were measured) was heated under the same conditions, the color of red Paprika changed to brown color and the breadmaking properties did not change but increased slightly. Suspension of the heated red Paprika was taken into a dialysis tube and dialyzed against water, and the water after dialysis was concentrated to syrup at 60°C. The concentrated syrup and dialyzed suspension in dialysis tube were blended with wheat flour, respectively, and breadmaking was performed. The results indicated that the improvement of breadmaking properties was occurred in the dialyzed outer solution, which was heat stable and low molecular weight materials from red Paprika. This suggested that the water insoluble carotenoid was not related to breadmaking properties.

Starch digestion of various noodle products in Korea

T. SEO (1), J. Han (2), S. Lim (1)
(1) School of Life Sciences and Biotechnology, Korea University, Seoul, SOUTH KOREA; (2) Department of Foodservice Management and Nutrition, Sangmyung University, Seoul, SOUTH KOREA
Cereal Foods World 54:A65

The *in vitro* starch digestibility of five typical Korean noodle products (total market share 99.8%, in the year 2000) were compared after cooking under the manufacture's recommended conditions. Those included spaghetti (durum wheat semolina 100%), *dangmyeon* (sweet potato starch 100%), *naengmyeon* (sweet potato starch 85% and buckwheat flour 15%), *ramyeon* (wheat flour 83%, potato starch 11%, acetic acid corn starch 6%, fried instant noodle) and *somyeon* (wheat flour 100%). Digestibility was determined using the method described by Englyst *et al*. with minor modifications. Based on their digestion rate, different fractions of starch were quantified. The spaghetti contained the highest amount of slowly digestible starch (SDS, 43%) and the lowest amount of rapidly digestible starch (RDS, 52.5%). On the contrary the *somyeon* contained the lowest amount of SDS (9.6%) and the highest amount of RDS (86.8%). Also the glycemic indices (GI) of the samples were estimated using Goñi' *et al*. method with white bread as the reference. The spaghetti had the lowest GI (87.8), whereas the *somyeon* had the highest GI (93.0). The kinetic constant (k), representing the rate of hydrolysis at initial digestion stage, was highest in the *somyeon* noodles (0.12^a), followed by *naengmyeon* (0.10^b), and was lowest in the spaghetti (0.04^e). However, the concentration of starch (C_∞) hydrolyzed over 2 hours was not significantly different between the *somyeon* (96.40^a) and the spaghetti (96.22^a), indicating that different digestion behaviors occurred in each type of noodle, even though the amounts of digested starch were similar. The *dangmyeon*, *naengmyeon* and *ramyeon* noodles showed relatively lower C_∞ values than the spaghetti and the *somyeon* noodles. The digestibility differences among the noodles were attributed to differences in their flour compositions and manufacturing processes. Finally, the SDS contents and GI values of the noodles were highly correlated with the kinetic constant k.

Effects of dietary oil on reducing starch digestive rate of cooked starchy foods

S. SETIAWAN (1)
(1) Iowa State University, Ames, IA
Cereal Foods World 54:A65

Slowly digestible starch (SDS) is known to have many benefits for human health, including reduced postprandial glycemic and insulin responses. The objective of this study was to reduce the digestive rate of starch by mixing starchy food with triglycerides using dietary oil as a source of the triglyceride. Different concentrations and dietary oils with different fatty acid (FA) compositions were used for this study. Long-grain rice, consisting of 75.2% starch (db), was mixed with dietary oil at 10, 20, 30% (v/v, db), stored overnight at the ambient temperature, and cooked with two volumes of water using a microwave rice cooker (Progressive GMRC, Boston, MA). The presence of different concentrations of dietary oil reduced the starch hydrolysis of the cooked rice. For example, starch hydrolysis, using porcine

pancreatic alpha-amylase, decreased from 99.3% to 90.4%, 82.5%, and 81.1% (on starch db) after 1 h in the presence of 0%, 10%, 20%, and 30% dietary oil, respectively. Stearic acid (SA), palm oil (PO, 64.1% saturated FA), 80% diacylglycerol oil (DAG, 59.5% PUFA) and corn oil (CO, 55.6% PUFA) were used at 20% (v/v) to represent lipids of different structures and compositions. Among dietary oils, the rice sample treated with CO showed 15.9% reduction in starch hydrolysis, DAG, which has one fatty acid chain missing on the C-2 position, showed 9.7% reduction, and PO showed 4.7% reduction. In comparison, a rice sample treated with stearic acid showed 56.7% reduction in starch hydrolysis. These results showed that dietary oil with a larger content of unsaturated fatty acid had more impact on the reduction in starch digestibility. The mechanism of starch-triglyceride interaction will be presented. Enzyme digestibility of the cooked rice samples stored at 4°C for 48 h showed that the addition of dietary oil reduced starch retrogradation.

Protective role of L-carnitine in albino rats treated with different concentrations of acrylamide

E. S. SHAKER (1)
(1) Minia University, Minia, EGYPT
Cereal Foods World 54:A66

L-carnitine (4-*N*-trimethylammonium-3-hydroxybutyric acid) has proved to be found in human nutrition and also synthesized from dietary amino acids. Carnitine was considered to be one of the important natural products, since it was found to form esters with fatty acids for transport across the mitochondrial membrane. Carnitine has many features, since it is widely distributed in the body. The research works on the ability of carnitine in protecting against acrylamide the neurotoxicant and carcinogen. L-carnitine (300 mg/kg bw) has a positive result against 50, 200 and 500 mg acrylamide/L). Liver function, lipid profile, antioxidant content, reduced glutathione, vitamin C, glucose content and cholinesterase activity have been investigated up to 5 weeks.

Effect of different compositions and mixing conditions on bread dough expansion determined by video image analysis

A. SHEHZAD (1)
(1) National Institute for Agronomic Research (INRA), Nantes, FRANCE
Cereal Foods World 54:A66

The objective of this study was to develop a method for determining dough porosity during fermentation in order to finally determine the influence of mixing conditions and dough composition. To achieve this, the modifications of cellular structure during fermentation resulting from growth and coalescence of bubbles were observed by digital camera and analyzed in terms of porosity and stabilization, by expansion and shape data recording, respectively. The evolution of porosity reflected the fermentation kinetics, governed by yeast action and to a lesser extent the difference of dough rheological properties. These results were also favorably compared with those obtained by X-ray tomography. Stabilization was more influenced by rheological properties, as shown by the influence of mixing conditions at different energy levels. This study helps to predict the changes of dough structure, and especially the occurrence of bubble coalescence within the dough, which in turn may affect final crumb grain.

Diffusion and rheology characteristics of arabinoxylan solutions and implications for digestion

K. J. SHELAT (1), A. Aufort (1), T. M. Nicholson (2), K. Wong (1), R. G. Gilbert (3), M. J. Gidley (1)
(1) Center for Nutrition and Food Science, University of Queensland, St. Lucia, QLD, AUSTRALIA; (2) Centre for High Performance Polymers, University of Queensland, St. Lucia, QLD, Australia; (3) Centre for Nutrition and Food Science, University of Queensland, Brisbane, QLD, Australia
Cereal Foods World 54:A66

Non-starch polysaccharides such as arabinoxylans (AXs) have important roles in the human diet, resulting in potential benefits such as increased microbial fermentation, promotion of beneficial microflora, prevention of re-absorption of bile acids leading to lower plasma cholesterol, and retardation of starch digestion. The latter two beneficial effects may arise from viscosity or diffusion phenomena contributed by arabinoxylan in the gastro-intestinal tract. In order to model the factors that may determine diffusion of e.g. alpha amylase or bile acid micelles in the presence of arabinoxylan, diffusion coefficients of a dextran probe in solutions of three AXs of different viscosities were measured over a wide concentration range using fluorescence recovery after photobleaching (FRAP). The diffusion coefficient of the dextran probe decreased with increasing concentration, as expected, but surprisingly showed an increase with increasing bulk viscosity of the different AX samples. This is the opposite trend to that expected from Stokes-Einstein diffusion of hard spheres. Marginal deviations from the Stokes-Einstein equation have been observed in many polymer solutions and are usually explained by the concept of microviscosity, in which the probe particle samples a volume where the viscosity is different from the experimentally measured bulk or macroscopic viscosity. This is the first time that anti-Stokes-Einstein behavior has been observed in polysaccharides. A detailed rheological study and size measurement experiments confirmed the presence of variable size aggregates and topological entanglement in the system, consistent with anti-Stokes-Einstein behavior. This has implications for understanding beneficial effects of non-starch polysaccharides in the human diet.

Iodine binding of amylopectin to explore the flexibility of internal chains

X. SHEN (1), E. Bertoft (2), G. Zhang (3), B. Hamaker (1)
(1) Purdue University, West Lafayette, IN, U.S.A.; (2) Åbo Akademi, Turku, Finland; (3) Jiangnan University, Wuxi, Jiangsu, China
Cereal Foods World 54:A66

Previous studies found that the proportion of long chains of amylopectin is correlated to its functional properties. The internal chains of amylopectin were suspected to contribute to this correlation. The purpose of this study was to test the ability of the internal chains to form helices for other intra- or inter-molecular interactions. Waxy and ae waxy corn starches were hydrolyzed by β-amylase for varied periods of time (0, 1, 5, 30 min, and 1, 3, 5, 24 and 48 h) to incrementally remove the external chains from amylopectin. The resulting β-dextrins were then exposed to iodine solution. The absorbance and the maximum wavelength of these mixtures at different holding times (0, 30, 60 min and 24 h) were recorded. Results showed that there were two binding types involved in the iodine-amylopectin interaction: iodine-external-chains and iodine-internal-chains. The former binding resulted in a higher λmax, while the latter in a lower λmax (around 530 nm). In the native molecule, iodine preferentially binds to external chains. After a small extent of hydrolysis, the amount of external chains decreased, resulting in lesser binding with iodine. With the continuous hydrolysis, more internal chains were exposed and apparently had more flexibility to bind iodine. During holding, all the β-amylase hydrolyzed samples lost their absorbance quickly. The binding of iodine to external chains was, thus, more stable than binding of iodine to internal chains. Also, at the beginning of iodine binding, the absorbance of waxy corn starch samples hydrolyzed for 5 and 24 h was similar to that of the native sample without β-amylase hydrolysis. This indicated that the amount of iodine binding to the internal chains was quite large. Therefore, internal chains have the flexibility to form helices under certain conditions, i.e. partial removal of external chains.

Whole and sprouted wheat dough properties and pasta quality

D. SHNEIDER (1), A. Moiseeva (1), I. Moiseev (2), D. Shneider (1)
(1) Moscow State University of Technology and Management, Moscow, Russia; (2) Harrisburg, PA, U.S.A.
Cereal Foods World 54:A66

Sprouted wheat had different dough structure compare to whole wheat. Dough water-absorption capacity reduced from 56.6 to 53.4%, dough formation period decreased from 7.5 to 4 min in general, dough stability fell down from 4.5 to 2.0 min, and dough liquefaction increased from 40 to 120FU. Flour mixing of sprouted or whole wheat produced homogeneous fine-friable dough mass and pressed into homogeneous pasta, which was free from traces of undermixing. When moisture content of whole wheat dough increased from 28 to 35.0%, pasta press reached maximum production rate and then fell down at 36% moisture level or above. The maximum press production rate of whole wheat pasta was at 34–35% moisture range. At lower moisture content dough from sprouted wheat required longer relaxation period, which affected pasta press performance. Pasta made from sprouted wheat in comparison to whole wheat had lower water-absorption capacity of 167.9 vs. 169.0%, lower cooking water free starch of 7.88 vs. 7.92%, higher plasticity of 0.326 vs. 0.259 mm and elasticity of 0.508 vs. 0.572 mm (n = 50). Pasta from sprouted wheat had sweetish malt flavor and aftertaste, when the whole wheat pasta had well-expressed bran flavor and aftertaste.

Addition of soy increases soft pretzel dough stability during frozen storage

A. SIMMONS (1)
(1) Ohio State, Columbus, OH, U.S.A.
Cereal Foods World 54:A66

Due to the increasing demand of soy containing foods, a highly acceptable frozen dough that delivers more than 5 g soy protein/serving would be of great benefit. However, soy incorporation in such a high level has resulted in deleterious effects on the quality and acceptability of baked products. Additionally, freezing the dough can pose significant challenges for quality of the final, baked product. Our objective was to characterize the changes in the physico-chemical and molecular properties of dough upon soy addition and after frozen storage and compare these to controls. 100% wheat dough and 25% soy dough were analyzed fresh and after being frozen at –25°C for 2 or 4 weeks. Thermal, textural and molecular (NMR) techniques were used to

characterize the changes in the wheat and soy dough during frozen storage. Soy dough had a higher amount of total water than 100% wheat dough and neither moisture contents change significantly after being frozen for 2 or 4 weeks. "Freezable" water represented a higher proportion of total water in soy dough than in wheat dough. The proportion of "freezable" water increased with increasing frozen storage time due presumably to the migration of water from a protein-bound state to ice crystals. Although the extensibility of the wheat dough decreased dramatically during 4 weeks of frozen storage due to the destruction of the gluten matrix, the extensibility of soy dough did not change significantly. Proton T1 relaxation times were higher in wheat dough vs. soy dough indicating lower 1H (associated with water) mobility. T1 values for both types of dough decrease with frozen storage time as ice crystals formed. In conclusion, soy dough is more stable during frozen storage than wheat dough suggesting that soy provides a functional advantage for frozen dough use additional to the perceived health benefits.

Psychosocial factors that influence whole grain bread consumption

S. A. SJOBERG (1), L. F. Marquart (1), M. Reicks (1)
(1) University of Minnesota, St. Paul, MN, U.S.A.
Cereal Foods World 54:A67

The purpose of this study was to apply the theory of planned behavior (TPB) to predict intention and consumption regarding 100% whole grain breads. Focus group interviews were conducted based on the TPB to inform the development of a questionnaire related to whole grain bread consumption. The questionnaire was pilot tested, modified, and administered to bread consumers (n = 270) at local grocery stores. Initially, subjects indicated their preference for whole grain or refined white bread, completed a food frequency questionnaire to estimate bread consumption, and listened to a 5-minute scripted lesson on whole grain breads. The questionnaire included items scaled to measure attitudes, subjective norms, perceived behavioral control, intention and behavior associated with whole grain bread consumption. Positive attitudinal factors included the perception that whole grain breads were healthy, hearty and robust. Family members were an important social influence on intentions. Influential control beliefs included "everyone eats white bread", "pieces of grain are hard to chew" and "one does not like to use whole grain bread for toast". Mean whole grain bread intake was 1.75 servings per day. Whole grain bread consumption was higher among subjects who preferred whole grain bread compared to those who preferred refined white bread. Subjects who preferred whole grain bread also had more positive attitudes, and greater perceived behavioral control and normative pressure toward whole grain breads than subjects who preferred refined white bread. The TPB provided a basis for understanding barriers and motivators that influence whole grain bread consumption.

Resistant starch generated from normal corn starch: The synergistic effect of acid treatment, autoclave, and beta-amylolysis

W. SONG (1), Y. Yao (1)
(1) Purdue University, West Lafayette, IN, U.S.A.
Cereal Foods World 54:A67

Resistant starch (RS) has been recognized as a beneficial ingredient intake in food. Mostly, RS is produced from high amylose starch due to a high yield. To expand the applications of RS, using low-cost starch sources, such as normal corn starch (NCS), is desirable. In an earlier study, we established an RS-enriching process in which NCS was autoclaved and subsequently treated using beta-amylase. In the current study, we further explored the enrichment of RS based on the synergistic effect among acid treatment, autoclave, and beta-amylolysis. NCS was treated by 1% HCl for 2, 5, 10, and 20 hours at 55°C. After neutralization and desalting, the starch materials were autoclaved for 3 cycles and followed by beta-amylolysis (beta-amylase 0.5% based on dry starch, pH 5.5, temperature 55°C, 20 hours). After beta-amylolysis, the starch solid was collected and the *in vitro* digestibility was analyzed using Englyst assay. Native NCS showed an RS content around 2.9%. For autoclaved and beta-amylase treated starch, the RS content was 15.8%, 22.6%, 27.8%, and 36.8% in corresponding to 2, 5, 10, and 20 hours of acid treatment, respectively. Conceivably, acid treatment partially degrades starch molecules and increases the mobility of linear chains during autoclave, leading to enhanced retrogradation. This effect, in synergy with enriched alpha-1,6 glucosidic linkages due to beta-amylolysis, resulted in a much reduced starch digestibility and increased RS content.

Effect of dough conditioners on small and large deformation behavior of wheat flour doughs

S. L. STEEPLES (1), H. Dogan (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A67

Rheological properties are significant in determining the behavior of wheat flour doughs during breadmaking and in end product quality. The objective of this study was to characterize the effect of dough conditioners on small and large deformation behavior of wheat flour doughs. Karl 92, hard red winter variety commonly grown in Kansas, was milled in a Buhler mill to produce straight grade flour of 12.6% protein. A reduced-protein flour (8.0%) was prepared by adding wheat starch. Additives used were α-amylase (CAS No: 9001-19-8) at .02 and .05IU, transglutaminase (CAS No: 80146-85-6) at 1 and 5IU, and xylanase (CAS No: 37278-89-0) at 1 and 10IU, and DATEM (CAS No: 100085-39-0) at 0.3 and 1%. AACC method 10-10B was used to prepare doughs. Dough was characterized with and without additives. Farinographs determined water absorption, and mixographs established optimal dough development time. D/R dough inflation system was used for biaxial extension measurements at large deformations to determine strain hardening indices. Small deformation oscillatory experiments used the ViscoAnalyser 50 (Rheologica Instruments) equipped with a serrated parallel plate of 25 mm diameter and 3 mm gap. Stress sweeps from 0.5 to 500 Pa at a frequency of 1 Hz, performed at room temperature, determined the linear viscoelastic region. Frequency sweeps were performed from 0.1 to 100 Hz at a strain rate of .0005 to generate w-dependent profiles of storage (G′) and loss (G″) moduli, and tan d at room temperature. The loss modulus, G″ was always lower than G′, showing a predominant elastic behavior, and followed similar trends in the presence of additives. G′ and G″ values increased from 1×10^{-3}–0.5×10^{-4} to 0.4×10^{-4}–1.1×10^{-4} Pa at higher additive levels. Effects of additives on dynamic rheological properties were more marked in reduced-protein doughs. Observed phase angle values decreased 5–10 degrees with additives present in both dough systems indicating more elastic behavior.

Evaluating sugar-snap cookie quality using digital image analysis

S. G. STEVENSON (1), P. Y. Fok (2), N. M. Edwards (2)
(1) Canadian Grain Commission, Winnipeg, MB, CANADA; (2) Canadian Grain Commission/Grain Research Laboratory
Cereal Foods World 54:A67

The AACC baking quality of cookie flour method 10-50D is a standard method performed to predict the general quality of soft wheat flour for use in cookies and pastry. High quality soft wheat flour is generally associated with larger sugar-snap cookie diameter (cookie spread). Subjective visual examination of the surface for degree of crackling, color and uniformity is also used as an indicator of the cookie making quality of the flour. The C-Cell imaging system was developed to measure characteristics such as surface topography, crumb structure and product dimension in bread and baked products hence, it seems logical to apply this technique to scoring of sugar-snap cookies. Investigations were conducted using 9 samples of commercially obtained Canada Western Soft White Spring wheat that were milled in duplicate. Cookies were assessed for diameter (D), thickness (T) and spread ratio (D/T). The surface was scored visually for appearance, color, uniformity and a total score assigned. Three cookies from each test bake were assessed using the C-Cell imaging system. As expected, cookie diameter and spread ratio were readily predicted by C-Cell measures of overall sample dimension. Cell related measures of contrast and number of cells were negatively related to visually assessed quality characteristics for appearance, color, uniformity and total score. Cell related measurements of wall thickness, diameter and volume demonstrated a strong positive relationship to visually assessed characteristics. It appears that the C-Cell imaging system is capable of providing rapid and accurate objective measurements of sugar-snap cookie quality.

Application of extruded whole grains as functional food in baking and extrusion technology

V. STOJCESKA (1), P. Ainsworth (1), A. Plunkett (1)
(1) Manchester Metropolitan Univ, Manchester, UNITED KINGDOM
Cereal Foods World 54:A67

Consumption of whole grains has been associated with a lower body mass index and a decreased risk of chronic diseases such as diabetes, obesity and heart disease. In addition to total dietary fibre (TDF), various phytochemicals, vitamins and minerals have been suggested to contribute to the health effects of whole grain foods. Among the cereals used for human food, iron is present at higher levels in teff, quinoa and buckwheat. Most of these grains, which contain higher levels of iron and other minerals do not contain a high amount of TDF. Extrusion parameters such as screw speed, material temperature, pressure and residence time can be changed to overcome these challenges. The objective of this work was to improve nutritional characteristics of whole grains by using extrusion technology. Whole grains were extruded using a twin-screw extruder at optimum process conditions such as screw speed, solid feed and water feed, finely milled and then used as potential functional ingredients in baking and extrusion technology. A number of different nutritional parameters such as iron, protein, TDF and polyphenol content were measured before and after extrusion. The results clearly showed that in pre-extruded samples a large variation was found in iron, TDF, protein and phenol content among all the whole grains examined. The iron content of teff was significantly ($P < 0.05$) higher while protein and fiber content significantly (P

< 0.05) lower when compared with that of buckwheat and quinoa. The phenolic compounds were significantly ($P < 0.05$) higher in buckwheat than teff and quinoa. Extrusion cooking significantly ($P < 0.05$) increased the iron and TDF level in all the samples, increased phenolic compounds in quinoa and decreased in teff and buckwheat but did not affect protein content. The effect of extruded powders on nutritional and textural characteristics of baked and extruded products will be discussed in details.

Influence of genotype and environment on the antioxidant activity of field pea (*Pisum sativum*) grown in Canada: A comparison of two analytical methods

M. D. STOUGHTON-ENS (1), D. Hatcher (1), N. Wang (1), T. D. Warkentin (2)
(1) Canadian Grain Commission, Winnipeg, MB, CANADA; (2) Crop Development Centre, University of Saskatchewan, Saskatoon, SK, Canada
Cereal Foods World 54:A68

Six field pea (*Pisum sativum*) varieties from five different growing locations in Saskatchewan in the 2006 and 2007 growing years were analyzed to determine the effect of genotype, environment and year on the antioxidant activities (AOX) using the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH). The conventional cuvette method and a modified microplate based system were compared. Both methods showed a significant effect of the genotype ($p < 0.05$) and location ($p < 0.05$) on AOX with a larger, significant effect of genotype and environment interaction ($G \times E$) ($p < 0.0001$) that was apparent in the 2007 and 2008 growing years. Growing year did not have a significant on AOX. Although there was some variation in the resulting AOX values between the two methods, these differences were found not to be statistically significant by means of a folded F-Test. These findings could potentially allow plant breeders, food scientists and nutraceutical manufacturers to manipulate field pea genotypes and growing conditions to attain an ideal antioxidant profile for use in functional foods and nutraceuticals. These results also indicate that a microplate may be used in place of cuvettes to determine AOX using the DPPH free radical to increase testing speed and reduce the amount of sample and reagent used.

Development and characterization of a functional material of low digestibility of starch for be used in food processing low glycemic index

T. SUAREZ-DIEGUEZ (1), G. Palma-Orosco (2), N. Guemes-Vera (3), J. Mendoza-Perez (2)
(1) Area Academica de Nutricion del Instituto de Ciencias de la Salud de la UAEH, Pachuca de Soto Hidalgo, Mexico; (2) Escuela Nacional de Ciencias Biologicas del IPN; (3) Centro de Investigaciones en Ciencia y Tecnologia de los Alimentos del Instituto de Ciencias Agropecuarias de la UAEH
Cereal Foods World 54:A68

The Legumes occupy an important place in human nutrition, in Mexico they are the primary source of dietary carbohydrates, besides cereals. The legumes are good sources of slow release carbohydrates because they contain about 30–40% of amylose compared to cereals. As a consequence of poor starch digestibility, legumes promote slow and moderate post-prandial glucose and insulin responses, is considered beneficial in the treatment of diabetes and hyperlipidemia. The purpose of this research is to develop a functional material of low digestibility of starch from beans (Flor de mayo M38), increasing the amount of slowly digestible starch (SDS) and resistan starch (RS), for being used in food processing low glycemic index. The starch samples with a range of SDS and RS were obtained by hydrolyzing with pullulanase in order to achieve an enzyme: substrate ratio of 1:15, 1:20 and 1:30 at different time periods (12 and 16 h) and then heated and cooled at 2°C for 3 days to form a precipitated polymer. The maximum SDS and RS content was obtained by debranching for 12 h with relationships 1:20, there were 31% SDS and 53% RS. The X-ray diffraction pattern for the treated samples, shown Crystalline polymorphism in varying proportions. The diffraction pattern of treated starch at optimal conditions correspond to a composite of the B-type crystalline structure and V-form of amylose-ethanol or amylose-lipid complex, and contain a ordered crystalline structures. In differential scanning calorimetry thermograms, the melting temperature and enthalpy of treated starches were gradually enhanced, this could represent the melting of a crystalline structure composed of longer chains of amylopectin resulting from reforming of doublé helix structure by low temperature recrystallization. These changes showed that variation in enzymatic debranching, retrogradation among the amount in the ratio of amylose / amylopectin starch of beans.

Effect of temperature on gelatinized starch solutions with different amylose/amylopectin content

R. SULAIMAN (1), K. D. Dolan (1), J. F. Steffe (1)
(1) Michigan State University, East Lansing, MI
Cereal Foods World 54:A68

Rheological properties of starch gelatinization are very important in food formulation. The most common empirical instrument used is the RVA. In this study an alternative way of measuring of starch gelatinization was presented by using a modification of the Brookfield viscometer. The equipment set-up consists of a Brookfield viscometer, connected to three constant temperature water baths (100°C, –5°C, and 60°C) and controlled by using a system of solenoid valves with a timer. Mixer geometry configurations with 13cc cup and flag impeller were used. Cornstarch samples (Amioca, Melojel, Hylon V, Hylon VII) from National Starch, NJ at different ratios of apparent amylose/amylopectin (0:100, 27:73, 50:50 and 70:30, respectively) were studied. The 'peak' viscosity during gelatinization showed apparent viscosity of Amioca>Melojel>HylonV>Hylon VII with values of 4765cP, 3395cP, 427cP and 145cP at sample temperatures of 70.3°C, 82°C, 84°C and 87°C reached at heating times of 1 min 10 sec, 3 min 30 sec, 12 min and 12 min, respectively. Apparent viscosity after gelatinization (at 40°C, 50°C and 60°C) at constant speed (100 RPM) was also studied. The results shows that the ratio of activation energy to universal gas constant, (E_a/R) for Amioca> Melojel>Hylon VII> Hylon V was 1479, 2077, 4135 and 4736 K, respectively. The peak viscosity trend and temperature range obtained were in agreement with other researchers who used the RVA and DSC. In conclusion, the apparent viscosity of starch gelatinization decreased with temperature, and was more sensitive to temperature with higher amylose content. This first step of the study shows that the modified Brookfield instrument provides a reliable, low cost, flexible, and sensitive device to study the rheological properties of starch gelatinization.

Heat-induced gelation of pea protein extracted by salt method: Effect of pH and NaCl

X. SUN (1)
(1) University of Manitoba, Winnipeg, MB, CANADA
Cereal Foods World 54:A68

Gelation is an important functional property for food proteins due to its strong effect on rheological, textural and sensory properties of food. Although traditionally wheat, corn, oats and rice are considered cereal, pulse crops such as pea are also in the category of cereal. In this paper, rheological method was employed to study the influence of two important factors, pH (3.0~10.0) and ionic strength (0~2.0M), on gelation properties of a pulse crop, pea protein. The strongest gel strength was achieved at 0.3M NaCl; higher or lower ionic strengths lead to weakening of the gel. The gelation temperature was also influenced by ionic strength; salt had a stabilization effect which inhibited pea protein from denaturation and higher ionic strengths resulted in higher gelling points. At a NaCl concentration 2.0 M, pea protein gelation was completely suppressed at temperature ≤ 100°C. pH also played a very important role in gel formation of pea protein isolates since acid and base could cause protein partial or even total denaturation. In this paper the maximum gel strength was determined to occur at pH 4.0 in 0.3M NaCl; higher or lower pH values result in reduced gel strength. pH also altered the denaturation temperature of the pea protein; higher pH values resulted in higher denaturation temperature and higher enthalpy of denaturation. Gelling point peaked at around pH 6.0 (89.1°C). Increase or decrease pH decreased gelling point. Careful adjustment of pH and NaCl concentration would enable the food industry to promote utilization of pea protein isolate as a functional and nutritional additive to increase elasticity, improve sensory property and enhance nutritional value and as a substitute of soy protein.

Effect of environment on flavonoid levels in sorghum grains

V. M. TALEON (1), L. Dykes (1), L. W. Rooney (1), W. L. Rooney (1)
(1) Texas A&M University, College Station, TX, U.S.A.
Cereal Foods World 54:A68

Sorghum flavonoids are used as natural food colorants and they have antioxidant, anti-inflammatory, and anti-cancer properties. Sorghum with black, red or yellow pericarp have high levels of flavonoids. The effect of environment on flavonoid levels in three black, four red and two yellow sorghum genotypes grown in four locations in Texas (Corpus Christi, College Station, Lubbock and Weslaco) were evaluated. Sorghums from Lubbock were more weathered than those grown in the other three locations, which affected flavonoid levels. In each location, the 3-deoxyanthocyanin levels were higher in the black sorghums (147–1047 µg/g) whereas flavanones were higher in the yellow sorghums (743–1823 µg/g) with the exception of R07007 from Lubbock (309 µg/g). Among locations, flavanone levels in the yellow sorghums from Lubbock were lower than those from the other three locations which could be due to the weathering of the grain. Flavone levels were consistently higher in the tan plant red sorghum (145–394 µg/g) in all four locations. Red sorghums grown in Lubbock were weathered and generally had higher flavone levels (4–394 µg/g) than those grown in the other three locations. For all flavonoids, there was a genotype × environment interaction ($p < 0.001$), which suggested that environment had an effect on flavonid levels.

Relating wheat starch A- and B-type granule reactivity to molecular reaction patterns on derivatized starch chains

V. THIRUGNANASAMBANTHAM (1), H. Kim (1), K. C. Huber (1)
(1) University of Idaho, Moscow, ID, U.S.A.
Cereal Foods World 54:A69

This study investigated the molecular bases for reactivity differences between wheat starch genotypes (normal vs. waxy), granule types (A- vs. B-type), as well as the possible influence of protein in wheat starch reactions. Isolated normal and waxy wheat starch A- and B-type granule fractions (both native and protease-treated) were derivatized with 5-(4,6-dicholortriazinyl)-aminofluorescein (fluorescent probe) under both non-hydrated and hydrated reaction conditions. Granular reaction patterns were visualized by confocal laser scanning microscopy (CLSM), while molecular derivatization patterns on isoamylase debranched starch chains were assessed via intermediate pressure size-exclusion chromatography (IPSEC) using fluorescence and refractive index detection. CLSM images revealed that reaction locale in non-hydrated reactions was confined to external granule surfaces (i.e., surface-reacted/SR), while hydrated starch reactions permitted reagent to react throughout the granule matrix (i.e., internally-reacted/IR). For all SR and IR granule derivatives, starch material eluting in the amylose (AM) region of IPSEC chromatograms was more densely reacted than that associated with amylopectin (AP) peaks. Protease treatment had no impact on extent of reaction in SR derivatives, while A-type (relative to B-type) granule reactivity in IR derivatives was enhanced after protease treatment. For both SR and IR starch derivatives, B-type granules were more heavily reacted than A-type granules, while for IR derivatives, waxy starch granules were reacted to a greater extent than normal starch granules. In those cases where differing extents of reaction were observed between starch granule derivatives, reactivity differences could be explained on the basis of differential reaction densities on starch AM and AP branch (long, medium, and short) chains.

Sampling plans for Japanese food inspection

Y. TSUKAKOSHI (1), T. Watanabe (2)
(1) National Agriculture and Food Research Organization, Tsukuba, JAPAN; (2) National Institute of Health Sciences, Tokyo, Japan
Cereal Foods World 54:A69

Sampling plans for Japanese food inspection is studied, especially ones for cereal foods. In this poster, we summarize wide range of sampling plans. For rice inspection for grading by quality, each rice package with 30 kg seeds is inspected and sample is obtained there. Approximately, 25 g of rice grain is sampled at one motion of the sampler. It contains approximately from 1100 to 1200 rice seeds. In the sample, if the number of defect rice is 1 the rice in the package is graded as first. If the number of colored grain is 3, the grade is 2. If the number of colored grain is 7, grade is 3. Other characteristics will be also studied by the number of fault grains in the sample. For inspection for grain variety required to label the variety of rice, DNA analysis are used as secondary information. And quantities analysis was carried out by one grain method for 25 grains. Alternatively, 2, 48, 50 grains may be inspected. For qualitative analysis, 5~25 is set as limit of detection and studied for variety and blending. The ministry of agriculture, fishery and forest of Japan also studies several contaminants in rice. For cadmium, packages which contain 30 kg or 60 kg rice seed was studied and samples are randomly selected and the size is the square root of lot is randomly selected. In the General Guideline on Sampling ~28CAC/GL 50~29, such sample size does not improve precision but they are meaningful because greater sample is inspected more accurately. Thus selecting sampling plan may have to consider total exposure to the chemical or risk based approach may also be useful in the future. Those sampling plans are discussed for their statistical characteristics and validity by drawing OC curves and comparing them to other sampling plans using in foreign and international organization. We also compare the sampling plans to JAS grading system and the result of total diet study samples.

Lower fecal short chain fatty acid concentrations in rats consuming polyphenol-rich sorghum bran diets results in fewer aberrant colonic crypts

N. D. TURNER (1), S. S. Taddeo (2), J. B. Lewis (3), R. J. Carroll (4), C. M. McDonough (5), L. W. Rooney (6)
(1) Texas A&M University, College Station, TX; (2) stellat@tamu.edu; (3) jaymebethlewis@gmail.com; (4) carroll@stat.tamu.edu; (5) casstx@gmail.com; (6) lrooney@tamu.edu
Cereal Foods World 54:A69

We have previously demonstrated that diets containing bran isolated from brown and black sorghum grain produce fewer (68 and 38%, respectively, $P < 0.04$) high multiplicity aberrant crypt foci (HMACF) in azoxymethane- (AOM) injected rats, relative to a cellulose diet. The production of short chain fatty acids (SCFA), in particular butyrate, is thought to protect against colon cancer development. Therefore, the goal of this project was to determine SCFA concentrations in feces (μM/g wet feces) from rats ($n = 10$/diet) consuming diets containing 6% fiber from cellulose or from bran decorticated from white, brown (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. Total SCFA were greatest ($P < 0.0001$) for white sorghum bran (32.0 μM), intermediate for cellulose (22.6 μM), and lowest for black or brown sorghum bran (15.4 or 14.7 μM, respectively). Butyrate concentrations were highest ($P < 0.0001$) for white sorghum bran (7.8 μM) and lowest for brown sorghum bran (1.07 μM), with intermediate concentrations found for black sorghum bran and cellulose (2.7 and 3.6 μM, respectively). Differences among diets were similar when butyrate was expressed as a percentage of SCFA. There were both positive and negative relationships between aberrant crypt formation and total or individual SCFA. These data suggest polyphenols in black and brown sorghum bran are suppressing colon carcinogenesis in part through their ability to suppress SCFA production or enhance epithelial cell transport of SCFA. Funded by USDA 58-5430-5-339, NCI (CA-57030, CA-90301), and NIEHS P30-ES09106.

Evaluation of chemical, physical and wet-milling properties of commercial corn hybrids

M. URIARTE (1), C. Reyes-Moreno (2), R. Gutierrez-Dorado (3), J. Milan-Carrillo (3)
(1) Facultad de Ciencias Quimico Biologicas, Universidad Autonoma de Sinaloa; (2) creyes@uas.uasnet.mx; (3) Universidad Autonoma de Sinaloa, Culiacan, Sinaloa, MEXICO
Cereal Foods World 54:A69

Forty-one commercial corn hybrids, including yellow and white corn, from different seed companies that represent the most widely grown in Sinaloa, Mexico were evaluated for basic chemical composition, physical and wet-milling properties. Although great variability among hybrids was observed, in general, commercial corn hybrids were characterized, particularly, by high thousand kernel weights and high kernel densities (mean values of 396.5 g and 1.29 g/cm^3, respectively). Wide ranges in protein contents (8.5–12.9%) and crude free fat contents (3.9–5.8%) of corn hybrids were found. Starch yields of studied hybrids ranged from 45.0% in hybrid CML-45XCLQ to 69.5% in hybrid 8371, both yellow corn hybrids. Residual protein levels in the starches recovered were relatively low, with a mean value of 0.41%, indicating high quality of the produced starches and an adequate starch-protein separation, but this characteristic varied among genotypes and reached a maximum of 0.69% in hybrid DK 2020 Y. Gluten yields ranged from 7.2% in hybrid TG 8990 to 11.1% in hybrid H-375, that also showed the highest grain protein content.

Preparation and chemical composition of whole grain bar

R. G. UTRILLA-COELLO (1), E. Agama-Acevedo (1), P. Osorio-Díaz (1), L. Bello-Perez (1)
(1) CEPROBI-IPN, Yautepec, Morelos, Mexico
Cereal Foods World 54:A69

Whole grains are important sources of many nutrients such as dietary fibre, resistant starch, minerals, vitamins, and other compounds including phytoestrogens and antioxidants that are important in the prevention of diseases. Breads, pastas, crackers, and other flour-based products made with high amounts of whole grains, retain the benefits of these grains. The aim of this study was to prepare cereal bars with whole grains and conduct chemical composition analyses. Whole grains (wheat, barley, oats and maize) were blended in the same amount. Two maize varieties: blue (CBBM) and white (CBWM) were used. Ingredients such as butter, milk, egg, baking powder and high fructose corn syrup were added during the blending of the grains. Moisture, ash, protein, lipid, total starch (TS), available starch (AS) and resistant starch (RS) content were measured. In both samples the moisture content was low (CBBM: 1.18% and CBWM: 1.28%), typical of this product with a long shelf-life. The ash content was similar (CBBM: 2.1% and CBWM: 2.2%). The CBMM showed higher lipid and protein content (21.49% and 11.11%, respectively) than CBWM (17% and 9.29%, respectively). The TS content was 43.20% for CBWM and 42.86% for CBBM. The AS content was slightly higher for CBWM (41.38%) than CBBM (40.71%), but an inverse pattern was obtained for RS content (CBMW: 1.82% and CBBM: 2.15%). The slight differences seen between samples were due to features of the maize varieties used. These results suggested that the non-digestible carbohydrates content could be significant for both samples and could have implications in carbohydrate metabolism.

Effects of extrusion processing on sensory attributes and shelf life of whole-grain and endosperm-only flour from three maize hybrids

M. Valladares (1), S. Weier (2), S. Cuppett (1), D. RICKERT (2)
(1) Department of Food Science and Technology, University of Nebraska-Lincoln, Lincoln, NE, U.S.A.; (2) The Food Processing Center, University of Nebraska-Lincoln, Lincoln, NE, U.S.A.
Cereal Foods World 54:A69

Whole-grain (WG) and starch-rich, endosperm-only (EO) flours were each prepared from respective blue, white, and yellow maize hybrids and were

extruded to determine how the higher fiber and fat contents of the whole-grain flour would affect sensory analysis scores and shelf life of expanded corn curls. It can be concluded from initial TBA data (< 30 days storage) from a six-month shelf life study with accelerated shelf life conditions of 90°F and 90% RH that oxidation in the WG corn curls was not higher than in EO corn curls, whether curls were stored with or without modified atmosphere packaging. Overall appearance of yellow EO curls was more acceptable than for yellow WG curls, but no difference for this comparison was observed for blue or white curls. EO curls for a given hybrid were not crisper than the respective WG curls. For curls from a given hybrid, corn flavor was not different between EO and WG. Off flavors perceived in WG curls were higher than in EO curls for blue and white, but not for yellow. Overall flavor acceptability within EO and within WG was lower for blue compared to white or yellow. Overall acceptability of EO compared to WG was not different for white and yellow, but WG was lower for blue. Overall acceptability for blue was lower than for yellow or white, which were not different from each other.

Effect of high hydrostatic pressure and temperature on the structural and rheological properties of sorghum starch

K. J. Vallons (1), L. A. RYAN (2), E. K. Arendt (1)
(1) Department of Food and Nutritional Sciences, University College Cork, Ireland; (2) University College Cork, Cork, IRELAND
Cereal Foods World 54:A70

Pressure-induced gelatinisation of sorghum starch was studied and compared to heat-induced gelatinisation. Starch suspensions were treated at increasing pressure (200 - 600 MPa) or temperature (60–95°C) for 10 min. The degree of gelatinisation was determined using differential scanning calorimetry, changes in birefringence and damaged starch measurements. Furthermore, the pasting behaviour and structural changes during gelatinisation were investigated using rheology and microscopy. The pressure-induced as well as the temperature-induced gelatinisation curves were sigmoid-shaped. Gelatinisation occurred between 300 MPa and 600 MPa or between 62°C and 72°C. No significant differences were found between the rheological properties and the microstructure of the pressure-treated samples and the temperature-treated samples within the gelatinisation intervals. Granules lost their birefringence, but granular structure was maintained. However, when heated beyond the endpoint of gelatinisation, the formation of a "sponge-like" structure was observed. This change in structure at very high temperatures was reflected by a decrease in complex viscosity.

Superior new enzyme technology for emulsifier replacement in bakery products

C. VAN BENSCHOP (1)
(1) DSM Food Specialties USA, Inc., Delft, Netherlands
Cereal Foods World 54:A70

Recently, the introduction of new lipases, such as phospho/galactolipase, has enabled the bakery industry to (partial) replace emulsifiers such as DATEM. Further development in the field of enzyme technology and an improved understanding on the role of emulsifiers has now resulted into the latest development of next generation emulsifier replacer for SSL/CSL. The role of SSL/CSL in baked goods has been recognized and will be addressed with this new technology. Bread will maintain all characteristics among which the texture of fresh baked bread and the ability to have an improved dispersion of the fat in the dough, making it softer while allowing less fat to be used. This new SSL replacer, entirely based on enzyme technology, will be of help in the development of clean label formulations and ultimately will also lead to cost reduction.

Influence of mixing process on dough rheological properties

F. VAN BOCKSTAELE (1), I. De Leyn (2), M. Eeckhout (2), K. Dewettinck (3)
(1) Hogeschool Gent, Gent, BELGIUM; (2) University College Ghent, Ghent, Belgium; (3) Ghent University, Ghent, Belgium
Cereal Foods World 54:A70

Dough rheological properties are a key factor in the processing of bread products. Next to flour quality and water absorption level, also the mixing process influences dough rheological properties. However, little or contradictory information is available concerning the effect of the mixing process on fundamental rheological properties. The effect of mixer type (farinograph and pin mixer) and mixing time on dough rheological properties determined by frequency sweeps, creep-recovery and uniaxial extension experiments was investigated. A standard Belgian bread flour was used and experiments were performed on a mixture of flour and water, and on a mixture which also included salt (1.5%) and ascorbic acid (25 ppm). Mixing time and mixer type only slightly influenced G′ and G″ in the frequency sweeps. However, increasing the mixing time caused a decrease of the phase angle delta in the lower frequency range (0.1-1Hz) for both mixer types. This effect was not observed when salt and ascorbic acid were added to the doughs. The maximum creep strain of water-flour doughs decreased when mixing time was increased. Also, mixer type had a significant effect on maximum creep strain as mixing in the pin mixer caused a steeper decrease than mixing in the farinograph. Finally, the uniaxial extension tests showed that an increasing mixing time caused a decrease in extensibility for both mixer types.

Relations between sensorial crispness and molecular mobility of model bread crust and its main components as measured by PTA, DSC and NMR

N. van Nieuwenhuijzen (1), R. HAMER (1), R. Tromp (2), J. Mitchell (3), C. Primo-Martin (1), T. van Vliet (1)
(1) TI Food & Nutrition, Wageningen, The Netherlands; (2) NIZO, Ede, The Netherlands; (3) Nottingham University, Nottingham, United Kingdom
Cereal Foods World 54:A70

Consumer appreciation of brittle cellular foods, like bread crusts, depends on textural properties such as crispness. This crispy character is lost above a certain water activity. It is still unclear if it is the change in the starch or the gluten that initiates the loss of crispness. In this presentation the effect of water on the glass transition of model bread crusts is shown by using two complementary techniques: phase transition analysis (PTA) and temperature modulated DSC(TMDSC). The mobility of water was studied with nuclear magnetic resonance (NMR). Results obtained were compared with sensory analysis of the model bread crusts at different water activities. Bread crusts prepared with different flours were tested to evaluate the effect of flour composition on crispness and glass transition temperature. In addition, the glass transition temperature was determined of starch and gluten separately. Sensory crispness scores decreased with increasing a_w from 0.55 upwards. At a_w 0.70 sensory crispness was completely lost. Both DSC and PTA showed a transition point at an a_w of 0.70–0.75. NMR gave a transition point in the mobility of the protons of water at a_w 0.58. This supports the hypothesis that loss of crispness starts as a result of processes at a molecular level, before the macroscopic glass transition. This also suggests that non-bound water (water that is not directly attached to the solid matrix) causes the loss of crispness at low a_w. At higher a_w increased mobility of the macromolecules will start to play a role. Increased mobility of small components and side chains might induce increased energy dissipation upon deformation of the material resulting in less available energy for fracture propagation and with that in a less crispy product. NMR experiments on the main flour components indicate that the T_2 transition point in starch samples occurs at a lower RH than for gluten and bread crust.

Effects of protease treatment on modified dry grind processes

B. C. VIDAL (1), K. D. Rausch (2), M. E. Tumbleson (2), V. Singh (2)
(1) University of Illinois, Urbana, IL; (2) University of Illinois at Urbana-Champaign
Cereal Foods World 54:A70

The dry grind corn ethanol process produces distillers dried grains with solubles (DDGS) as the only coproduct, which is used as an ingredient in animal diets. In the US, large quantities of DDGS are generated because of recent expansion in ethanol production capacity. Fractionation of the corn kernel prior to fermentation forms the basis for modifications to the dry grind process, leading to multiple coproducts such as germ and fiber with higher market values. However, fractionation has the disadvantage of reducing ethanol yields due to starch loss from the fermentation stream; therefore, improvements in processing techniques are needed. To improve fractionation efficiency in modified dry grind corn processes, we evaluated protease treatment effectiveness in reducing residual starch in endosperm fiber. Three processes were used for the study; (1) E-Mill, wet fractionation of germ and fiber by specific gravity difference followed by no cook (raw starch hydrolysis) fermentation, (2) *dry RS,* dry fractionation of endosperm followed by no cook (raw starch hydrolysis) fermentation and (3) *dry conv,* dry fractionation of endosperm followed by sequential liquefaction and fermentation. Kinetics of free amino nitrogen production were similar in dry and wet fractionation, indicating that proteolysis was effective in all three schemes. Using protease treatment, starch in the endosperm fiber after fermentation was reduced by 1.9% w/w (22% relative reduction) in *dry conv* and 1.7% w/w (8% relative reduction) in *dry RS*, while no reduction was observed in E-Mill. Protease treatment increased ethanol production rates early in fermentation (≤ 24 hr) but final ethanol concentrations were unchanged in both *dry RS* and E-Mill. In *dry conv*, the addition of protease resulted in a decline in final ethanol concentration by 0.3% v/v, as well as greater variability in liquefaction products concentrations (glucose and maltose yields).

HCl assay for residual starch determination in corn germ and fiber

B. C. VIDAL (1), K. D. Rausch (2), M. E. Tumbleson (2), V. Singh (2)
(1) University of Illinois, Urbana, IL; (2) University of Illinois at Urbana-Champaign
Cereal Foods World 54:A70

A straightforward way to measure the effectiveness of corn kernel fractionation is by determining the residual starch in germ and fiber.

Currently, the enzymatic method is the established way for measuring total starch in cereal products (Method 76-13, AACC International 2000). However, as a tool for measuring residual starch in samples that have gone through enzymatic processes (eg, starch hydrolysis and fermentation), employing another enzyme (ie, thermostable α-amylase) does not seem ideal. A starch assay based on acid hydrolysis, referred to as HCl assay, was applied to corn germ and pericarp fiber obtained by enzymatic wet fractionation (E-Mill) and dry fractionation (3D). Grinding of germ and fiber samples increased assay precision, as indicated by a smaller pooled standard deviation in ground samples, by factors of 10 and 6.5 in 3D germ and fiber, respectively. When compared to the standard enzymatic method, referred to as MZYM assay, HCl assay results for E-Mill samples were not different, but results for 3D germ and fiber were higher by 5.3 and 4.4% w/w, respectively ($p < 0.01$). Observed bias persisted even when dimethyl sulfoxide (DMSO) was added and when 3D samples were destarched enzymatically. When destarched samples were added incrementally (spiked) with endosperm flour (83% w/w starch), HCl assay response was consistent with sample spiking as shown by assay results following expected values. Using resistant starch assay (employing pancreatic α-amylase for *in vivo* like hydrolysis conditions), results for 3D samples were not different from HCl assay results, indicating the bias likely was due to MZYM assay underestimation of residual starch content in these samples. HCl assay was satisfactory for determining starch content in fractionated corn germ and fiber and could be useful for evaluating fractionation processes to maximize starch recovery.

The ingredient wheat aleurone the most valuable fraction from the outer layer of the wheat with health and technological benefits

W. VON REDING (1)
(1) Buhler AG, Uzwil SG, SWITZERLAND
Cereal Foods World 54:A71

The pure wheat aleurone cells with its valuable dietary fibre mainly the arabinoxylans from the aleurone cell wall with a high content of antioxidants and other micronutrients shows within pre-clinical studies protective benefits for intestinal health. Process – technology - In innovative process has been developed, based on milling technology and electrostatic separation of wheat bran fractions to isolate wheat aleurone cells in high purity. Wheat aleurone - This aleurone cells isolate has now been used in a variety of studies addressing its bio-actives content, its post ingestion intestinal effects and metabolism as well as systemic effects. These studies have shown that isolated wheat aleurone is slowly but completely degraded during *in vitro* fermentation by the human microbiota (2), compared to bran of which a significant fraction remains unfermented, even after 24 hours. Because of its complete fermentation, components “entrapped in the fiber cell wall” become available for absorption. Alternatively, the microbiota may use aleurone fiber components for bio-conversion into short chain fatty acids (SCFA) and mammalian lignans, which also can be absorbed. Due to its complete fermentation, wheat aleurone results in a high production of SCFA with a relatively high amount of butyric acid (2, 3). Recent fermentation trials with human microbiota (3) revealed that aleurone significantly elevated bifidobacteria. Gut fermentation products of wheat aleurone suppresses cell growth and survival of human adenocarcinoma cells (4). 1. Hemery et al. Journal of Cereal Science 46, 327–347, 2007. 2. Amrein et al. Lebensmittel Wissenschaft und Technologie, 36 (4),451–460, 2003. 3. Mateo Anson et al. J. Agric. Food Chem. 56 (14), 5589-5594, 2008. 4. Anke Borowicki, Katrin Stein, Michael Glei, Friedrich-Schiller-University Jena 2008.

Use of iodine vapour as a tool to understand the wheat starch granule structure during maturity

R. N. WADUGE (1), K. Seetharaman (1)
(1) University of Guelph, Guelph, ON, CANADA
Cereal Foods World 54:A71

The objective of this research is to use iodine vapour as a tool to investigate the structural development of starch granules during kernel growth. Starches from hard red spring wheat (SW) and hard red winter wheat (WW) in three different maturities were isolated, and equilibrated to 0.33, 0.75 and 0.97 water activities (aw). Equilibrated starches were exposed to iodine vapour for 24 hr at the same aw, and studied for K/S spectra (the ratio of absorption and scattering coefficients), X-ray pattern and relative crystallinity. Increasing moisture content increased the polymer mobility of all starches, as indicated by different absorption maxima. Both SW and WW starches at all maturities showed characteristic A-type X-ray pattern before and after exposing to iodine. Further, iodine significantly affected the intensity of main X-ray peaks of all starches, except starches equilibrated at 0.33 aw. This effect was greater in SW starches compared to in WW starches. All starches demonstrated the formation of V-type crystallinity with iodine. All maturities of WW starches exhibited crystalline lamellae disruption effect with iodine. However, only the higher maturities of SW starches exhibited this effect, while lower maturities showed a crystalline lamellae rearrangement and/or new crystalline lamellae formation effect. However, the formation of V-type crystallites compensated the disruption of the crystalline lamellae for the total crystallinity of most starches. These observations suggested that, despite of the maturity, all the starches formed V-type crystallites with iodine and crystalline lamellae was affected by iodine. And, the ability of starch polymers to bind with iodine was strongly affected by the maturity and aw. Further, the crystalline lamellae packing of starches at early maturities were weaker than that of mature starches.

Genotypic and environmental effect on resistant starch, oligosaccharide and trypsin inhibitor activity levels in field peas (*Pisum sativum*)

N. WANG (1), D. Hatcher (1), R. Toews (1), T. Warkentin (2)
(1) Canadian Grain Commission, Winnipeg, MB, CANADA; (2) Crop Development Centre, University of Saskatchewan
Cereal Foods World 54:A71

This study was aimed to investigate how genotype, growing location and year affect resistant starch, oligosaccharide (raffinose, stachyose and verbascose) and trypsin inhibitor activity levels of field peas, and to determine the relationship between them. Such information will benefit health professionals, the food industry and pulse breeders in effort to improve quality of new pea cultivars. Six field pea cultivars (CDC Striker, Cooper, Cutlass, Eclipse, SW Marquee and SW Sergeant) were grown over two seasons (2006 and 2007) at five locations (Indian Head, Melfort, Rosthern, Saskatoon and Swift Current) in Saskatchewan, Canada, in a randomized complete block design as part of the provincial regional variety trials. The cultivars chosen are commonly grown in western Canada. Resistant starch content ranged from 3.9 to 40.8 (g/kg dry matter). Raffinose from 3.7 to 12.9 (g/kg dry matter), stachyose from 17.0 to 38.5 (g/kg dry matter) and verbascose from 3.2 to 19.9 (g/kg dry matter), respectively. TIA levels were in the range of 1.1 to 7.8 (mg/g dry matter). Analysis of variance showed that genotype, growing location and year had a significant effect on resistant starch and oligosaccharide contents of field peas. Trypsin inhibitor activity of field peas was significantly affected by genotype and growing location. Resistant starch content was positively correlated with raffinose and stachyose contents. Raffinose content was positively correlated with stachyose but was negatively correlated with verbascose content.

Evaluation of arabinoxylans in hard red spring wheat grown in Minnesota for refrigerated dough production

K. WHITNEY (1), S. Simsek (1), J. Anderson (2), J. Ohm (3), M. Mergoum (1)
(1) North Dakota State University, Dept. of Plant Sciences, Fargo, ND, U.S.A.; (2) University of Minnesota, St. Paul, MN, U.S.A.; (3) USDA-ARS Hard Red Spring Wheat and Durum Wheat Quality Laboratory, Fargo, ND, U.S.A.
Cereal Foods World 54:A71

Refrigerated dough products use wheat flour as their primary ingredient, so the quality and the chemical composition of the flour determine the quality of the final product. Six varieties of Hard Red Spring Wheat, grown in three locations in Minnesota, were evaluated for use in refrigerated dough products. The total starch and protein content of the flour was determined and ranged from 76.99–56.24 percent and 17.12–13.00 percent, respectively. An important factor in the suitability for refrigerated dough is the arabinoxylan. The total arabinoxylan and the arabinose to xylose (A/X) ratio were determined in the flour and whole wheat. The total arabinoxylan was higher in the whole wheat for all varieties. Traverse from Lamberton and Morris had the highest total arabinoxylan in the flour with 1.50 and 1.54 percent respectively. Glenn from Crookston and Oklee from Morris had the lowest arabinoxylan content with 0.97 and 1.03 percent respectively. The flour with the highest A/X ratio was Oklee from Crookston and Glenn from Morris being 0.82. The lowest A/X ratio was for Faller from Morris with 0.67. The extent of dough syruping was measured over a period of ten days. There was a large amount of variability between the varieties and locations. Traverse from Crookston and RB07 from Morris had the highest dough syruping on day ten with 14.83 and 13.50 percent respectively. Oklee from Lamberton and Faller from Morris had the lowest percent of dough syruping on day ten with 2.05 and 2.80 percent respectively. Morris had the highest dough syruping overall and Lamerton had the lowest dough syruping overall. Varieties and locations which, produced less syrup are more desirable for refrigerated dough. Flours which produce a high level of syrup will produce a sticky liquid that will leak out of the package during storage. This is highly unacceptable to consumers.

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

P. C. WILLIAMS (1), P. Dardenne (2), D. B. Funk (3), D. W. Hopkins (4), J. Huang (5), B. Igne (6), F. H. Long (7), B. Pfahringer (8), D. J. Ryan (9)
(1) PDK Projects Inc, Nanaimo, BC, CANADA; (2) Walloon Agricultural Research Station, Gembloux, Belgium; (3) USDA-GIPSA-Technical Services Division, Kansas City, MO; (4) Private consultant; (5) Wyeth Pearl River, NY; (6) Iowa State University; (7) Spectroscopic Solutions LLC, Randolph, NJ; (8) Department of Computer Science, University of Waikato, Hamilton, NZ; (9) Solae LLC, St. Louis, MO
Cereal Foods World 54:A72

The main factors that affect wheat quality are kernel texture, kernel colour, protein content, and gluten "strength" (GS). Recent advances in NIRS prediction of functionality parameters in whole kernels have simplified selection for quality factors in early generations. Prediction of GS in whole-grains by NIRS, in terms of physico-chemical dough properties, has so far proved to be elusive. The paper will describe the application of several chemometric approaches to the prediction of wheat quality in whole grain by NIRS. The objective was to see how advanced chemometrics, in the hands of experienced users, would allow development of calibration models, based on 7 years of data, that would predict data for an eighth year reliably. Growing season strongly affects wheat quality and spectral characteristics. The calibration sample set (N = 775) included samples of western Canadian wheat (whole-grain) drawn from growing seasons 1998–2005, excluding the 1999 season. The validation set (N = 107) consisted of the 1999 Plant Breeders' samples. Quality factors were protein content, test weight, kernel texture (particle size index, or PSI), Farinograph water absorption, dough development time (DDT) and mixing tolerance (MTI). Results for protein content, test weight and PSI ranged from excellent, to acceptable for screening purposes. For water absorption r-squared ranged from 0.84 - 0.94, for DDT r-squared ranged from 0.24 - 0.59, and for MTI r-squared ranged from 0.57 - 087. Respective RPD values ranged from 2.4 - 4.8, 0.4 - 1.8, and 1.3 - 3.7. The Random Forest approach appeared to have the best potential for prediction of physico-chemical properties.

Resistant starch: The evolution of starch molecule size during in-vitro digestion

T. Witt (1), M. J. Gidley (2), R. GILBERT (1)
(1) Centre for Nutrition and Food Science, Brisbane, AUSTRALIA; (2) University of Queensland, Brisbane, QLD, Australia
Cereal Foods World 54:A72

High levels of resistant starch have beneficial effects in human digestion. In-vitro digestion techniques have been applied to a group of extruded maize starches (a model for cooked pasta) with varying amylose contents, to observe the evolution of molecular size distributions as a function of digestion time. The results of size exclusion chromatography (SEC) on whole-molecule starches show the long-time appearance of very small starch molecules as a characteristic of enzyme-resistant starch. Debranched SEC (GPC) distributions of the same starches show a decrease in the relative proportion of longer chains, and an increase in shorter chains as enzyme digestion proceeds. These trends are seen for all starches examined, with a decrease in the amount of the small size 'resistant' starch species correlating with a lower digestion yield. Results are in line with the general observation that higher amylose content correlates with a higher content of resistant starch. This is most obviously seen in the case of waxy maize (1–3% amylose), which exhibits rapid, nearly complete, digestion while showing no formation of the small size 'resistant' starch species. NMR studies reveal some structural characteristics of the small size species such as the number average degree of polymerization and average branching fraction.

Hamster feeding study with phosphorylated cross-linked resistant (CL RS4) wheat starch

K. WOO (1), P. A. Seib (2)
(1) MGP Ingredients Inc, Shawnee, KS; (2) Kansas State University
Cereal Foods World 54:A72

Dietary fiber intake has been related to a reduced risk of many diseases, including colonic disorders, cardiovascular diseases, diabetes and obesity. CL RS4 wheat starch is white in color, neutral in flavor and has a smooth mouth-feel. Also it absorbs little water, which can alleviate rheological changes in fiber-fortified food during processing. Increasingly, CL RS4 wheat starch is of interest in the development of health-promoting foods that require a high level of dietary fiber without compromising eating quality. CL RS4 wheat starch is prepared by reaction of starch with a mixture of sodium trimetaphosphate and sodium tripolyphosphate; it contains ~0.4% phosphorus and 76–100% total dietary fiber (TDF) when assayed by the AOAC-International Official Method 991.43. *In vitro* enzymatic digestion of CL RS4 wheat starch shows it contains 42% slowly digestible starch and 58% resistant starch. A diet containing 10% TDF prepared with CL RS4 wheat starch having 76% TDF was fed to weanling hamsters for 6 weeks, and the results compared to diets with the same levels of TDF in the forms of cellulose (control) and retrograded resistant corn starch (RS3). Compared to the diet containing cellulose, hamsters fed CL RS4 wheat starch showed 1) lower feed consumption, 2) lower weight gain, 3) higher levels of colonic short chain fatty acids, especially butyric acid, and 4) a higher blood level of high-density lipoprotein cholesterol and a lower blood level of low and very low density lipoprotein cholesterol. The results of feeding RS3 were generally intermittent between the control and CL RS4 wheat starch. Those data suggest that CL RS4 wheat starch could provide broad opportunities for the development of foods with potential physiological benefits related to dietary fiber.

Lipid distribution in milled rice kernels

D. F. WOOD (1), T. G. Williams (1), W. J. Orts (1), G. M. Glenn (1), A. Graves (2), T. J. Siebenmorgen (2)
(1) USDA, ARS, WRRC, Albany, CA, U.S.A.; (2) University of Arkansas, Division of Agriculture, Fayetteville, AR, U.S.A.
Cereal Foods World 54:A72

Rice lipids are located almost exclusively at the kernel periphery in the bran and germ. During milling, the bran and germ, and therefore lipids, are progressively removed. The degree of milling is a measure of milling quality and has traditionally been evaluated by the color of milled rice kernels, but more recently is also being assessed by the lipid content of milled kernels. The color is determined by the pigment-containing bran remaining on the kernel surface. The bran and germ area contain lipid, therefore bran remaining on the kernel surface and lipid content are related. Thus, surface lipid content is often used as an indicator of degree of milling. Kernel morphology and physical characteristics affect milling performance. Microscopy in conjunction with a lipid-specific probe provided a procedure to highlight milling characteristics and varietal differences. A protocol for sectioning of whole milled rice while preserving lipid was used and modified for this study. 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 followed by the addition of dilute potassium or sodium hydroxide. The sections were observed using fluorescence illumination in a stereo microscope. Intact kernels of rice pureline varieties and hybrids were milled for 0, 10, 20, 30 and 40 sec and treated to reveal lipid distribution in kernels and thus illustrate the effectiveness of the method.

The functional significance of starch-branching enzyme Ia in the synthesis, hydrolysis, and utilization of maize endosperm starch

H. XIA (1), M. J. Guiltinan (1), D. B. Thompson (1)
(1) The Pennsylvania State University, University Park, PA, U.S.A.
Cereal Foods World 54:A72

Starch-branching enzyme (SBE) isoforms play an important role in starch biosynthesis by introducing branches. We explored the effect of SBEIa deficiency on maize endosperm starch structure and digestibility. Starch isolated from non-mutant (wild-type, Wt) and *sbe1a* mutant endosperm was subjected to *in vitro* pancreatic alpha-amylase digestion over 16 h. The proportion of resistant starch was quantified at the end of 16 h, and the digestion kinetics were analyzed using a double-exponential decay fit. *sbe1a* mutant starch had a higher resistant starch value (13.2%) compared to Wt (1.6%). Scanning and transmission electron micrographs show that the resistant starch from *sbe1a* mutant retained more of the initial granule integrity. Digestion of *sbe1a* starch was slower than that of Wt starch. Amylopectin fractionated from Wt and *sbe1a* starch was subjected to *in vitro* beta-amylase hydrolysis over 24 h. Hydrolysis of *sbe1a* chains was slower as compared to Wt, indicating a higher proportion of closely associated branch points in the *sbe1a* starch. The amylose fraction from Wt and *sbe1a* starch was subjected to exhaustive beta-amylolysis. *sbe1a* starch had more long residual chains, indicating an altered branching pattern. During the germination of *sbe1a* mutant seeds, starch utilization was reduced and cotyledon growth was retarded as compared to Wt. Our results suggest that deficiency of SBEIa in endosperm starch may result in an altered branching pattern, leading to a less readily digested granule. These results contribute to the understanding of the role of SBEs in biosynthesis, hydrolysis, and utilization of starch granules. Moreover, the novel starches developed might have application as food starch ingredients.

Value-added utilization of hemicellulose in distiller's dried grains with solubles

Y. XU (1), M. A. Hanna (1)
(1) University of Nebraska-Lincoln, Lincoln, NE, U.S.A.
Cereal Foods World 54:A72

The supply of distillers dried grains with solubles (DDGS) is increasing rapidly with production of fuel ethanol. Currently, the vast majority of DDGS is directly used for low-value livestock feed. Exploring alternative value-added uses of DDGS is needed. Lignocellulosics are one of major

undeveloped components in DDGS. The objectives of this study are to evaluate chemical composition of DDGS and to investigate the effects of the hydrolysis conditions on yield and composition of mono-sugars from hemicelluloses. The results of evaluation of DDGS obtained from two different Nebraska ethanol plants showed that hemicellulose contents were 21.4% and 28.9%, respectively, and were two or three times higher than their cellulose counterparts (8.7% and 14%). DDGS further were hydrolyzed and the effects of the independent variables of reaction temperature (110–130°C), time (30 min to 2 hr), and acid concentration (1–5%) on yield and composition of hydrolyzed sugars were determined using response surface methodology. The hydrolyzed solutions exhibited to be a dark brown color, which was attributed to the Maillard reaction between reducing sugars and amino acid of protein. It was found that the optimum level for each variable was identified as determined to be 130°C, 30 min reaction time and 3% acid concentration to obtain maximum pentose yield (73 g per 100 g dry DDGS). The longer reaction time and higher acid concentration resulted in a decrease in pentose yield due to a dehydration reaction and production of by-products. These hydrolyzed mono- sugars represent large potential sources of value-added intermediate chemical precursors and chemicals and converting them into value-added chemicals will be investigated in our future research. Converting DDGS into green chemicals provides an alternative new process and pathway for higher value uses of this by-product of ethanol fermentation.

Micro-heterogeneity of cellulosic fiber biopolymer prepared from corn hulls

J. XU (1), W. Cheng (2), G. E. Inglett (3), P. Wu (2), S. Kim (3), S. X. Liu (3), Y. Tseng (2)
(1) USDA ARS NCAUR, Peoria, IL; (2) Department of Chemical Engineering, University of Florida, Gainesville, FL, U.S.A.; (3) NCAUR, USDA, Peoria, IL, U.S.A.
Cereal Foods World 54:A73

The micro-structural heterogeneities of Z-trim, a zero calorie cellulosic fiber biopolymer produced from corn hulls, were investigated by monitoring the thermally driven displacements of well-dispersed micro-spheres via video fluorescence microscopy named multiple-particle tracking (MPT). This work indicated a relatively rapid concentration-induced transition of the properties of the Z-trim. Pre-transitional effects were apparent at low concentrations as clearly detected by the shape of the MSD distribution of imbedded particles. At lower concentration of 0.5% of Z-trim, the overall ensemble-averaged MSDs were very similar to that of a viscous homogenous liquid glycerol with a slope of unity. The diffusion coefficient for the 0.5% Z-trim was independent of time just like glycerol. The contributions of the 10%, 25%, 50% highest MSD values to the ensemble-averaged MSD for the 0.5% Z-trim were also similar to those for homogeneous solution of glycerol. Therefore, 0.5% Z-trim mostly behaved like a homogeneous viscous fluid. However, the time-dependence and asymmetry profiles of the MSD distributions and higher standard deviation of the normalized MSD distribution implied that even at 0.5% concentration, Z-trim showed a symptom of trend of heterogeneity. For the 1% Z-trim colloidal dispersion, though it behaved like a liquid from a relatively macroscopic standpoint because of its close to unity slope of ensemble-averaged MSD trace. It exhibited more heterogeneity as evidenced by the slightly time-dependence diffusion coefficient, time-dependence and asymmetry profiles of the MSD distributions, higher standard deviation of the normalized MSD distribution, and higher contributions of the 10%, 25%, 50% highest MSD values to the ensemble-averaged MSD. At higher concentration of 2% Z-trim, the heterogeneity became more evident.

Storage of yogurts with added beta-glucan from oats

N. YAO (1)
(1) Iowa State University, Ames, IA
Cereal Foods World 54:A73

The Food and Drug Administration regulations require at least 0.75 g of beta-glucan/serving of a food product. Thus, a 6-oz serving of yogurt requires 0.44% beta-glucan to make a health claim. Yogurt with 0, 0.44, 0.68, and 0.84% of added beta-glucan was prepared, and evaluated for syneresis, color, pH, and textural properties. Yogurt fortified with beta-glucan tended to have a similar or lower pH than a control yogurt made without added beta-glucan. The pH of all yogurts decreased at a similar pace during storage. Syneresis, indicating the whey separation, decreased with greater amounts of beta-glucan. Only lactic acid increased during storage, and no other short-chain fatty acids were detected. A descriptive sensory panel of 10 members determined that beta-glucan fortified yogurt was similar to the control yogurt in creaminess and the greater the percentage of beta-glucan, the browner the yogurt. Chalky texture was not detected in all yogurts. All yogurts fortified with different levels of beta-glucan had similar compression peak forces (8–20 g) measured on a TA XT 2i Texture Analyzer and all were lower than the control yogurt (80 g). Beta-glucan concentrations in the yogurt after storage at 4°C for one week and two weeks were unchanged and equal to the original amount added; however, the average molecular weight of the beta-glucans decreased slightly. These results suggest that yogurt is a suitable food product for incorporating beta-glucans to provide a healthful product.

Physical and digestive properties of cookies using OSA rice starches with different amylose contents

H. YOON (1), J. Han (1)
(1) Sangmyung University, Seoul, Korea
Cereal Foods World 54:A73

For the goal of making slowly digestible cookies with rice, rice starches containing different amylose contents (0 or 28%) were esterified by octenylsuccinic anhydride (OSA) and then they were added into wheat flour by 10, 30 and 50% based on total powder amount, respectively. After making cookies, textural and digestive properties were evaluated. For the textural properties, the hardness and brittleness increased as OSA rice starch amount increased from 10 to 30%, however, the values of cookies containing 50% OSA rice starch decreased. Hardness was higher in cookies containing OSA rice starch with 28% amylose than in those containing OSA rice starch without amylose, however, in the case of brittleness, the cookies with OSA rice starch without amylose showed higher value. For color, the cookies containing OSA rice starches showed higher L* and lower a* values than control (prepared by only wheat flour), because of decreased protein amount which caused Maillard reaction. For the digestive properties, the cookies containing 10 or 30% OSA rice starch weren't significantly different from control. However, the cookies containing 50% OSA rice starch with 28% amylose significantly decreased rapidly digestible portion, and increased slowly digestible portion leading to lower Glycemic value (GI). The addition of 0.5% xanthan gum into the dough containing 50% OSA rice starch with 28% amylose could improve the texture of cookies as well as keeping the lowest GI.

HPLC determination of insoluble phenolic acids in selected Japanese grains: Comparison of photodiode array detector and electro- chemical detector

A. YOSHIDA (1), K. Miyagi (1), H. Ohta (1), S. Hashimoto (1)
(1) Nakamuragakuen University, Fukuoka, AC, JAPAN
Cereal Foods World 54:A73

Epidemiological studies indicate that a high consumption of whole grain products may reduce the risk of chronic disease. These effects have been ascribed to dietary fiber and other constituent, including phenolic acids. In this study, the photodiode array detector (PDA) and electro- chemical detector (ECD) in the determination of insoluble phenolic acids, including *p*-coumaric acid, ferulic acid and caffeic acid, by high performance liquid chromatography（HPLC）were compared to develop more sensitive method. The grain samples in Japan were used as follows: reddish rice, black rice, unpolished rice, polished rice, foxtail millet, Japanese barnyard millet, grain amaranth, and three wheat flours (soft, medium and hard). Each sample was lyophilized and ground with an Ultra Centrifugal Mill. The ground powder were sieved, and stored at –20°C until analysis. All samples were discarded to remove fat with n-hexane, then soluble components with 80% ethanol. The residue was hydrolyzed with 1M NaOH at room temperature under nitrogen gas. Phenolic acids were extracted with ethyl acetate, and analyzed by PDA-HPLC or ECD-HPLC. The content of ferulic acid by PDA-HPLC was 21.8~2.5 mg/100 g of powder, while those by ECD-HPLC 76.5~1.9 mg/100 g. The content of ferulic acid in black rice by ECD-HPLC increased to 76.5 mg /100 g compared with 21.8 mg/100 g by PDA-HPLC. No caffeic acid was detected by PDA-HPLC, whereas caffeic acid (0.061 mg~0.002 mg/100 g) in all samples was detected by ECD-HPLC. The content of phenolic acids in rice was larger in unpolished rice than polished ones, showing the high content in the rice bran. Phenolic acids (ferulic, *p*-coumaric and caffeic acid) in whole black rice were predominant, followed by unpolished rice, reddish and ricefoxtail millet. In conclusion, ECD-HPLC was a useful method to investigate the phenolic acids in the grain samples.

The milling of soft and hard wheat, and their blend with test mill

B. ZHAO (1), N. Zhou (1), T. Hansen (2), D. Gannon (2), L. Haynes (1), J. Zimeri (1)
(1) Kraft Foods, East Hanover, NJ; (2) Kraft Foods
Cereal Foods World 54:A73

Baking industry needs flour with different strengths, depending on the end use. Flour strength for a specific wheat variety also changes with environmental conditions. A common practice, to produce flour with a specific strength, is to mill a blend of various wheat varieties (soft and hard, for example). However, when milling a blend of wheat with the same milling conditions, extraction rates may vary depending upon the blend ratio. The objective of this study is to observe the extraction rate of various blends of hard and soft wheat, and measure the functional characteristics of the flours produced. The wheat is milled with a lab test mill (Chopin), consisting of two

pairs of break and one pair of reduction roll. The results show that the extraction rate is 69% for 100% soft wheat and 49% for 100% hard wheat. Furthermore, the extraction rate for 50/50 blend is 62%, higher than the average of soft and hard wheat [(68%+49%)/2 = 59%]. The curvature relation of the extraction rate, (68.7%, 67.7%, 65.3%, 62.0%, 57.8%, 48.8%) for the respective blending ratios (100/0, 85/15, 70/30, 50/50, 30/70, 0/100 of soft/hard) indicate that the extraction rate of flour is higher than expected based on the individual extraction rate of each wheat in the blend. Functional analysis, using alveograph and SRC, demonstrate flour rheological characteristics and solvent sorption levels are indicative of a greater proportion of soft wheat than the blend ratio actually milled. The range of particle size distribution tended to be broader with the increase of hard wheat in the blend. If the samples went through the reduction roll a second time, the extraction rate improved, especially for hard wheat. These results may help to optimize wheat blending to achieve desired flour, but need to be confirmed with commercial mill.

Evaluation of different types of fats used in high-ratio layer cakes

J. ZHOU (1), C. Walker (1), J. Faubion (1)
(1) Kansas State University, Manhattan, KS, U.S.A.
Cereal Foods World 54:A74

Shortening is a major ingredient used in high-ratio layer cakes. Plastic shortenings are most commonly used by the U.S. baking industry, but the possibility of high levels of trans or saturated fats cause health concerns to some consumers. Compared to plastic shortenings, liquid shortenings could significantly reduce the dependence on high melting point fats and the emulsifiers used would enhance the shortening's functionality. The objective of this research was to compare the influence of different types of fats on the texture and shelf-life of high-ratio layer cakes. Cakes were baked with soybean oil to evaluate the function of three emulsifiers (PGMS, GMS, and Lecithin) on layer cake quality, including volume, cake score, internal crumb texture (by C-Cell), and firmness (by Voland-Stevens). An optimum emulsifier combination for the liquid oil was identified as; PGMS 1.8%, GMS 1.0% and Lecithin 0.8%. Four groups of layer cakes were baked using plastic shortening, liquid shortening, liquid oil and liquid oil plus emulsifier combination. Cake performances and shelf-lives were evaluated. The liquid shortening produced the best fresh cake characteristics with cake volume 132, cake score 94, brightness 153, wall thickness 0.493 mm and firmness (1st day) 173 g/force. Liquid oil combined with emulsifiers had very similar firmness performance to the liquid shortening, indicating the important role emulsifiers played in the improvement of shelf-life in this food system.

Effects of temperature cycling and starch concentration on retrogradation of waxy and normal corn starches

X. ZHOU (1), S. Lim (1), B. Baik (2)
(1) Graduate School of Life Sciences and Biotechnology, Korea University, Seoul, KOREA; (2) Washington State University, Department of Crop & Soil Sciences Pullman, WA, U.S.A.
Cereal Foods World 54:A74

Gelatinized waxy and normal corn starches at various concentrations (20–50%) in water were stored under temperature cycles of 4°C for 1 day and 30°C for 1 day up to 7 cycles or at a constant temperature of 4°C for 14 days to investigate the effects of starch concentration and temperature cycling on the retrogradation of both starches. Compared to the storage only at 4°C, both starches stored under the 4/30°C temperature cycles exhibited smaller melting enthalpy (ΔH), but the onset temperature (To) increased by 18–19°C regardless of the starch concentration studied, whereas the melting temperature range was decreased. Less crystallite might be formed under 4/30°C temperature cycles compared to the constant 4°C storage but the crystallites formed were more homogeneous. Starch concentration has greater effect on the starch retrogradation under cycled temperatures than constant 4°C. The reduction in ΔH and the increase in Tc by the retrogradation under 4/30°C temperature cycles became more apparent when the starch concentration was lower. It indicated that greater annealing effect occurred in lower concentrated starches under 4/30°C temperature cycles. Degree of retrogradation based on ΔH was greater in normal corn starch than waxy corn starch when starch concentration was low (20 or 30%), indicating that the amylose might have synergistic interactions with amylopectin for recrystallization when the starch mobility was high.

Studying the effects of phosphate salts on instant fried ramen noodle quality

Y. ZHOU (1), G. G. Hou (2), L. Zhou (3)
(1) Wheat Marketing Center, Portland, OR, and Dept. of Food Science, Anhui Agricultural University, Hefei, China; (2) Wheat Marketing Center, Inc., Portland, OR; (3) ICL Performance Products LP, Webster Groves, MO
Cereal Foods World 54:A74

The use of phosphate salts in instant ramen noodles is thought to improve the cooked noodle texture; however, little information is available to explain what roles the phosphate salts play in noodle quality. The objective of this research is to investigate the effects of phosphate salts and their usage levels (0.1–0.3% of flour weight) on instant noodle dough and finished product characteristics. The noodle dough pH was directly affected by the type of phosphate salts. Monosodium phosphate anhydrous (MSP), sodium acid pyrophosphate (SAPP), sodium trimetaphosphate anhydrous (STMP), sodium hexametaphosphate (SHMP), sodium potassium hexametaphosphate (SKMP), and calcium acid pyrophosphate (CAPP) reduced noodle dough pH values; while disodium phosphate anhydrous (DSP), trisodium phosphate anhydrous (TSP), tetrasodium pyrophosphate anhydrous (TSPP), and dipotassium phosphate anhydrous (DKP) increased noodle dough pH values. Sodium tripolyphosphate anhydrous (STPP) and Tricalcium phosphate (TCP) did not affect pH values. The peak viscosity of noodle dough measured by Rapid Visco Analyzer was significantly increased by phosphate salts. Raw noodle sheet color L* (brightness) values at 0 and 24 hr were significantly improved by all phosphate salts. Phosphate salts that reduced dough pH gave larger L* values. Color change (ΔL* 0–24 hr) reduced significantly with the addition of phosphate salts. Noodle cooking weight gain was significantly increased by most phosphate salts. Cooked noodle hardness, cohesiveness, and resilience values as measured by the TA.XT2 Texture Analyzer generally increased with the increasing phosphate salt level. In summary, the use of phosphate salts in instant ramen noodles changed dough pH, increased dough pasting viscosity, made fried noodle brighter, increased cooking weight, and improved the hardness, cohesiveness, and resilience values of cooked noodles.

Differences in biscuit flour functionality as affected by wheat type and region of origin

J. ZIMERI (1), L. Haynes (1), N. Zhou (1), B. Zhao (1)
(1) Kraft Foods, East Hanover, NJ, U.S.A.
Cereal Foods World 54:A74

Biscuit flour functionality ranges according to the type of wheat grown in specific regions around the world, among other factors such as milling and % extraction. In the U.S., soft wheat flours are utilized to produce most of the flours for biscuit manufacturing. This is not the case in other parts of the world, where different countries have different strategies to overcome the unavailability of soft wheat in their regions. Commercial refined flours used to produce biscuit-type products around the world were evaluated in terms of functionality. The flours differed in wheat origin, wheat type and blends, and % ash content. Flour functionality was evaluated using solvent retention capacity, SRC (AACCI method 56-11), and baked using the wire-cut cookie baking test (AACCI method 10-53). SRC results were used to predict baking parameters. Gluten potential, which is important in cracker manufacturing, was captured by the lactic acid ratio. Results showed that flours varied widely in functionality, depending on the type of wheat and region of origin. A strong correlation was found between cookie spread (diameter), moisture loss during baking and final cookie moisture content, with the most desirable cookies having large spread, high moisture loss and low final product moisture content. Sodium carbonate SRC and sucrose SRC predicted cookie spread, indicating that cookie geometry and moisture-color balance was highly dependent on starch damage and pentosan content in the flours, respectively. Overall, flours obtained from harder wheats performed poorly as compared to softer wheats.

AUTHOR INDEX

Errata

CEREAL FOODS WORLD Supplement • Vol. 54, No. 4

The following symposia abstracts were submitted for presentation at the 2009 annual meeting in Baltimore, Maryland, September 13–16, 2009.

The Effects of Dietary Fiber from Cereals on Gut Health

Effects of arabinoxylan oligosaccharides on the gut

C. Courtin
University Leuven, Heverlee, Belgium
Cereal Foods World 54:A79

Arabinoxylans (AX) are cereal cell wall components that constitute an important part of the dietary fibre intake in humans. Hydrolysis of AX using xylanolytic enzymes yields arabinoxylan-oligosaccharides (AXOS), consisting of arabinoxylooligosaccharides and xylooligosaccharides (XOS). Such AXOS can be made as ingredients but are also produced in cereal-derived food products such as bread and beer, as well as in the colon upon ingestion of AX. This presentation focuses on the prebiotic effects that AXOS and XOS exert in the colon of humans and animals through selective stimulation of beneficial intestinal microbiota. In vitro experiments and in vivo intervention studies on animals or humans that have investigated potential health-related effects resulting from dietary intake of AXOS or XOS are discussed.

Characterizing the Size and Molecular Weight Distributions of Starch

Modern size-exclusion techniques for characterizing starch

P. Kilz
PSS Polymer Standards Service GmbH, Mainz, Germany
Cereal Foods World 54:A79

Molecular characterization of macromolecules by chromatographic methods has been important in the elucidation of structure property action relationships. Available techniques allow the in-depth characterization of multiple property distributions, e.g. dispersity in chain length, branching frequency and branch length, chemical composition and even constitution. This has been achieved by a combination of fractionation techniques like SEC, LAC, FFF and information-rich detectors e.g. MALLS, viscometry, IR and NMR. Application of such methods to starches, however, is still not a standard technique for several reasons: - sample preparation to achieve molecular dissolution is still difficult and not easily reproducible; - starch itself is a highly complex and analytically challenging product; - the correlation of macroscopic properties to structural features is complicated by the complex morphology. Many product properties of starches like sensory behavior, gel formation and gel stability, are affected by processing conditions. Starches modified by dry- and wet-milling formed particle gels in water and may find their application in non-cooked food systems as an alternative to pre-gelatinized, chemically modified starches, maltodextrins and food gums. This contribution summarizes the state of the art of advanced SEC characterization of starches using viscometric and light scattering detectors to study the influence of mechanical starch treatment on its molecular characteristics. Different milling methods were used to modify native starch samples. Multi-detector SEC results for different native and milled starches will be presented and their correlation with physical properties determined with different techniques will be discussed.