

Management of Grain Quality and Security in World Markets

NC-213

(The U.S. Quality Grains Research Consortium)

2007 Annual Progress Reports
From Participating Stations

NC-213 is a project team of engineers, scientists, and economists from leading U.S. land grant universities and government research centers that conduct research to create and disseminate the technical knowledge needed to manage quality food safety and bio-security efficiently in world grain markets.

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(The U.S. Quality Grains Research Consortium)

2007 ANNUAL PROGRESS REPORTS

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MANAGEMENT OF GRAIN QUALITY AND SECURITY IN WORLD MARKETS

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¹ Please note that some reports have more than one contributing institution and author. In the Contents, only the principal investigator, along with their institution, is listed, please refer to the individual report for a complete list.

Management of Grain Quality and Security in World Markets

NC-213 (The U.S. Quality Grains Research Consortium)

Objective 1

Develop practices and technologies to support quality management systems for production, distribution, processing, utilization of quality grains and oilseeds.

Title

Whole Soybean Calibrations Research

Project Objectives

Calibrations for measuring subunit (amino acid, fatty acid, etc) factors of corn and soybeans will be extended. The local chemometrics and information technology necessary to optimize use of very large databases will be developed.

By

Hurburgh, C.R., Jr.

Iowa State University, Department of Agricultural and Biosystems Engineering

Results for 2007

Whole soybean calibrations for four NIRS brands were developed to measure linolenic acid and total saturated fats. In one case, the standard error of prediction was less than 0.5% pts for each factor, which meant that discrimination to the nearest whole percentage (eg 1% vs 2%) was possible.

Rancidity factors were measureable by NIRS using a simple, disposable sample cup placed under the beam of a reflectance NIRS spectrometer. Measures of free fatty acids (FFA), total polar materials (TPM), and conjugated dienoic acids (CDA), typical indices of oil degradation, were analyzed in daily oil aliquots taken from soybean oils with different linolenic acid concentrations used to fry French fries. The oils also were scanned with a reflectance spectrometer by using a wavelength range of 350 to 2500 nm. By using partial least squares and one-out cross validation, calibrations were developed to quantitatively determine FFA, TPM, and CDA by near-infrared spectroscopy (NIRS). The coefficients of determination (R^2) when compared to the standard methods were 0.973 for FFA, 0.984 for TPM, and 0.902 for CDA. NIRS was an accurate and fast method to determine FFA, TPM, and CDA in oxidized oils. The ability to obtain different parameters simultaneously makes NIRS a potentially valuable tool for food quality assurance.

The 10-year soybean protein and oil database of Iowa State University was used to quantify the progressive increase in overall variation among units on individual samples as more brands and configurations of NIRS are introduced to a system. Standard errors increased from 0.30 and 0.25 percentage points (for protein and oil, respectively) when only one transmission NIRS model was used to 0.90 and 0.80 percentage points when three transmission and three reflection instrument models were used.

The transfer of calibration from instrument to instrument has been widely studied over the past 20 years and methods such as piecewise direct standardization, slope and bias post-regression correction, Shenk-Westerhaus algorithm, and robust techniques have been successfully applied in various situations. However, a network of instrument is rarely composed by instruments of the same brand and the transfer of prediction models among brand remains an area not fully explored. Robust models are very attractive because they allow the use of historical

spectral databases but they show often a reduction of the calibration performances due to the additional variability they include. The goal of this study was to measure the effectiveness of different spectral pretreatment techniques for the reduction of the spectral variability included in the calibration set. The network of instrument contained Foss Infratecs (1229 and 1241) and two Dickey-John OmegAnalyzer G's and partial least squares regression technique was applied to soybean moisture, oil, and protein. First results show that robust techniques using the spectral information from all the network instruments (moisture: $r^2 = 0.987$, SEP = 0.278; protein: $r^2 = 0.963$, SEP = 0.518) performed as well as calibrations developed using traditional optical correction techniques ($r^2 = 0.988$, SEP = 0.279; protein: $r^2 = 0.958$, SEP = 0.561). These results are very promising not only from a chemometrics point of view but also from an economic purpose.

Based on the development of a triticale protein calibration over four years, several validation scenarios were evaluated (cross validation, a validation set coming from the calibration set with two sizes (10 and 25%) and a validation set containing only next year samples) performed by two regression methods (Partial Least Squares and Least Squares – Support Vector Machine Regression). While same-year sample validation methods give reasonable results, the next year validation set method provided the real accuracy of the calibration. In these sets, the RPD values were half those of same year calibration. There was not a significant difference between 10% and 25% of the calibration set as validation set. Three production years or cycles were required to obtain a stable calibration that was not likely to need changing in the following cycle.

Plans for 2008

Increase the number of algorithms tested for interbrand standardization and database combination. Update the fatty acid calibrations and release for general use. Add calibrations for oleic acid and sugar content in soybeans. Develop standard methods for calibration-related activities.

Publications

- Hurburgh, C. R., Jr. 2007. Measurement of fatty acids in whole soybeans with near infrared spectroscopy. *Lipid Technology* 19(4): 450. April 2007. (CY07, FFY07)
- Hardy, C.L., J. Gerde, C.R. Hurburgh, Jr., and P.J. White. 2007. Rapid Determination of Oxidation in Frying Oils by NIR Spectroscopy. Proc. 98th Annual Meeting, American Oil Chemists Society, Quebec City, QC. May 13, 2007. Oral presentation. (CY07, FFY07)
- Hurburgh, C.R., Jr. 2007 Harmonizing Near Infrared Spectroscopic Measurements and Terminology: NIRS Component of the AOCS Soybean Quality Traits (SQT) Program. Proc. 98th Annual Meeting, American Oil Chemists Society, Quebec City, QC. May 13, 2007. Oral presentation. (CY07, FFY07)
- Igne, B., G.R. Rippke, C.R. Hurburgh. 2007. Robust Regression for Inter-Brand Standardization. Proc. 13th International Conference on Near Infrared Spectroscopy, Umeå, Sweden, June 13-17, 2007. Poster. (CY07, FFY07).

- Yang, CiWen, Suming Chen, Charles R. Hurburgh, Jr, I-Chang Yang, Chih-Hsiang Wu. 2007. Standardization of soybean spectra across NIRS instruments using support vector machines. Proc. 13th International Conference on Near Infrared Spectroscopy, Umeå, Sweden, June 13-17, 2007. Poster. (CY07, FFY07).
- Igne, B., L. Gibson, G. Rippke and C. Hurburgh. 2007. Triticale Moisture and Protein Measurement by Near Infrared Spectroscopy. *Cereal Chemistry* 84:239-241 (CY07, FFY07)
- Kovalenko, I, G. R. Rippke, and C. R. Hurburgh, Jr. 2007. Dimensionality reduction of near infrared spectral data using global and local implementations of principal component analysis for neural network calibrations. *JNIRS* 15:21-28.
- Gerde, J., Connie L. Hardy, Charles R., Hurburgh, Jr. and Pamela White. 2007. Rapid determination of degradation in frying oils by near-infrared spectroscopy. *JAOCS* 84:519-522 (CY07, FFY07)
- Thakur, M. and C. R. Hurburgh, Jr. 2007. Quality of U.S. Soybean Meal compared to the Quality of Soybean Meal from other Origins. *JAOCS* 84:835-843. (CY07, FFY07)
- Igne, B., L. Gibson, G. Rippke and C. Hurburgh. 2007. Influence of yearly variability of agricultural products on the NIRS calibration process: a triticale example. *Cereal Chemistry* 84(6):576-581 (CY07, FFY07)

Issues

Fatty acid composition (of oil) must be measured in the raw soybeans in order for fair trade and accurate processing decisions to be made.

Trade and user networks of near infrared instruments (for measuring compositional factors) should be able to use more than one make and model of NIRS instrument without reduction in overall accuracy. NIRS instruments differ among models and even across copies of the same model, so the traditional thinking has been that only one make and model should be used for a given application. Accuracy may be protected but competition and new instrument development is retarded.

Standard methods for calibration, calibration validation, calibration transfer and update are needed to promote uniformity of results in NIRS practice. These methods can be published in Official Methods of scientific groups, which then encourages their use in future applications.

Impacts

Modified fatty acid soybeans were a \$100 million product in 2007. Separation from commodity soybeans is necessary to preserve the unique value and functionality of oil modifications, such low linolenic acid, or low total saturated fats.

There are at least 40 companies manufacturing or developing near infrared instruments that could be applied to grains. Several provide more spectral information at higher levels of precision than units now used in trade and

processing. Harmonization of databases and calibration methodologies could accelerate the acceptance of new technologies with greater capabilities.

Standard methods are the basis for legal trade and arbitration. For NIRS, and the properties that it measures, to become accepted in legal metrology, its capability for standardized use must be demonstrated and scientifically accepted. Publication in refereed methods compendia is one means by which scientific acceptance is registered.

Contacts

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Title

Development of Fractionated Soy Protein Ingredients from Solvent-Extracted Soybean Meal and Gas-Supported Screw Pressed (GSS) Meal.

Project Objectives

Improve utilization processes corn and soybeans.

By

Johnson, L.

Iowa State University, Center for Crops Utilization Research

Results for 2007

We continue to develop and assist our industry partner to develop fractionated soy protein ingredients from solvent-extracted soybean meal and from gas-supported screw pressed (GSSP) meal. We have provided quality control data on protein dispersibility (a measure of protein extractability and heat denaturation), protein content and residual fat as the plant commenced operations. We tested DuPont Pioneer high-sucrose soybean lines in our fractionation process and found these beans produced fractions with unique compositions. We also determined for the first time the fate of phytic acid, a natural compound that binds nutritionally important minerals preventing their availability.

We participated in a collaborative study to determine inter-laboratory testing of wet-milling properties of corn. Our data compared well with three other laboratories and our protocol was effective in discriminating among samples with known differences. A manuscript is in press for publication by Cereal Chemistry.

We also demonstrated the utility and effectiveness of transgenic corn containing green fluorescent protein (GFP) as a tool to test efficiencies of new dry-milling procedures. Lines of corn expressing GFP in different tissues allows a direct and simple measure of amounts of germ and endosperm in various fractions. Two manuscripts are in press for publication by Cereal Chemistry.

Publications

Deak, N.A., and L.A. Johnson. 2007. Preparation of Glycinin and β -Conglycinin from High-sucrose/Low-stachyose Soybeans. J. Am. Oil Chem. Soc. 84(3):260-279.

Deak, N.A., and L.A. Johnson. 2007. Fate of Phytic Acid in Producing Soy Protein Ingredients. J. Am. Oil Chem. Soc. 84(4):369-376.

Shepherd, C.T., N. Vignaux, J.M. Peterson, L.A. Johnson, and M.P. Scott. 2007. Green Fluorescent Protein as a Tissue Marker in Transgenic Maize Seed. Cereal Chem. (accepted).

Shepherd, C.T., N. Vignaux, J.M. Peterson, M.P. Scott, and L. Johnson. 2007. Dry-milling and Fractionation of Transgenic Maize Seed Tissues with Green Fluorescent Protein as a Tissue Marker. Cereal Chem. (accepted).

Lee, K., T.J. Herrman, L. Rooney, D.S. Jackson, R. Scott, R. Bean, J. Lingenfelter, K.D. Rausch, J. McKinney, C. Liams, L. Byrum, C.R. Hurburgh, L.A. Johnson, and S.R. Fox. 2007. Corroborative Study on Maize Quality, Dry-Milling and Wet-Milling Properties of Selected Maize Hybrids. J. Agric. Food Chem. (accepted).

Issues

The health community is recognizing the benefits of various soy protein fractions. Our soy protein fractionation procedure allows us to produce more potent protein fractions delivering health benefits (cardiovascular health and cancer protection). Soybeans containing high-sucrose instead of oligosaccharides are specialty soybean that do not have intestinal gas producing sugars and as a result are easier to process.

There is considerable variation in wet-milling properties that result in large differences in starch extractable by in industrial wet milling. Seed companies are developing corn lines that have superior wet-milling characteristics, but having reliable and robust methodology to assess starch yield and quality are important to developing such lines.

We have been testing the effectiveness of alternative degerming and dry-milling procedures to enable “on-farm” recovery of corn germ containing recombinant proteins for use in pharmaceuticals. These procedures could greatly reduce the risk of contaminating commodity corn with unapproved recombinant proteins. Our corn expressing GFP allows us to test various low-cost technologies suitable for on-farm use.

Impacts

Producing soy protein fractions rich in either of the two major proteins (glycinin and beta-conglycinin) is key to delivering healthier and better performing soy protein products. We are working with commercial companies to adopt our simple process.

GSSP has the potential to be a very effective means of identity preserving soybeans during their processing. Unlike alternative processes, little protein denaturation occurs during oil recovery and the meal can be used to produce organic or certifiable non-GMO soy protein ingredients for which customers in Europe and Asia are willing to pay premium prices. U.S. processors could again become a preferred source of food-grade soybean meal.

Our GFP containing corn enables rapid evaluation of new corn fractionation procedures. Some of the new fractionation procedures being developed may be suitable for on-farm use reducing the risk of contaminating commodity corn with unapproved transgenics.

The collaborative study on wet-milling identifies laboratories and protocols that are effective in discriminating corn lines with superior wet-milling characteristics. This will enable corn breeders to develop value-enhanced corn for the wet milling industry.

Contacts

Dr. Lawrence Johnson, Professor, Food Science and Human Nutrition, Director, Center for Crops Utilization Research, 1041 Food Science, Iowa State University, Ames, IA 50011, T: 515-294-4365, e-mail: ljohnson@iastate.edu

Title

Evaluation of High Fermentable Corn Hybrids in Kentucky.

Project Objectives

The primary objective of this project is to determine what corn hybrids are optimal for use in ethanol production in Kentucky.

By

Montross, M.D.

University of Kentucky, Biosystems & Agricultural Engineering

Results for 2007

Several major seed corn companies, such as Pioneer Hi-Bred and Monsanto, are marketing corn hybrids for dry and wet mills. The dry mill process is being used by Commonwealth Agri-Energy in Hopkinsville, KY.

A primary factor in ethanol production from dry mills is the quantity of starch in the feedstock and the percentage available for fermentation. A feedstock with a higher quantity of fermentable starch would be more economical for the plant and could represent a niche opportunity for producers to grow specific hybrids.

The seed corn industry has recognized this potential niche market and has started identifying hybrids for ethanol production. Both Pioneer and Monsanto have proprietary assays and NIR (near infrared transmittance) calibrations to determine potential ethanol production. These hybrids could offer dry mill plants up to a 7% increase in ethanol yield (Pioneer, Industry Select Program, Johnston, IA). However, the assays and protocols to validate the NIR calibrations have not been published. In addition, each ethanol plant has slightly different yields of ethanol due to differences in enzyme and yeast products. These differences could affect the calibrations developed by the seed corn industry.

Samples during corn harvest from fall 2005 and 2006 have been analyzed. We have utilized four separate measurements of ethanol production; gas chromatograph, enzymatic assays, Fourier Transform Infrared Spectroscopy, and CO₂ production (weight loss). The ethanol production measured using everything except the weight loss gives identical results. The weight loss measurement substantially underestimates the ethanol production.

There was considerable variation between hybrids; however the total ethanol yield per acre was not as significant. This was due to the higher grain yield of some of the lower ethanol yielding hybrids. Some of the hybrids were not entered into the yield trial during 2006. Due to the drought in 2006, some of the hybrids reversed their position in terms of ethanol production per g of corn. For instance, one hybrid in 2005 produced 0.34 g ethanol per g of corn. In 2006, the same hybrid produced over 0.38 g ethanol per g of corn. During 2006, the ethanol production per gram

of corn was higher. All samples were rerun to take into account potential changes in the enzymes and yeast. The starch content measured using NIR was not significantly different between the two years.

There has been concern by individuals in the ethanol industry that drying and storage has a significant impact on ethanol yield from corn. This was simulated by cutting the seed tip off of the corn or storing the corn in a plastic bag at 35°C to speed mold development. Moldy corn could result in a 15% reduction in ethanol yield. This would be in addition to any potential concerns about mycotoxin development.

Publications

Montross, M.D., C.L. Crofcheck, C.D. Lee. 2007. Influence of Hybrid on Laboratory Scale Dry Grind Ethanol Production. Paper No. 076149 Presented at the 2007 ASAE Annual Meeting, Minneapolis, MN.

Impacts

Ethanol production is influenced by numerous variables. Comparing the effects of agronomic, hybrid, drying and storage practices on ethanol yield will result in better decision making tools for producers and processors. Mold development during storage had a 15% reduction in ethanol yield.

Funding Sources

USDA/CSREES Special Grant on New Crop Opportunities

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Title

Comprehensive Research Results on Soft White Wheat Varieties.

Project Objectives

Examine milling properties, dough characteristics, protein functionality, and baking properties of soft white wheat varieties.

By

Ng, Perry K.W.

Michigan State University, Department of Food Science & Human Nutrition

Results for 2007

Examination of soft wheat varieties for milling and baking qualities continues. Quality evaluation of selected wheat crops harvested in 2007 has been completed. Data are being analyzed and will be presented at the Michigan State Millers' Association Annual Meeting in January 2008. In addition, biochemical studies on flour proteins have also been conducted. The use of transglutaminase (TG) to improve dough strength of weak gluten protein flour samples has continued to be one of the foci of our investigations. It is known that addition of fiber or of flour with lower molecular weight proteins alters the pasting profile of wheat flour (analyzed by a viscometer). Results show that when barley flour is incorporated (much higher fiber content than wheat flour), the peak viscosities of the wheat-barley flour blend decreased substantially as compared to the control wheat flour. However, when TG was added to the wheat-barley flour blend, the peak viscosities were increased almost to the level of the control wheat flour sample. This may present unique opportunities for the food industry

Another area of focus in 2007 was the examination of effects of various antioxidants and resistant starch on flour dough properties. The addition of antioxidants did not have a significant influence on the mixing properties of flour samples examined. On the other hand, the addition of antioxidants decreased the maximum resistance of fermented dough samples. Understanding the changes in rheological properties upon the addition of the studied antioxidants would be relevant to the baking industry, especially during dough processing. Among the studied samples, starch-supplemented doughs were weaker and absorbed more water than doughs made from the base flour. Resistant starch contents of baked starch-supplemented breads increased significantly as the starch addition level increased. The commercial starches used did not have substantial deteriorative effect on crumb color values, external appearance, nor on symmetry of bread loaves.

Plans for 2008

Continue to evaluate the intrinsic quality parameters of various soft wheat varieties relative to their respective milling and baking characteristics, to continue identifying possible biochemical markers for these characteristics,

and to publish available data. In addition, functional and thermal properties of dough/flour samples treated with TG will be further examined. Effects of various antioxidants and resistant starch on dough rheology and baking properties will continue be studied.

Publications

Ng, P.K.W., Siler, L., Tanhehco, E. MSU Wheat Quality Testing of Advanced Lines: Report on Milling and Baking Test Results for Selected Michigan-Grown Soft Wheats Harvested in 2006. January 2007. 35 pp.

Ozturk, S., Koxsel, H., and Ng, P.K.W. 2007. Production of bread enriched with commercial starch high in resistant starch. *Cereal Foods World* 52(4):A56 for AACCI Annual Meeting.

Mariotti, M., Lucisano, M., Pagani, M., and Ng, P.K.W. 2007. The role of corn starch, amaranth flour, pea isolate and *Psyllium* flour on the rheological properties of gluten-free doughs. *Cereal Foods World* 52(4):A51 for AACCI Annual Meeting.

Rhim, J.W., Lee, J.H., and Ng, P.K.W. 2007. Mechanical and barrier properties of biodegradable soy protein isolate-based films coated with polylactic acid. *Lebens. Wiss. Technol.* 40:232-238.

Cha, J.Y., Ng, P.K.W., Shin, H.S., and Cash, J. 2007. Effects of extrusion conditions on pasting properties of potato. *Food Science and Biotechnology* 16(5):783-788.

What Was Done

Samples were obtained from the Michigan State University Wheat Quality Testing Program, from various breeding programs in the country, and from commercial wheat flour samples. Experimental analyses were carried out either according to AACC official methods or following published procedures. Partial results were presented at the Michigan State Millers' Association Annual Meeting and at the AACCI Annual Meeting, and published in refereed journals.

Impacts

This project will result in a better understanding of wheat flour quality in relation to end-use products. The use of TG will potentially allow (1) bakers to use weaker flour to produce satisfactory baked products, and (2) millers to provide more consistent flour quality to bakers in spite of environmental growing factors. In addition, understanding effects of addition of antioxidants or resistant starch in a flour-base system could provide vital information for bakers to utilize these nutraceutical ingredients in their baked products to benefit consumers' health in general via cereal diets.

Funding Sources

Cereal Industry, Michigan State Millers' Association, State of Michigan

Contacts

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Title

Effect of Preharvest Production Practices on End-Use Quality of Durum Wheat.

Project Objectives

Overall objective is to determine the effect of preharvest production practices on end-use quality of durum wheat.

Specific objectives:

To determine the content and composition of carotenoid pigments deposited in the endosperm during grain filling.

To determine the effects of cultivar and kernel weathering on the color and pigment content of pasta.

By

Manthey, F.A.

North Dakota State University, Department of Plant Sciences

Results for 2007

All cultivars evaluated showed a similar pattern of pigment deposition. RP-HPLC analysis showed that lutein, zeaxanthin and β -cryptoxanthin content per kernel increased during initial grain filling. Lutein and β -cryptoxanthin contents declined and zeaxanthin content remained constant during kernel desiccation phase of grain fill. At harvest, lutein was the predominant pigment. Results indicate that β -carotene can be detected early in grain development but is absent in the fully developed grain. Total yellow pigments and zeaxanthin were more concentrated in the bran/germ layer than the endosperm. Lutein content was greater in the endosperm than in the germ/bran layer. Lutein was uniformly distributed in the endosperm.

Durum cultivars varied in pigment content, which ranged from 6.0 to 8.2 ppm. Removing bran and germ during milling reduced the pigment content an average of 30%. Similarly, pasta extrusion followed by low temperature drying reduced pigment content an average of 24%. Artificially weathering durum wheat reduced pigment content but did not seem to enhance pigment decline during milling or pasta processing.

Plans for 2008

Experiments will be conducted to continue characterizing the deposition and composition carotenoid pigments during kernel development and to determine the relationship between the location on the spike and kernel pigment concentration. New experiments will be conducted to determine the effect of environment and cultivar on oxidative stress level in harvested grain and to determine the relationship between grain oxidative stress level and pigment loss during pasta processing.

Publications

Manthey, F.A. and Elias, E.M. 2007. Effect of weathering on color and pigment content of pasta. *Cereal Foods World* 52:A23. (Abstract).

Singh, V., Manthey, F., and Elias, E.M. 2007. Deposition of carotenoid pigments in durum wheat. *Cereal Food World* 52:A28. (Abstract).

Issues

Pasta industry needs a reliable source of durum wheat that contains levels of carotenoid pigments that will result in a rich yellow pasta product. Industry has observed that occasionally, semolina that contained seemingly adequate levels of carotenoid pigment produced pasta with poor color. Limited information is available concerning the effects of genotype and environment on carotenoid pigment deposition, composition and retention during kernel development. More knowledge is needed concerning the relationship between carotenoid pigment deposition and weathering of grain on final pigment content in durum wheat and ultimately in the pasta produced from durum wheat.

What Was Done

The five durum cultivars were grown in field plots located near Prosper, ND. The experimental design was a randomized complete block. Cultivars were blocked into four replicates. Spikes from each cultivar were harvested every 5 days until harvest beginning 7 days after anthesis. Total pigment content, lutein content, zeaxanthin content and β -cryptoxanthin content were determined using RP-HPLC.

Ten durum cultivars replicated four times were grown at Prosper and Langdon, ND. Each grain sample was subdivided. One subsample (2 kg) was used as a control and the other subsample (2 kg) was artificially weathered by tempering to 35% moisture for six days. The weathered sample was air dried at room temperature. All samples were tempered to 17.5% moisture and milled on a Bühler experimental mill fitted with two Miag laboratory-scale purifiers. Semolina was hydrated to 32% mb, extruded under vacuum and dried using a low temperature (40C) drying profile. Pasta color score was determined using a color map. Pigment content was determined using water saturated n-butanol (AACCI Method 14-50).

Impacts

This research increases the understanding of factors that affect carotenoid pigment content in grain and pasta. Ultimately, the enhancement of carotenoid pigment content will improve the aesthetic and nutritional quality of durum wheat produced in the US. The knowledge gained by this research will eventually contribute to increased economic opportunities for producers and food manufacturers by improving quality and increasing value of durum wheat and its end-use products.

Funding Sources

North Dakota Wheat Commission

Contacts

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Title

Characterization of Hard Spring Wheat (HSW) polysaccharides in relation to end-product quality.

Project Objectives

The overall goal of the project is to determine the effect of polysaccharides found in HSW on end-product quality. The specific objectives include i) characterization of starch properties and ii) structural characterization of arabinoxylans in relation to end-product quality. The results from this project would be useful to select the wheat varieties for certain food industry applications.

By

Simsek, S.

North Dakota State University, Department of Plant Sciences

Results for 2007

This project was initiated in January 2007. Currently, starches were isolated from several wheat cultivars, which are planted in different locations. Experiments are being continued to determine the relationship between the physicochemical properties of starches and tortilla quality. Results related to arabinoxylan structure showed that arabinoxylan chemistry (total amount, ratio of water extractable to unextractable, degree of arabinose substitution, molecular weight and cross-links with other molecules) have significant impact on end-product quality, especially in certain food products such as refrigerated dough. Additionally, water absorption capacity of arabinoxylans has important role on dough quality. Flours with higher ratio of water unextractable arabinoxylans have negative effect on refrigerated dough quality.

Plans for 2008

Experiments will be performed to characterize arabinoxylans and starches from HSW cultivars. Physicochemical properties of starches and arabinoxylan structure will be correlated to tortilla and refrigerated dough quality, respectively.

Publications

Simsek, S., Whitney, K., Mergoum, M. and Mehmet Tulbek, H. "Flour, Dough, Baking Quality Attributes Hard Red Spring Wheat Cultivars Grown in North Dakota". American Association of Cereal Chemist-International Annual Meeting, Cereal Foods World, 52:A65. October 7-10, 2007, San Antonio, Texas, U.S.A

Issues

Arabinoxylans have high water holding capacity, which can impact the end-use quality of food products produced with wheat through modification of water relations. Arabinoxylans are functionally divided into the classes of i) water-extractable and ii) unextractable. Unextractable arabinoxylans are associated with cell wall structure, while soluble arabinoxylans have been shown to affect flour end-use quality. Wheat and rye arabinoxylans are important functional ingredients in baked products affecting water binding, rheology and starch retrogradation. They also protect the gas retention in dough due to the viscous influence on gluten-starch films. Therefore, it is important to investigate their functions in HSW flours.

Physicochemical properties of HSW flours (including total starch, starch damage, pasting profile, flour and dough characteristics, and amylose/amylopectin ratio) are significantly related to bread quality. ND HSW is mainly used in bread-baking industry. There are extensive and detailed studies that have been done to determine the relationship between the protein properties and baking quality for HSW, and there is a demand to determine the relationship between baking quality and physicochemical properties of starches for HSW flours.

What Was Done

Starch properties: Six wheat cultivars from three locations were collected, and milled. Proximate analysis was performed. Starches were isolated using dough washing method. Starch samples were freeze-dried and analyzed by DSC, RVA. Samples will be further analyzed using HPLC and X-Ray diffraction. Then, flours will be used to bake tortilla. Starch properties will be correlated to tortilla quality.

Arabinoxylan chemistry: Refrigerated doughs were prepared using different flours. Arabinoxylans were isolated from these flours, and analyzed by GC-MS, HPLC and NMR.

Funding Sources

North Dakota Wheat Commission

North Dakota Agricultural Product Utilization Commission

Contacts

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Title

Improving Marketing, Processing, Nutritional and Functional Quality of Sorghum, Maize and Wheat.

Project Objectives

Evaluate methods for measuring the physical, chemical and processing properties of sorghum and corn and develop improved food quality cultivars.

Identify and develop sorghum hybrids with unique phenolic compounds for use in healthy foods.

Define the attributes of wheat flours with excellent quality for flour tortillas. Determine the major factors affecting quality of tortillas.

Evaluate the baking quality of Texas wheat breeder samples with emphasis on early generation screening to remove undesirable quality traits early to improve efficiency.

Develop science-based risk management technology and practices to mitigate food safety hazards.

By

Rooney, L.W. and Herrman, T., Waniska, R.D., Lee, K.M., Jones, E.

Texas A&M University, Cereal Quality Lab, Soil & Crop Sciences Department

Results for 2007

Sorghum Quality: New special black sorghums with and without pigmented testa vary in tannin content and in the relative levels of luteolinidin and apigeninidins. Certain hybrids have high levels of luteolinidin or apigeninidins which was confirmed by comparison of grains grown at several locations. Thus, special sorghums with high levels of unique anthocyanins with or without condensed tannins can be produced to optimize health benefits and improve functionality in colored foods. The pigments are stable over a large pH range which is a significant advantage over other natural plant pigments. Grain yields of black sorghum hybrids are high; grain is easily decorticated to concentrate the pigments. Significantly large quantities of flavones and flavanones are found in some sorghum varieties which were significantly higher than other sources of the compound when sorghums were grown in several environments. Extracts of some of them have significantly inhibited in-vitro human colon and breast cancer cells. In cooperative trials, rats fed tannin and black sorghum brans had significantly less colon cancer cells than those fed cellulose or white sorghum brans. The quantity of anthocyanins and flavanoids of sorghum are affected by variety, environment and their interactions.

Several products containing bran from black and tannin sorghums had excellent flavor and color with high levels of antioxidants and dietary fiber. Significant reduction in measurable antioxidant activity occurs when grain is processed because of interactions among the tannins, proteins and carbohydrates. In addition, the high-tannin and

black sorghum porridges were more slowly digested using in-vitro assays that estimated the glycemic index. Some processes such as high-friction extrusion may depolymerize the condensed tannins. The potential for use of whole-grain specialty sorghums in foods is excellent because they provide significant nutritional and functional benefits with a healthy, natural, dark color and whole-grain taste.

Flour Tortilla Research: The effect of amylase, protease, transglutaminase and xylanase on the quality and staling properties of hot-press type flour tortillas was determined. Addition of amylase improved shelf-stability of tortillas, produced dextrans and sugars, increased amylose solubility, and weakened partially gelatinized starch granules. Amylase did not interfere with amylopectin crystallization. Staling of tortillas involves the reassociation of starch into non-crystalline areas that are affected by amylase treatments. The protease and transglutaminase adversely affected tortilla structure. Microscopic observations showed that the protease disrupted the continuous protein network of the tortilla while transglutaminase created thicker protein strands that were heterogeneously distributed and contributed to firmer, more brittle, undesirable tortillas. Xylanase was ineffective in improving shelf stability of tortillas.

In collaboration with the US Grain Marketing Lab in Manhattan, KS, a small-scale baking procedure to evaluate wheat cultivars for tortilla quality was applied to wheat cultivar evaluation.

Wheat Quality for Baking: Nearly 3,000 preliminary nursery wheat samples were analyzed prior to planting to enable breeders to make selections for milling and bread-baking quality attributes. Single-kernel hardness testing was used as the first screen, followed by protein and mixograph properties. Advanced wheat lines are evaluated for quality in the USDA Grain Marketing Laboratory. This combination has improved the overall efficiency of the Texas wheat improvement program. Several potential new wheat varieties are in advanced testing. TAM-112 is being released currently.

Corn Quality Evaluation: A corroborative study was conducted on maize quality and dry- and wet-milling quality properties by 6 participating industry and university laboratories. The statistical results for maize physical properties showed acceptably low standard deviations of within-laboratory repeatability and between-laboratory reproducibility except for two or three physical properties. The results verify the suitability and reliability of the current test procedures commonly used in grain quality laboratories. Large variations in wet and dry milling properties were due to genetics with significant variation among laboratories. Thus, careful evaluation of new experimental hybrids is required during final evaluations. The use of two or more labs in final evaluations should be considered.

Another goal is to identify and develop corn inbreds with characteristics that reduce the risk of aflatoxin and produce high-yielding hybrids. Low aflatoxin accumulation is associated with good husk coverage, flinty endosperm texture, good kernel integrity, high grain yield, and late maturities. The combined evaluations of aflatoxin content and agronomic performance has led to lines with better adaptation, yield potential, stability, and reduced aflatoxin risk. The longer-term goal is to incorporate aflatoxin resistance factors into commercial hybrids. Departure of Dr. Betran, the corn breeder, has slowed these activities.

Corn Tortilla Quality: Use of soy flour, guar gum, CMC and maltogenic amylases significantly improved texture of corn tortillas stored at room temperature and refrigeration. Soy flour addition improved the nutritional and anti-

staling properties of corn tortillas. In terms of functionality, the best soy products are those with low-heat treatments, but they affect tortilla flavor at levels above 5% in the formula.

Risk Analysis: The application of multivariate statistical analysis to assess risk analysis was examined to characterize Texas feed and fertilizer firms using historical product violation records over a 3-year period. The Ward's minimum variance method, a hierarchical clustering algorithm, classified the feed and fertilizer firms into 6 to 7 unique subgroups. Each cluster consisted of firms with similar compliance history. Thus, the best performing feed and fertilizer manufacturers were randomly sampled at the lowest sampling rate. Use of this systematic approach should improve the efficiency of maintaining compliance within the industry.

A census was performed of all country elevators in TX to identify how many facilities were testing for and correctly labeling aflatoxin contaminated grain. Results revealed that 92% of the grain elevators licensed to handle and distribute aflatoxin contaminated grain were testing incoming grain. The census also revealed that of these elevators, 73% of the facilities identified aflatoxin levels above the 20 ppb action level. The Office of the Texas State Chemist (OTSC) harvest samples revealed that 62.5% of the grain harvest in 2006 contained mycotoxins (aflatoxin and fumonisin) over the action level compared to 2007, in which 12% of the grain contained more than 20 ppb aflatoxin and 40% of the grain contained over 5 ppm fumonisin. The OTSC census indicated that 71% of the grain industry was properly labeling grain containing mycotoxin.

Education: Six MS and two PhD students graduated this year with theses related to sorghum quality and tortilla properties. They have positions in the food industry.

Plans for 2008

Concentrate on identification and analysis of flavanoids in sorghums with special characteristics. Evaluate factors affecting processing quality of corn and sorghum, especially changes in anthocyanins and procyanidins of special sorghums. Continue to evaluate wheat flours and other ingredients for tortilla quality. Determine factors affecting the quality of wheat for use in tortillas.

Publications

Dlamini, N.R., Taylor, JRN, Rooney, L.W. 2007. The effect of sorghum type and processing on the antioxidant properties of African sorghum-based products. *Food Chemistry* 105:1412-1419.

Dykes, L. and Rooney, L.W. 2007. Phenolic compounds in cereal grains and their health benefits. *Cereal Foods World* 52:(3)105-111.

Gu, L., House, S.E., Prior, R.L., Rooney, L. 2007. Sorghum bran in the diet dose dependently increased excretion of catechins and microbial derived phenolic acids in female rats. *Journal of Agricultural and Food Chemistry* 55(13):5326-5334.

- Ioerger, B., Bean, S.R., Tuinstra, M.R., Pedersen, J.F., Erpelding, J., Lee, K.M. and Herrman, T.J. 2007. Characterization of polymeric proteins from vitreous and flouy sorghum endosperm. *J. Agric. Food Chem.* 55:10232–10239.
- Kebakile, Martin M., Rooney, Lloyd W., and Taylor, John R.N. 2007. Effects of hand pounding, abrasive decortication-hammer milling, roller milling, and sorghum type on sorghum meal extraction and quality. *Cereal Foods World* 52:(3)129-137.
- Lee, K.M., Herrman, T.J., Bean, S.R., Jackson, D.S. and Lingenfelter, J. 2007. Multivariate classification of dry milled maize grit yield groups by quadratic discriminant analysis and decision tree algorithm. *Cereal Chem.* 84:152-161.
- Lee, K.M., Herrman, T.J., Rooney, L.W., Jackson, D.S., Lingenfelter, J., Rausch, K.D., McKinney, J., L.A. and Fox, S.R. □C., Byrum, L., Hurburgh Jr., C.R., Johnson, □Iiams, 2007. Corroborative study on maize quality, dry-milling and wet-milling properties of selected maize hybrids. *J. Agric. Food Chem.* 55:10751-10763.
- Calderon Zacatares, Vilma Ruth. December 2007. Changes in quality of whole cooked sorghum [*Sorghum bicolor* (L.) Moench] using precooking methods. MS Thesis. Texas A&M University, College Station, Texas. 88 pp.
- Guajardo Flores, David. December 2007. Effect of antioxidants, color and sensory attributes of inclusion of different sorghum brans in model baking systems. MS Thesis. Texas A&M University, College Station, Texas. 106 pp.
- Yeung, Hway-Seen. December 2007. Evaluation of legume cooking characteristics using a rapid screening method. MS Thesis. Texas A&M University, College Station, Texas. 74 pp.
- Ayap Alviola, Juma Novie. May 2007. Roles of carbohydrates and proteins in the staling of wheat flour tortilla. PhD Dissertation. Texas A&M University, College Station, Texas. 91 pp.
- Barron, Marc E. May 2007. The effect of flaxseed hulls on expanded corn meal snacks. MS Thesis. Texas A&M University, College Station, Texas. 110 pp.
- Dlamini, Nomusa Rhoda Ngwenya. May 2007. Effect of sorghum type and processing on the antioxidant properties of sorghum [*Sorghum bicolor* (L.) Moench] based foods. PhD Dissertation. Texas A&M University, College Station, Texas. 130 pp.
- Hines, Lindsey Wortham. May 2007. Development of specialty breads as nutraceutical products. MS Thesis. Texas A&M University, College Station, Texas. 111 pp.
- Pineda, Monica de la Torre. May 2007. Fortification of baked and fried tortilla chips with mechanically expelled soy flour. MS Thesis. Texas A&M University, College Station, Texas. 109 pp.

- Gu, L., House, S.E., Prior, R.L., Rooney, L. 2007. Contents of procyanidins in sorghum and the bioavailability in weaning pigs. International Food Technology, July 28-August 1, 2007, Chicago, Illinois. 2007 IFT Annual Meeting Book of Abstracts, ISSN: 1082-1236. Program No. 227-02.
- Prior, R.L., Howard, L., Gu, L., Rooney, L., Hager, A. 2007. Procyanidins: Effects of source and extrusion conditions on structure, degradation and absorption/metabolism. American Chemical Society 234th National Meeting and Exposition, August 19-23, 2007, Boston, Massachusetts. Abstract AGFD 209. 2007 CDROM.
- Lee, K.M., Herrman, T.J. and Jones, B. 2007. Risk Management and the Application of Multivariate Statistics for Animal Feed. Abstract No. P-262, CFW52:A49 in: Program Book of the 92th AACC International Annual Meeting, San Antonio, TX. October 7-10, 2007.
- Lee, K.M., Herrman, T.J., Rooney, L.W., Jackson, D.S., Bean, S.R., Lingenfelser, J., Rausch, K.D., L.A. McKinney, J., Iiams, C., Hurburgh Jr., C.R. and Johnson, 2007. Corroborative study on maize quality, dry-milling and wet-milling properties of selected maize hybrids. Abstract No. O-47, CFW52:A22 in: Program Book 92th AACC Int'l Annual Meeting, San Antonio, TX. October 7-10, 2007.
- Alviola, J. Novie and Waniska, Ralph D. 2007. Effects of protein-modifying enzymes on the structure and shelf-stability of flour tortillas. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma06.htm>
- Austin, Dilek, Rooney, Lloyd, McDonough, Cassandra. 2007. The effects of sorghum bran substitution and whole grain flours on starch digestibility and Estimated Glycemic Index (EGI) of porridges. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma12.htm>
- Cardenas-Hinojosa, A.P., Njongmeta-Nenge, L.A., Dykes, L., Cisneros-Zevallos, L. and Rooney, L.W. 2007. Concentration and temperature stability of anthocyanins in black sorghum. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma26.htm>
- Dykes, Linda, Rooney, W.L., Peterson, Gary C. and Rooney, L.W. 2007. Phenol profile and antioxidant activity levels of black sorghums grown in different environmental conditions. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma39.htm>
- Gritsenko, M., Alviola, N., Rooney, L.W., McDonough, C., Waniska, R.D. 2007. Buckwheat in wheat flour tortillas. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma50.htm>
- Guajardo-Flores, D., Alviola, N., McDonough, C.M., Waniska, R.D. and Rooney, L.W. 2007. Tortilla quality and antioxidant properties of flour tortillas with tannin sorghum bran and brown flaxseed. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma51.htm>

- Njongmeta, Nenge, Cardenas-Hinojosa, A.P., Dykes, Linda, Cisneros-Zevallos, L. and Rooney, Lloyd W. 2007. Solvents for the extraction of 3-deoxyanthocyanins from sorghum. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma116.htm>
- Njongmeta, Nenge, Cardenas-Hinojosa, A.P. Dykes, Linda, Cisneros-Zevallos, L. and Rooney, Lloyd W. 2007. Stability of colored compounds from black sorghum: Effects of pH and water activity. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma116.htm>
- Poland, Nathan and Rooney, Lloyd W. 2007. Infrared heating and processing of whole Sorghum for use in RTE cereal bar. AACC, San Antonio, TX, October 7-10. <http://www.aaccnet.org/meetings/2007/abstracts/p07ma140.htm>
- Austin, D.L., Rooney, L.W. and McDonough, C.M. 2007. The effects of sorghum bran substitution and whole grain flours on starch digestibility and Estimated Glycemic Index (EGI) of porridges. Texas A&M University Student Research Week, March 26-30, College Station, TX.
- Calderon, V.R., Rooney, L.W., C. McDonough. 2007. Developing quick methods to cook sorghum for different food applications. Texas A&M University Student Research Week, March 26-30, College Station, TX.
- Cardenas-Hinojosa, A.P., Guajardo-Flores, D., Dykes, L., McDonough, C.M., and Rooney, L.W. 2007. Analysis of phenols, tannins, and antioxidant activity of grain legumes compared with different whole grain cereals. Texas A&M University Student Research Week, March 26-30, College Station, TX.
- Guajardo-Flores, D., Cardenas-Hinojosa, A.P., Dykes, L., McDonough, C.M., and Rooney, L.W. 2007. Comparison of total phenol, antioxidant activity and tannin content in different grains. Texas A&M University Student Research Week, March 26-30, College Station, TX.
- Yeung, H., Waniska, R.W., Ehlers, J. 2007. Evaluation of legume cooking characteristics using a rapid screening method. Texas A&M University Student Research Week, March 26-30, College Station, TX. (double award)
- Calderon, Vilma. 2007. Sorghum cooking quality and effect of pretreatment on physical properties of sorghum kernels. (Spanish oral) Program Cooperativo CentroAmerica de Cultivos y Animales (PCCMCA), April 22-28, Guatemala City.
- Ontiveros Martínez, María del Refugio, Morales Castro, Juliana, Delgado, Efrén, Serna- Saldívar, Sergio, Waniska, Ralph, Rooney, Lloyd W. 2007. Efecto del uso de masas madre sobre las propiedades reológicas de la tortilla de harina de trigo. Program Cooperativo CentroAmerica de Cultivos y Animales (PCCMCA), April 22-28, Guatemala City.

Rooney, Lloyd W. 2007. Supply Chain Management for Profitable Food/Feed Products from Traditional Grains Traditional Grains for low Environmental Impact and Good Health, International Foundation for Science (IFS) Workshop, November 6, Pretoria, South Africa.

Rooney, Lloyd W. 2007. Looking back on forty plus years of teaching cereal science, technology and common sense - at the end of the trail. October 7-10. AACC, San Antonio, TX, <http://www.aaccnet.org/meetings/2007/abstracts/s07ma22.htm>

Rooney, Lloyd W. 2007. Progress in utilization of sorghum for healthy foods and phytochemicals. AACC, October 7-10, San Antonio, TX, <http://www.aaccnet.org/meetings/2007/abstracts/s07ma60.htm>

Rooney, Lloyd W. 2007. Mycotoxins in grains. Workshop: Supply chain management of millets for processing into feeds and foods, May 16, Dakar, Senegal.

Rooney, Lloyd W. 2007. Phytochemicals and other healthy components of cereals. 34th Annual Texas Human Nutrition Conference, TAMU, February 2, College Station, TX.

Yeung, H., Waniska, R.D., Ehlers, J. 2007. Evaluation of legume cooking characteristics using a rapid screening method. Southern Region American Society for the Horticulture Science 67th Annual Meeting (Vigna), February 4, Mobile, AL.

Issues

Sorghum varieties exist that have high levels of antioxidants and anthocyanins that have greater stability than natural pigments from fruits and vegetables. Information on their attributes will document their potential use in different food and nutraceutical applications.

Fresh corn and flour tortillas have excellent taste and texture, but many consumers have never tasted a fresh tortilla. Methods to maintain texture and taste during storage are needed.

What Was Done

We have confirmed that special sorghums produce high levels of apigenidin and luteolinidin that have good color stability. More information is required, but special sorghum varieties were effective against colon cancer and breast cancer in human cell cultures. Work continues in this area.

Sorghum food products containing special varieties were developed, and demonstrated the potential of sorghum in numerous healthy food applications. The natural dark color of tannin sorghums provides attractive naturally pigmented baked products with high antioxidant activity and dietary fiber when sorghum bran was used. These products have efficacy for type 2 diabetes as well.

Impacts

Some sorghum varieties contain very high levels of flavanoids and are an excellent natural source of these very rare compounds that have implications in human health.

Special sorghums can be used to produce health foods containing high levels of antioxidants and insoluble fiber with a dark-brown natural color.

Whole sorghum can be extruded to produce excellent products for special dietary (Celiacs) and ethnic needs.

Wheat flour quality attributes for tortillas is significantly different from that of bread flour. Methods to evaluate the quality of wheat specifically for tortillas have been developed and are being used in breeding programs.

Amylase enhanced the shelf stability of flour tortillas, but protease, transglutaminase and xylanase negatively affected the texture and stability of flour tortillas.

More information on the effect of flour quality on tortilla properties was obtained by evaluation of wheat samples from the Wheat Council.

Funding Sources

Texas Agricultural Experiment Station, INTSORMIL USAID CRSP, ARS, USDA and commercial sources of funding.

Contacts

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Title

Grading and End-Use Property Assessment of Single Kernels and Bulk Grain Samples.

Project Objectives

Develop sensors, instrumentation, and procedures for objective grading, on-line measurement, and end-use property assessment of single kernels or bulk samples.

By

Pearson, T.C., Dowell, F.E., Armstrong, P.R.,

USDA, ARS, GMPRC - Engineering Research Unit, Manhattan, Kansas

Results for 2007

Rapid single-kernel NIR measurement of grain and oil-seed attributes. Seed development requires the evaluation of hundreds of seed lines over multiple years to produce only a handful of commercial varieties or hybrids each year. Single-kernel near infrared (SKNIR) measurement has been used to improve and accelerate this process by being able to measure and sort seed for desirable characteristics. A new system was designed and tested that can measure seed characteristics for corn and soybeans at 10 kernels/s, which is a 10-fold throughput increase over previously available technology. Results show the instrument worked well for measuring corn and soybean. The new SKNIR system has excellent potential for reducing the time and costs associated with the development of corn hybrids and soybean lines with specific composition or processing traits. This accomplishment addresses National Program problem areas 1b: Methods to Evaluate Quality.

Detection of Wheat Kernels with hidden insect infestations using an electrically conductive roller mill: Grain kernels infested by insects may show no indication on their exterior, but often contain hidden larvae. Although grain is always inspected for insect infestations upon shipping and receiving, many infested samples go undetected. Many methods for detecting infested wheat have been developed but none has seen widespread use due to expense or inadequate accuracy, or both. In this study, a simple laboratory roller mill system was modified to measure and analyze the electrical conductance of wheat as it was crushed. This facilitated detection of wheat kernels with live insects hidden inside of them. Furthermore, the apparatus is low cost (~1500 for parts) and can inspect a one kg sample in less than two minutes. This technology should help grain handlers and millers detect grain that is infested and take action before the insect population increase and damage more grain. The technology is currently being transferred to General Mills, Inc.

The Relationship of Bread Quality to Kernel, Flour, and Dough Properties: It is difficult to examine wheat kernels, or the flour or dough from those kernels, and determine if they can be used to make a good loaf of bread. However, breeders need to know if their breeding lines will bake well, and millers and bakers need to know if grain or flour they buy will result in good quality bread. We worked with the Federal Grain Inspection Service in order to develop models to predict bread quality including loaf volume, bake mix time, and water absorption. Resulting

models showed that these quality indicators could be predicted with accuracies sufficient for screening samples. These results will help breeders develop lines with good bread quality, and help millers and bakers adjust their processes to maximize profits and give domestic and international consumers a consistently high-quality product. This accomplishment addresses National Program problem areas 1a and 1b: Definition and Basis for Quality, and Methods to Evaluate Quality.

An automated near-infrared system for selecting individual kernels based on specific quality characteristics:

There is currently no method to select kernels with specific end-use characteristics to assist breeders in developing cultivars for specific grower needs or for specific markets. Current methods of developing new cultivars require many years of repetitive crosses to attempt to develop pure lines with specific traits. We developed a system that can automatically select specific kernels with specific traits from populations. The system utilizes near-infrared spectroscopy that measure attributes such as protein content, starch levels, or kernel hardness in individual kernels, and then removes those kernels from the sample at a rate of about 1 kernel/2 s. These kernels can then be used by breeders to develop cultivars with specific traits that will result in crops with improved agronomic performance and improved end-use quality. Also, the selection of kernels can occur in a few minutes and does not require years of crossing required in current breeding programs. The system can also be used to measure the variability of quality within samples, providing valuable information to grain handlers, storage managers, millers, and grain processors. The system has been applied to wheat and proso millet, and could apply to other grains.

Rapid assessment of insect fragments in flour milled from wheat infested with stored grain insects: The process of milling wheat infested with low densities of insects can result in flour containing insect fragments. We milled small lots of wheat infested with common insects found in stored grain to determine how many fragments would be produced; additionally, we tested near-infrared spectroscopy as a novel method to rapidly estimate the number of fragments in a sample. Immature insects produced 0.4 to 1.5 fragments per insect, but adults produced an average of 27 fragments per insect. Spectroscopy was successfully used to categorize samples containing fragments of immature insects but not fragments resulting from adult insects. These data will enable millers to better predict how many fragments may result in a lot of flour, and rapidly test a finished flour sample to determine if it contains excessive numbers of insect fragments.

Additional results and summary included the development of high speed detection and sorting technology to remove toxins from grain, and to sort breeder samples for significant attributes. Systems can process kernels from 1 to 1000 kernels/s. Developed methods to detect insect damaged wheat using an acoustic method and using computed tomography. Both of these methods have promise to inspect large samples very accurately. Also developed an NIR system capable of capturing NIR spectra from 900 to 1700nm on single grain kernels at rates up to 10 kernels/second. Details of these projects and others are outlined in this report.

Plans for 2008

Continue development and refining moderate throughput (~10 kernels/second) sorting devices based on full NIR spectra or visible color images. These will be put to use for separating traits desired for breeding programs such as separating red wheat from white wheat, selecting high oil corn, and waxy wheat. We will also continue work on increasing the throughput and accuracy of the image sorting system.

Publications

- Aldrich, B.T., Maghirang, E.B., Dowell, F.E., and Kambhampati, S. 2007 Identification of termite species and subspecies of the genus *Zootermopsis* using near-infrared reflectance spectroscopy. 7pp. *Journal of Insect Science*. 7:18, available online: insectscience.org/7.18.
- Cheng, E. M., S. Alavi, T.C. Pearson, and R. Agbisit, 2007. Mechanical-acoustic and sensory evaluations of corn starch-whey protein isolate extrudates. *Journal of Texture Studies*. 38(2007):485-510.
- Jia, F., Maghirang, E., Dowell, F., Able, C., and Ramaswamy, S. 2007. Differentiating tobacco budworm and corn earworm using near-infrared spectroscopy. *J. Econ. Ent. Principal author*. 100(3):759-764. Log no. 207103.
- Pearson, T.C., Cetin, A.E., Tewfik, A.H., and Haff, R.P. 2007. Feasibility of impact-acoustic emissions for detection of damaged wheat kernels. *Digital Signal Processing Journal*. Vol. 17(3):617-633.
- Toews, M. D., J. Perez-Mendoza, J. E. Throne, F. E. Dowell, E. Maghirang, F. H. Arthur and J. F. Campbell. 2007. Rapid assessment of insect fragments in flour milled from wheat infested with known densities of immature and adult *Sitophilus oryzae* (Coleoptera: Curculionidae). *J. Econ. Entomol.* 100(5):1714-1723.

Funding Sources

USDA, ARS

Contacts/Collaborations

Tom Pearson, Ph.D., USDA, ARS, 1515 College Avenue, Manhattan, Kansas 66503, T: 785-776-2729, e-mail: Thomas.pearson@ars.usda.gov. The author(s) of this report recognize that strong collaborations are maintained for these projects and others. They wish to acknowledge these collaborations by this listing:

FGIS – Kansas City for end use quality of wheat studies.
USDA-ARS-Biological Research Unit for studies involving detection of insect damaged grain.
USDA-ARS-Grain Quality and Structure Research Unit for end use quality of wheat studies.
USDA-ARS-NCAUR-Mycotoxin Research Unit, Peoria, IL for corn mycotoxin and fungal studies.
USDA-ARS-ISL – Beltsville, MD for basic NIRS research and scab damage research.
Perten Instruments for development of commercialized automated NIR sorter.
Satake USA for use and support of high speed grain sorting equipment.
General Mills in studying the feasibility of detecting insect infested wheat using our technologies.

Management of Grain Quality and Security in World Markets

NC-213 (The U.S. Quality Grains Research Consortium)

Objective 2

Develop basic knowledge, science-based standards, and technologies that promote crop quality, food security and food safety in grain markets.

Title

Monitoring of Liquefaction in dry grind ethanol production with FT-NIR.

Project Objectives

Develop basic knowledge, science-based standards, and technologies that promote crop quality, food security and food safety in grain markets.

By

Paulsen, M.R., Rathore, S.

University of Illinois, Illinois Agricultural Experiment Station, Agricultural and Biological Engineering Department

Results for 2007

Liquefaction is a unit operation in which starch slurry is broken down to lower molecular weight polymers using an alpha amylase enzyme. The extent to which starch is hydrolyzed into dextrins during liquefaction affects how much work is left for the glucoamylase enzymes to convert dextrins into glucose during the subsequent simultaneous saccharification and fermentation (SSF) process. Dextrose Equivalent (DE) is a measure of the extent of starch hydrolysis, which is expressed as the reducing power of the sugars or other compounds as compared to that of the dextrose (glucose) as a standard on dry basis. The objective of this study was to determine the effect of reaction time, initial enzyme dose and corn hybrid on DE values at the end of liquefaction; and to investigate the feasibility of developing calibrations for predicting DE values using a Fourier-Transform Near-Infrared (FT-NIR) Perkin Elmer Spectrum One NTS spectrometer. Calibrations models using PCA, and PLS were investigated.

An analysis of variance was performed using a model where enzyme dose (25, 50, 100 and 200 μ L)/ 50g slurry, for four hybrids (waxy, hi-amylose, and two yellow dents), and time (1 and 2 hr from the start of liquefaction) were the independent class variables. The interaction terms were Enzyme x Hybrid, Hybrid x Time, Enzyme x Time, while DE values were treated as the dependent variable. The model had an F- value of 28.08 with 27 degrees of freedom, and R^2 values of 0.78 indicating that independent variables had a statistically significant influence on the dependent variable.

The individual variables (enzyme dose, hybrid, time and interaction) were statistically significant (0.05 level) based on F-values and p-values obtained for each term. Least Significant Difference tests (t-tests) were performed to determine significant differences between levels for (Enzyme dose, Hybrid, and Time). Least significance difference for DE among Hybrids was 0.79. Of the four hybrids, DE values for yellow dent corn were highest with means varying from 12.8 to 13.9%. Waxy corn mean was 11.2% DE and high amylose corn was lowest with 9.7% DE. For Enzyme dose, least significance difference was 0.71. All the enzyme dose levels were significantly different from each other. Mean levels of DE values for enzyme doses of 25, 50, 100 and 200 μ L/ 50 g were 8.5, 11.1, 12.9, and 16.4 %, respectively. Time for 1 hour and 2 hours after the start of liquefaction were both statistically different

with mean DE levels of 11.8% and 12.6% for 1 and 2 hours, respectively. All of the interaction terms were found to be statistically significant.

About 230 samples were scanned in duplicate in the range of 12000 to 4000 cm^{-1} (833 to 2500 nm) with 2 cm^{-1} interval. Most of the variations in the spectra were in the region 7500 to 5500 cm^{-1} (1333 to 1818 nm) and 5200 to 4000 cm^{-1} (1923 to 2500 nm). The Unscrambler © (CAMO Software AS) software was used for regression analysis, and PLS1 and PCR methods were used for building the calibration. The Jackknife method (Esbensen et al., 1998) with full cross-validation was used for elimination of the non-significant variables. In the Jackknife method, standard errors for the coefficients were calculated, and wavelengths with standard errors that crossed the zero lines were removed from the calibration. The model with lowest RMSEP (1.5% DE) was found by using the raw spectra with PLS1. Its offset was smallest with 1.4, slope (0.89) was closest to 1.0 over the DE range from 5.4 to 22.4 %; and the PLS1 model had a RPD value of 2.7.

Plans for 2008

To validate liquefaction and fermentation NIR calibrations in industrial dry-grind ethanol processing plants.

Publications

Rathore, S.S., Paulsen, M.R., Sharma, V, and Singh, V. 2007. Use of near-infrared spectroscopy for monitoring fermentation in a corn dry grind ethanol process. *Trans of ASABE*. Vol. 50(6) 8pp.

Rathore, S.S., Paulsen, M.R., and Singh, V. 2007. Measuring dextrose equivalents of liquefaction slurry for dry-grind corn ethanol processing using near-infrared spectroscopy. Presented as AACC Poster Oct 7-10, 2007 San Antonio, TX.

Issues

The ability to quickly measure liquefaction and fermentation processes in dry-grind ethanol plants.

What Was Done

Calibrations for measuring DE in liquefaction and ethanol and total sugars in fermentation processes with FT-NIR spectroscopy were developed.

Impacts

U.S. ethanol production capacity was 4.4 billion gallons per year in February of 2006 and as of October 2007 the Renewable Fuels Association (RFA) estimates that 131 plants were producing 7.02 billion gallons of ethanol annually. An additional 6.49 billion gallons of ethanol production is expected by the end of 2009 based on 72 more new plants and 10 plant expansions already underway (RFA <http://www.ethanolrfa.org/industry/locations/>).

Ability to rapidly measure and monitor liquefaction and fermentation processes and variability in DDGS quality is needed.

Funding Sources

DICKEY-john Corporation

Illinois Agricultural Experiment Station

Contacts

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Title

Traceability Research.

Project Objectives

Iowa State has assisted a large country elevator in the creation of a certified quality management and product tracking system, based on the American Institute of Baking Quality Systems Evaluation System (QSE). The QSE system will be converted to the more management-based ISO 9000 format and applied to other grain and feed locations. At one location historic performance data sufficient to document the economic efficiency benefit of the quality management system will be compiled. A procedure and template for converting alternative or industry-specific quality management system formats to ISO 9000-2000 certifiable formats will be created.

High value (pharmaceutical, industrial) grains will require extremely stringent isolation from staple commodities if they are to be grown in commodity-producing areas. Operations from planting to end-use will be quantitatively assessed for their potential to contribute either accidental or malicious mixing.

By

Hurburgh, C.R., Jr.

Iowa State University, Department of Agricultural and Biosystems Engineering

Results for 2007

A traceability system was tested at an Iowa grain elevator company. Mock recalls of random outbound lots were used to determine the time and precision of source identification. Traceability index varied from 8 to 1000 with an average of 290 over 41 mock recalls. An index of 1 would mean perfect IP tracking. All elevators were able to complete the tracking to whatever degree of precision was possible, within 24 hours. Presently grain flow modeling is being used to improve the precision of the grain handling recalls.

A GIS-based lot identification system was developed, using the output from one dump of a combine as the smallest possible trade lot. A date-time stamped GIS code represents a unique coding that will never have a duplicate; lots identified in this way can be aggregated in databases with GIS identified storage, and time identified position within storage.

A cost benefit procedure for traceability at market points was developed.

ISU scientists represented the USA on three ISO technical advisory groups; biotech testing, 22005 (traceability) and 22006 (production agriculture).

Plans for 2008

Publish elevator case study data. Expand the ISO development to agronomy input supply and link with the GIS-based farm traceability model. Develop a flow model approach to tracking grain within bulk handling, and estimating the probability of given input lots being in specific output lots. Develop training materials to support the use of cost benefit studies of traceability.

Publications

- Hurburgh, C.R., Jr. 2007. Tracing GMOs in the US Bulk Agricultural Market. 3rd annual meeting of CoExtra 6th Framework EU Project, Bologna, Italy February 4, 2007. (CY07, FFY07)
- Bennett, G., and C. R. Hurburgh, Jr. 2007. Cost-Benefit analysis flow chart for identity preservation systems: A case study of ultra-low linolenic soybeans grown on Iowa farms. Second Annual Symposium, Institute for Food Safety and Security, Ames Iowa. April 12, 2007. Poster. (CY07, FFY07)
- Shepherd, H. and C. R. Hurburgh, Jr. 2007. FDA Registration and Record Maintenance for Grain Handling Facilities and Feed Mill Facilities. Second Annual Symposium, Institute for Food Safety and Security, Ames Iowa. April 12, 2007. Poster (CY07, FFY07)
- Gemesi, H. G., and C. R. Hurburgh, Jr. 2007. Geographic Food Origin Traceability Model. Second Annual Symposium, Institute for Food Safety and Security, Ames Iowa. April 12, 2007. Poster (CY07, FFY07)
- Laux, C., and C. R. Hurburgh, Jr. 2007. Traceability of commodity grain using a quality management system. Second Annual Symposium, Institute for Food Safety and Security, Ames Iowa. April 12, 2007. Poster (CY07, FFY07)
- Hurburgh, C.R. Jr. 2007. Developing traceability of bulk agricultural products. 3rd Annual Meeting, TRACE 6th EU Framework project, Iraklion, Crete April 27, 2007. Invited presentation. (CY07, FFY07)
- Bennett, G., and C. R. Hurburgh, Jr. 2007. Cost-Benefit analysis flow chart for identity preservation systems: A case study of ultra-low linolenic soybeans grown on Iowa farms. 3rd Annual Meeting, TRACE 6th EU Framework project, Iraklion, Crete April 27, 2007. Poster. (CY07, FFY07)
- Shepherd, H. and C. R. Hurburgh, Jr. 2007. FDA Registration and Record Maintenance for Grain Handling Facilities and Feed Mill Facilities. 3rd Annual Meeting, TRACE 6th EU Framework project, Iraklion, Crete April 27, 2007. Poster. (CY07, FFY07)
- Gemesi, H. G., and C. R. Hurburgh, Jr. 2007. Geographic Food Origin Traceability Model. 3rd Annual Meeting, TRACE 6th EU Framework project, Iraklion, Crete April 27, 2007. Poster. (CY07, FFY07)

Laux, C., and C. R. Hurburgh, Jr. 2007. Traceability of commodity grain using a quality management system. 3rd Annual Meeting, TRACE 6th EU Framework project, Iraklion, Crete April 27, 2007. Poster. (CY07, FFY07)

Issues

For a variety of business, safety, security and regulatory reasons, traceability of food products from source to use is becoming necessary. Bulk products, such as grains, are particularly difficult to trace, especially when lots are blended and mixed in the distribution network. The recent problems with wheat gluten, aflatoxin, and contaminated vegetables demonstrate the need to develop more sophisticated tracking systems that can reduce the number of possible source lots for any contaminated lot.

Impacts

Accurate traceability of bulk materials will increase compliance with bioterrorism regulations and improve brand protection. One incident, such as the Diamond Pet Food issue, can easily create tens of million of dollars or more in legal and sales loss costs. The work with the elevator demonstrated that ISO-compliant traceability systems generated net revenue (2-5 cents per bushel) from efficiencies and conformance to specifications, greatly in excess of costs. This means the traceability issue can be a business benefit rather than a cost.

Contacts

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Title

Effect of Low Temperatures on Mortality of Indianmeal Moth (*Plodia interpunctella*).

Project Objectives

The primary objectives are to study the effects of low temperatures on mortality of Indianmeal moth (*Plodia interpunctella*), model temperatures inside grain bins under various management schemes, and use this information to develop stored grain management recommendations that will reduce problems with Indianmeal moth.

By

Morey, R.V., University of Minnesota Bioproducts and Biosystems Engineering Department
Wilcke, W.F., University of Minnesota Bioproducts and Biosystems Engineering Department

Kells, S.A., University of Minnesota Entomology Department

University of Minnesota, Bioproducts and Biosystems Engineering Department

Entomology Department

Results for 2007

Accomplishments and results for 2007 include:

Published a paper on using low-temperature aeration to control Indianmeal moth.

- Developed, validated, and published a cumulative lethality index (CLI) model to estimate mortality of *P. interpunctella* larvae under changing temperature conditions. Presented the results in a paper and submitted it for publication.
- Information on using low storage temperatures to kill insects has been incorporated into Extension presentations given to stored-grain managers.

Plans for 2008

Finalize publications on research.

Publications

Kaliyan, N., R.V. Morey, W.F. Wilcke, M.A. Carrillo, and C.A. Cannon. 2007. Low-temperature aeration to control Indianmeal moth, *Plodia interpunctella* (Hübner), in stored grain in twelve locations in the United States: A simulation study. *Journal of Stored Products Research* 43: 177-192.

Kaliyan, N., M.A. Carrillo, R.V. Morey, W.F. Wilcke, and S.A. Kells. 2007. Mortality of Indianmeal moth (Lepidoptera: Pyralidae) populations under fluctuating low temperatures: model development and validation. *Environmental Entomology* (in press).

Issues

Alternatives to chemical insecticides are needed for managing stored grain insects. Insects have become resistant to some traditional stored grain chemical insecticides and there is growing concern about the impact of insecticides on the environment and on human health. It is well known that insect activity slows as temperature decreases. Most insects become dormant below certain critical temperatures and many insects die if held at a low enough temperature for a long enough time. In the northern parts of the U.S. grain growing areas, it should be possible to manage stored grain insect populations by using aeration with outdoor air to control temperatures inside bins of stored grain at levels that limit insect activity and possibly even kill insects. More information is needed on the specific time-temperature relationships needed to kill insects and on the typical number of hours available at various outdoor temperatures in order to develop recommendations that can be used to limit stored grain insect populations and reduce the need for chemical insecticides.

What Was Done

The primary activity in 2007 was to complete work on the effects of low temperatures on mortality of Indian meal moth [*Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae)].

In addition, the effect of broken corn on Indianmeal moth (*Plodia interpunctella*) survivability was determined. Researchers developed, validated, and published a cumulative lethality index (CLI) model to estimate mortality of *P. interpunctella* larvae under changing temperature conditions.

A model for predicting mortality of *P. interpunctella* larvae under fluctuating low-temperature conditions was developed. The time and temperature combinations required to achieve 100% mortality of field-collected, cold-acclimated *P. interpunctella* larvae obtained from laboratory mortality experiments were used to develop the mortality model. Accumulation of mortality rate over time was called the Cumulative Lethality Index (CLI). Complete mortality of insect populations would occur when CLI equals one. Observed mortality of field collected, cold-acclimated *P. interpunctella* larvae in five 76.2-T (3,000-bu) shelled corn bins located in Rosemount, Minnesota during the winters of 2003-2004 and 2004-2005 were used to validate the CLI model (i.e., mortality model). Excellent agreement between predicted and measured time to 100% larval mortality was observed. The CLI model would be useful for developing low-temperature aeration management strategies for controlling overwintering *P. interpunctella* in grain bins. In addition, this model will be useful when determining if additional control measures will be required as a result of above-seasonal ambient temperatures.

Impacts

It is expected that this research will lead to recommendations for storage bin equipment and for stored grain management that can be used to limit insect populations without the use of chemical insecticides. Reduced use of chemical insecticides should reduce grain storage costs and reduce potential harmful environmental and human health impacts from chemical insecticides.

Funding Sources

Minnesota Agricultural Experiment Station

Contacts

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Title

Aeration-based management of insects in on-farm stored wheat.

Project Objectives

Develop basic knowledge, science-based standards, and technologies that promote crop quality, food security and food safety in grain markets.

By

Weaver, D.K.

Montana State University, Montana Ag Experiment Station, Department of Land Resources and Environmental Sciences

Results for 2007

Multi-year pitfall trapping data from three sites in Montana were analyzed to determine the potential population suppression using natural air aeration to chill the newly-stored commodity. The pest complex in the experimental bins was almost exclusively secondary species, and the insect most commonly captured was the rusty grain beetle. An array of seventeen WBII pitfall probe traps, deployed continuously in the grain bulk from fall through spring, never captured more than 20 primary pest individuals, all of which were lesser grain borers. All lesser grain borers were captured in the autumn; none were captured the following spring. Comparative sampling using grain triers failed to recover any insects more than ninety percent of the time.

Aeration rapidly decreased grain temperatures to levels that were unsuitable for insect activity and were deleterious to survival and reproduction. Uniform temperature distributions prevented the formation of overwintering “hotspots”, which contribute to population growth of the secondary pest species inhabiting newly-stored wheat.

Plans for 2008

Contour maps and comparative spatial analysis will be conducted using this data. An Extension publication will be prepared.

Publications

Weaver, D.K. Stored grain weevils. In W.W. Bockus et al. [eds.] Compendium of wheat diseases – 3rd Edition. APS Publications, St. Paul, Minnesota. In Press.

Issues

Facilitate aeration based management of stored product insect pests as an alternative to the use of protectant insecticides. Residues of protectant insecticides are undesirable components of wheat being exported to international markets, due to end-user preference.

What Was Done

Aeration protocols were demonstrated to suppress insects in storage.

Impacts

The methodology developed should reduce the use of protectant insecticides on wheat stored in Montana, and has applicability to other regions of the northern Great Plains. This should create a more favorable climate for annual negotiation of international grain contracts, particularly when residual pesticides are an issue.

Contacts

David K. Weaver, Department of Land Resources and Environmental Sciences, 334 Leon Johnson Hall, Montana State University, Bozeman, MT 59717-3120; 406-994-7604; fax: 406-994-3933; e-mail: weaver@montana.edu

Title

Assessing and Improving End-Use Quality and Safety of Grain and Grain-Based Products.

Project Objectives

Develop measurement techniques that reliably predict end-use characteristics of corn.

Identify the impact of agronomics on grain quality traits.

Identify marketable properties and potential of “new” grain traits.

Improve the safety of grains and grain-based products.

By

Jackson*, D.S., Bullerman, L.B.

University of Nebraska–Lincoln, Nebraska Agricultural Experiment Station, Department of Food Science and Technology

Results for 2007

(Dr. Jackson) Decortication of corn was found to not result in loss of ethanol yield and protease treated corn more quickly reached its maximum ethanol yield; protease enzyme(s) can be used to shorten fermentation times.

RVA pasting curves showed that amylose dispersed within a waxy wheat (native) granule increases the viscosity of the paste beyond that of mechanically mixed native granules at nearly the same % amylose. Hydroxypropylation "stabilizes" the final viscosity of mechanically blended waxy wheat starches and higher amylose genotypes, and cross-linked genetically blended waxy wheat amylose viscosity is depressed compared to mechanically blended amylose. These results suggest that unique starch viscosity characteristics can be obtained from waxy wheats and partially waxy wheats. Blends of waxy and wild type wheats (compared to an amylose content similar to a partially waxy wheat) are not likely to result in the same viscosity profile.

(Dr. Bullerman) Extrusion of corn grits contaminated with fumonisin in the presence of 10% glucose resulted in an apparent loss or reduction of the fumonisin. However mass balance calculations showed that most of the fumonisin was accounted for in other forms of fumonisins. The predominant form found was N-(1-Deoxy-D-Fructos-1-yl)FB1. Small amounts of hydrolyzed fumonisin (HFB1) and N-carboxy methyl fumonisin B1 (NCMFB1) were also formed.

Plans for 2008

Additional work will be conducted on understanding fumonisin destruction, reduction and conversion in grains and grain products; fermentation studies will continue to focus on improving our ethanol yield evaluation methods applicable to a wide range of grain substrates and process conditions; novel grain product/use research will continue with modified and native waxy wheats.

Publications

Bullerman, L.B. A. Bianchini, L. S. Jackson, J. Jablonski, M. A. Hanna, and D. Ryu. 2008 Reduction of Fumonisin B1 in Corn Grits by Single-Screw Extrusion. *J. Ag. Food Chem.* (in press).

Kaye, N.M., S.C. Mason, D.S. Jackson and T.D. Galusha. 2007. Crop rotation and soil amendment alters sorghum grain quality. *Crop Science*: 47:722-727.

Lee, K.-M., Herrman, T. J., Bean, S. R., Jackson, D. S. and Lingenfelter, J. 2007. Classification of Dry-Milled Maize Grit Yield Groups using Quadratic Discriminant Analysis and Decision Tree Algorithm. *Cereal Chemistry* 84(2):152-161.

Ratnayake, W. S, Wassinger, A.B., and Jackson, D.S. 2007. Extraction and characterization of starch from alkaline cooked corn masa. *Cereal Chemistry* 84(4):414-420.

What Was Done

(Dr. Jackson) Investigated the effect of decortication and protease enzyme addition pretreatments on corn ethanol production. Whole yellow dent corn and corn with 10% and 30% of the pericarp removed were used as raw materials. A slurry (containing 30% w/v solids) was prepared by mixing hammer milled corn (2mm mesh) and distilled water. The slurry was then partially liquefied using thermostable alpha-amylase and cooked on a hot plate for 1h from the time the slurry begins to boil. The samples were then cooled to 65°C and additional alpha-amylase and amyloglucosidase was added for saccharification. The mash was then fermented by adding a yeast (*Saccharomyces cerevisiae*) inoculum. Samples were obtained from fermentation flasks over time, from 24h to 72h, and the ethanol concentration was determined.

In separate work, investigated the functionality of waxy and partially waxy wheat starch. These starches were compared when blended to a specific amylose content (mixture of waxy granules and native granules) vs. having granules with a single amylose content (unmixed). Starch functionality was also assessed when chemically modified. Starches from each genotype of four partially waxy wheats grown at Yuma, AZ, during two crop years were isolated using AACC dough ball washing followed by flow table separation. Starch from fully waxy wheats and wild type wheats were also obtained. Amylose content of all native starches and blends was determined using a dual wavelength. Starches were chemically modified using a) 4.1%, dsb, propylene oxide, and b) cross-linking with 0.0165%, dsb, POCl₃. Rapid Visco-analyses (RVA) were performed upon all native and modified starches using 25 gm of water and 2.5 gm starch. All samples were pasted in triplicate. The results of the experimentation outlined above were presented at the Annual Meeting of AACC International to academic and food industry scientists.

(Dr. Bullerman) Research was designed to determine the efficacy of extrusion in reducing fumonisin B1 (FB1) in corn flaking grits in the presence and absence of glucose. In addition, degradation products of FB1 during extrusion were identified and quantitated with a mass balance approach. Uncontaminated clean corn grits, grits spiked with 30 micrograms per gram of FB1, and grits fermented with *Fusarium verticillioides* M-2552 (40-50 micrograms per gram of FB1) were extruded in the presence and absence of glucose (10%, w/w) using a single screw extruder. Extrusion decreased FB1 21-37% while the same process with added glucose further decreased FB1 77-87%. LC-MS showed that the most of fumonisin in extruded samples, in the absence of glucose, was the FB1 form, while the main degradation product in grits extruded with glucose was N-(1-deoxy-D-fructo-1-syl) FB1. The formation of hydrolyzed FB1 was not significant during extrusion. Results suggest that extrusion in presence of glucose may reduce FB1 in corn grits significantly, and also reduced toxicity.

As a result of Dr. Jackson's and Dr. Bullerman's research, here are impacts on the overall research:

Developed fermentation test procedures suitable for evaluating novel grains and process modifications.

Process modifications and/or use of modified grain substrates have potential to increase the production efficiency and economic viability of grain-based ethanol production systems.

Food processors can use waxy wheat varieties, blends of waxy and non-waxy wheat varieties, or partially waxy wheats to obtain starches with the specific viscosity profile they desire, potentially allowing for the production of improved food and industrial products.

Results have shown that FB1 products formed during extrusion are very probably less toxic than the parent FB1, resulting in lower toxicity of the extruded product and improving food safety.

Funding Sources

Private industry, internal resources and grants.

Contacts

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Title

Flaxseed Quality Assessment: Factors Affecting Seed Quality.

Project Objectives

The long-term goals of the flaxseed research group at North Dakota State University are to enhance flaxseed quality, through seed characterization, and to assess the feasibility of flaxseed as a food ingredient. The specific objective was to assess antifungal activity of flaxseed. The information gained through research will be useful to the flaxseed and food industries to better select flaxseed for food applications.

By

Hall III, C., Department of Cereal and Food Sciences, Wolf-Hall, C., Department of Veterinary and Microbiological Sciences

North Dakota State University, Department of Cereal and Food Sciences

Department of Veterinary and Microbiological Sciences

Results for 2007

Flaxseed (*Linum usitatissimum*) has never been considered as a food preservative. The objective of this study was to investigate the antifungal activity of flaxseed and flaxseed extracts, as well as the stability of the antifungal activity. High quality flaxseed was used as the source of the antifungal extracts. Strains of *Penicillium chrysogenum*, *Aspergillus flavus*, *Fusarium graminearum*, and a *Penicillium* sp. isolated from molded noodles were used as test microorganisms. Flaxseed protein extract was found to possess fungistatic activity in potato dextrose agar (PDA) media. The stability of the fungistatic activity of the protein extract was evaluated as part of the investigation. Response surface methodology (RSM) using Box–Behnken factorial design was used to evaluate the effects of treatment variables, namely temperature (50–90°C), time (1–29 min), and pH(2–8) on the residual fungal inhibition against the microorganisms given above. Regression analyses suggested that the temperature and time had significant ($p<0.05$) negative effects on the residual inhibition against all test fungi, whereas that of pH had a significant ($p<0.1$) positive role on the residual fungal inhibition of all three fungi. The interaction (temperature-pH) was found to significantly ($p<0.1$) affect the residual fungal inhibition against both *Penicillium* strains tested.

To explore further the antifungal activity of the protein, protein extracts were produced from solvents with different pH values. Protein extracts (1%) inhibited all molds and the most effective extracts were obtained from solutions with pH values of 5 and 10. Sixty percent of the antifungal activity was retained after flaxseed was heated at 100 °C for 15 min. At pasteurization condition, $\geq 50\%$ activity of flaxseed protein were retained except for *P. chrysogenum*.

Further characterization of the antifungal components of flaxseed lead to the following discoveries: flaxseed gum and cyanogenic glycosides did not inhibit the growth of the molds whereas crude phenolic extracts did inhibit mold.

The crude phenolic extracts obtained from extraction with 60% methanol were the most effective. Partial purification of the 60% methanol extracts improved the antifungal activity.

Plans for 2008

Continue to evaluate the component(s) responsible for the antifungal activity and determine the influence of seed quality on antifungal activity. Furthermore, the characterization of the seed will be completed to determine if poor quality seed impacts end use (i.e. antifungal activity). Additional evaluations will be completed to determine the influence of flaxseed on product quality.

Publications

Y. Xu, C. Hall III, C. Wolf-Hall, F. Manthey. Fungistatic activity of flaxseed in potato dextrose agar and a fresh noodle system, *International Journal of Food Microbiology* (2007), doi:10.1016/j.ijfoodmicro. 2007.11.005.

Y. Xu, C. Hall III, C. Wolf-Hall. Antifungal Activity Stability of Flaxseed Protein Extract Using Response Surface Methodology. *Journal of Food Science (Online Early Articles)*. doi:10.1111/j.1750-3841.2007.00576.x).

Impacts

Flaxseed and flaxseed extracts may be promising as natural multifunctional ingredients due to their health benefits and preserving effect. These results suggested that flaxseed and flaxseed protein had certain degrees of stability and thus can be targeted to food systems that would not inhibit the antifungal activity. This project demonstrated the feasibility of flaxseed as an antifungal agent.

Funding Sources

North Dakota Agricultural Products Utilization Commission.

Contacts

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Title

Effectiveness and Profitability of Alternative Insect Control Strategies in Grain Storage and Processing Firms.

Project Objectives

Investigate effectiveness and profitability of alternative insect control strategies in grain storage and processing firms.

By

Adam, B.D.

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Results for 2007

Previous cost-benefit work with an interdisciplinary, multi-institutional team of scientists had assessed costs of failing to control insects in IPM and chemical-based strategies using a simulation approach. Results showed that insufficient control of insects is a significant cost, especially if insect problems are undetected. Also, sampling adds unnecessary cost in some situations where it does not change the treatment. These results are important because they help explain why some elevator managers are reluctant to adopt IPM techniques. Work this year on costs, benefits and risks expanded upon that simulation to reflect more realistic insect growth and immigration parameters, weather conditions, and effects of treatment methods.

Plans for 2008

Work already completed analyzing costs and benefits of implementing IPM in grain storage firms will be expanded to agribusiness processing firms. A key part of the work is to construct a framework for selecting appropriate insect-control methods for each stage of the production process.

Publications

Adam, Brian D. "Cost Comparison of Methyl Bromide and ProFume® for Fumigating a Food Processing Facility: A Report to National Pest Management Association and Dow AgroSciences." Working paper #AEP-0704, Oklahoma State University, Dept. of Agricultural Economics, 2007. Available at http://agecon.okstate.edu/faculty/publications_results.asp?page=1.

Issues

Although consumers and food processors express desires for reduced pesticide use in the food chain, agribusiness managers will not adopt Integrated Pest Management (IPM) practices voluntarily unless their cost and effectiveness

compare favorably with conventional chemical-based practices. An economic analysis comparing costs, benefits, and risks of IPM vs. conventional pest management practices is needed to determine if IPM is cost-effective for stored grain and grain processing functions, as well as to identify potential cost-savings for implementing IPM.

Funding Sources

2007-2009 "Integrated Post-Harvest Rice Management: Optimizing Insect Control, Grain Quality, and Information Delivery." USDA-CSREES-CAR. 9/1/2007-8/31/2009. \$612,199 total, \$75,674 to OSU. PIs Lloyd T. (Ted) Wilson and Yubin Yang, Texas A&M U.-Beaumont; Franklin H. Arthur and James F. Campbell, USDA-ARS; Terry Siebenmorgen and Jean-Francois Meullenet, U. of Arkansas-Fayetteville; Brian D. Adam, Oklahoma State U.; Eugene Reagan, Louisiana State U.; Tanja McKay, Arkansas State U.-Jonesboro.

2005-2009 - USDA CSREES Risk Avoidance and Mitigation Program, "CIMSPIP: Integrated Management of Storage Pests from Farm to the Table," for \$1,700,000 total and \$420,017 to OSU. TWP is the lead PI for OSU and co-PI to the larger project with PI S. Ramaswamy (KSU) and co-PIs Subramanyam (KSU), Arthur (USDA ARS Kansas) and Maier (Purdue).

Contacts

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Title

Investigation of Methods to Improve the Flowability of Dried Distillers Grains with Solubles (DDGS) during Processing, Handling, Storage and Transport.

Project Objectives

The focus of this research was to determine the physical and flow properties of DDGS for designing handling, transport and storage systems to ensure smooth flow. In particular researchers investigated the effect of DDGS process variables on the product quality and flow properties and also the effect of handling on particle segregation. The specific objectives that were investigated are:

Objective 1. Particle segregation during handling of DDGS.

Objective 2. The effect of process variables on DDGS physical and chemical characteristics, and

Objective 3. An investigation of standard methods to determine the moisture content of distillers dried grains with solubles (DDGS)

By

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Purdue University

University of Wisconsin-Madison

Results for 2007

Objective 1: Dried distillers grains with solubles (DDGS), is a granular bulk solid and co-product of corn ethanol production that is used primarily as a livestock feed. Bulk handling of DDGS such as in gravity-driven discharge from a hopper or vessel vibrations during transportation could cause particle segregation which may lead to nutrient inconsistency within the bulk. The major objectives of this study were to investigate the occurrence of particle segregation induced by three handling scenarios normally experienced in bulk handling of DDGS from production through to product delivery. In studies conducted with samples of DDGS from an "old" generation fuel ethanol plant, particle segregation occurred for all the three particle segregation scenarios. Morphological analysis of the DDGS particles confirmed that it consisted of a heterogeneous mixture of particles of corn kernel components: germ, fiber, tip cap and other solids. DDGS particles were classified into three distinct groups, on the basis of differences in particle size. Groups I, II, and III consisted of particles retained on U.S. sieve no.'s 4 - 12, 16 - 30 and 40 - 140, respectively. The morphological, particle density and particle size distribution analyses showed distinct differences in particle physical characteristics in the three groups. The major findings of this work is the need to emphasize the use of an appropriate and uniform sampling protocol industry wide to minimize errors that may result from localized granulometric and/or chemical variation in bulk DDGS caused by handling.

In another study, particle segregation of DDGS due to gravity-driven discharge and its effect on the chemical variability of the bulk was investigated by analyzing samples collected from various locations in piles formed in a laboratory experiment and piles formed in the flat storage of a commercial ethanol plant after discharge from the rotary drum dryer. Results from piles formed in both the laboratory and plant study confirmed gravity-driven discharge creates particle segregation of DDGS in the pile formed. Particle segregation in the piles formed gave rise to significantly different particle sizes at the various sampled locations in the pile. Smaller particles tended to concentrate at the centre of the pile and the particle sizes increased with radial distance in the direction of the free surface. Additionally the particle sizes decreased with increasing height in the pile. Also it was found that there was no significant difference in crude fat and fiber content within the bulk due to particle segregation. However, there was significant difference in moisture content of DDGS particles that was most likely due to particle segregation. While there were significant differences in crude protein and ash content, the differences observed did not follow any distinct pattern.

Objective 2: The production of ethanol from the dry-grind process generates two by-products namely, wet distillers grains (WDG) and condensed distillers solubles (CDS) which are mixed together and dried to form dried distillers grains with solubles (DDGS). A problem in the DDGS market is that there is a lot of nutrient variability in DDGS and this has made livestock nutritionist skeptical about its inclusion in feed rations. The objective of this study was to determine whether CDS has an effect on both physical and chemical characteristics that are associated with quality. Three treatments of DDGS with 0, 10 and 20% by weight of CDS to WDG were produced in a bench-scale rotary drum dryer and evaluated based on their physical properties (color, particle size and particle size distribution), chemical properties (proximate analysis and amino acid profiles) and moisture sorption isotherm. Results showed that the particle size expressed as the geometric mean diameter (d_{gw}) was significantly different ($p < 0.05$) and increased with CDS levels from 0 to 20%. Also, the particle size variation increased with increasing levels of CDS from 0 to 20%. Trends for DDGS color showed that increasing CDS levels in DDGS caused samples to become increasingly darker. Proximate and amino acid analyses showed that DDGS samples with varying CDS had significantly different ($p < 0.05$) amounts of crude protein, crude fat, ash and total reducing sugars. Higher levels of crude protein, fat and fiber were recorded in the dried distillers grains (DDG) samples produced from 100% WDG. Higher levels of ash and residual sugars were recorded in the CDS. Therefore, increasing CDS fraction decreased crude protein and fiber, but increased fat, ash and residual sugars. The total amino acids from Methionine, Lysine, Threonine and Tryptophan were much higher in the WDG fraction than in the CDS fraction. Higher total amino acids were attributed more to higher levels of amino acids in WDG compared to CDS. Moisture isotherm graphs were determined using the Dynamic Dewpoint Isotherm (DDI) method. CDS did have an effect on moisture content; the moisture content increased with increasing levels of CDS as the water activity increased.

Objective 3: This study quantified the variability among various standard testing methods used for moisture content determination by gravimetric determination, also known as moisture loss on drying methods. There were fifteen standard moisture loss on drying methods examined which have been used in the literature for moisture determination of DDGS or related products. Additionally, two moisture loss on drying methods using a Thermo-balance (HB43 halogen moisture analyzer, Mettler Toledo Inc., Columbus, OH), a common instrument used for moisture determination of DDGS in fuel ethanol plants were examined as well. The Karl Fischer titration (KF) method was used as the standard method to evaluate all the moisture loss on drying methods evaluated. Samples of DDGS from three different fuel ethanol plants that included both 'old' and 'new' generation plants were used in this

study to evaluate the moisture loss on drying methods. In other to investigate the effects of DDGS chemistry on moisture determination, proximate analyses and quantities of reducing sugars were estimated for the samples investigated. There was statistical significant difference among the methods investigated. A difference of as much as 8.17 percent points, the largest, occurred between the AOAC 930.15 (4.1.06) method (drying 2 g of ground sample in air oven at 135 °C for 2 hours) and the KF method, while the least difference, 0.02 percent point occurred between the Thermo-balance method (drying 1 g sample at 105°C for about 5 min). Findings show the need to standardize moisture content determination of DDGS. The Thermo-balance method, drying 1 g sample at 105°C for about 5 min, gave the best estimate of moisture content and this would be the method to use based on speed and accuracy. Statistical analyses of the chemical data by regressing the moisture content (dependent variable) with the crude fat, crude protein, crude fiber, ash and total reducing sugars indicated that that the crude protein, fat and fiber contents affected the moisture content at $\alpha = 0.05$ probability level.

Plans for 2008

Recent lab studies have shown that granulometric heterogeneity (particle morphology and size) is a major cause of bulk variability in the physical and chemical properties of DDGS. Furthermore, the variability in bulk DDGS is magnified by particle segregation that occurs during bulk handling. Two recent studies by the group; Ileleji et al., 2007 (lab-scale) and Clementson et al., 2007 (plant-scale) showed the effect of particle segregation during various handling scenarios normally encountered in the production and delivery of bulk DDGS. Researchers are currently investigating particle/bulk density and flow property variability cause by granulometric heterogeneity in order to determine appropriate measures to mitigate against this effect.

Studies have already shown the effects of process variables on the physical and chemical composition of DDGS using both bench-scale and plant-scale experiments. The current effort is to use the data collected to develop predictive models for the physical and chemical composition of DDGS using their process variables. Additionally, researchers are investigating the effects of DDGS chemistry on water sorption behavior, caking and flow properties of DDGS. The ultimate goal is to develop rapid analysis tools for either product quality control or evaluating potential handling risks when shipping product.

Publications

Ileleji, K.E., K.S. Prakash, R. L. Stroshine and C.L. Clementson. 2007. An investigation of particle segregation in corn processed dried distillers grains with solubles (DDGS) induced by three handling scenarios. *Submitted to Bulk Solids and Powder Science Journal (November 2007)*.

Ileleji, K.E., K.S. Prakash and R. L. Stroshine. 2007. Morphological characterization of particles taken from bulk samples of distillers dried grains with solubles (DDGS). 9th International Conference on Bulk Materials, Storage, Handling & Transportation, 9th - 11th October, 2007, Callaghan, NSW, Australia.

Clementson, C.L., K.E., Ileleji and R.L. Stroshine. 2007. Particle segregation in bulk dried distillers grains with solubles (DDGS) and its effect on chemical variability and flowability of the bulk. ASAE Paper No. 076214. St. Joseph, Mich.: ASAE.

Ileleji, K.E., R.L. Garcia, A., and Clementson, C. 2007. A comparison of standard methods to determine the moisture content of distillers dried grains with solubles (DDGS). ASAE Paper No. 076254. St. Joseph, Mich.: ASAE.

Ileleji, K.E., R.L. Stroshine and K.S. Prakash 2006. Segregation during gravity-driven discharge of distillers dried grains with solubles (DDGS). ASAE Paper No. 066115. St. Joseph, Mich.: ASAE.

Clementson, C., K. E. Ileleji and R. L. Stroshine. 2007. Particle segregation and its effect on spatial chemical variability in a pile of dried distillers grains with solubles (DDGS) formed by gravity-driven discharge. *In preparation for Powder Technology Journal*.

Ileleji, K.E., K.V. Probst, A.R.P. Kingsly, C.L. Clementson, and A. Garcia. 2007. The effect of condensed distillers' solubles on the physical and chemical properties and moisture sorption isotherm of corn dried distiller's grains with solubles - Bench scale experiments. *In preparation for Bioresource Technology Journal*.

Issues

Dried distillers grains with solubles (DDGS) quality and the logistics of transporting bulk DDGS is one of the major challenges facing the utilization of DDGS as feed. Feed nutritionists have concerns about using DDGS due to its variable quality. Studies have shown that DDGS nutrient quality varies widely in the industry and even from batch to batch within the same plant. Understanding the cause for this variability and developing rapid tools to estimate product nutrient value with respect to process variables will provide the industry with optimum pathways for product inclusion and efficient utilization in livestock feed.

DDGS has been known to bridge in the hopper of railcars, thus preventing efficient unloading of this product. This adds huge cost to the shipper when special equipment is needed for handling and product dislodgement or when railcars are damaged from aggressive effort to dislodge DDGS from them. The chemical composition of DDGS directly affects the moisture sorption isotherm which relates to product caking potential and flowability under certain environmental conditions. Therefore, a good understanding of the interaction of product chemistry and bulk handling characteristics under various environmental conditions during transport and storage is essential for developing a quality management system that will ensure the delivery of a good quality product from production to the end-user.

The development of established and acceptable industry standards for DDGS product evaluation is essential for this rapidly growing industry. Currently, there is a lack of standard methodology for the measurement of simple components like moisture content, among other nutritive values. Because of this deficiency, trade of DDGS with a uniform industry-wide subjective criteria has been quite challenging and could potentially stifle the growth of this emerging market for co-product streams. Research in evaluating standard methodologies for chemical composition analyses, which include the development of sampling protocols and other rapid tools like NIR spectroscopy are essential to the growth of the industry.

What Was Done

Objective 1: Particle segregation of DDGS for three handling scenarios was determined by bench-scale experiments. This involved the formation of a pile by gravity driven discharge with and without vibration of the vessel with DDGS and then sampling selected portions of the pile to measure segregation tendency. The sampled portions of the pile were analyzed for particle size (geometric mean particle diameter, d_{wg}), particle size distribution and morphology. Statistically analysis, the PROC GLM analysis of variance (ANOVA) was used to determine which differences in d_{wg} among the DDGS particles sampled from the designated portions of the pile were statistically significant. Particle segregation and its effect on chemical variability within the bulk in a pile formed by gravity-driven discharge were also investigated using both bench-scale and plant-scale experiments.

Objective 2: A bench scale rotary dryer was designed, built and tested to investigate the effect of process variables on DDGS physical and chemical variability. The bench-scale study involved blending various ratios of wet distillers grains (WDG) and condensed distillers solubles (CDS) and drying at low temperature (about 100°C air drying temperature). The DDGS produced were evaluated for their physical and chemical properties, as well as their moisture sorption isotherms. Three trial runs were conducted per treatment.

Objective 3: Fifteen standard loss on drying methods and two Thermo-balance methods commonly used in fuel ethanol plants for DDGS moisture estimation were compared with the standard Karl Fischer (KF) method which measures the true water content of a product. The samples of DDGS used were from three different fuel ethanol plants that included both "new" and "old" generation plants.

Impacts

Because of DDGS particle heterogeneity and particle segregation during bulk handling, it is recommended that a standard bulk sampling protocol be used industry wide in order to obtain representative samples from bulk DDGS and thus reduce variability due to poor sampling. Appropriate sampling of DDGS bulk is a first step to reducing the variability in DDGS currently seen in the industry.

The effect of process variables (CDS and WDG co-products blending ratios and drying) on the bulk physical and chemical composition of DDGS that was shown will be used in developing quantitative predictive models that would serve as rapid analyses tools for either product quality control or evaluating potential handling risks when shipping product.

The standard loss on drying methods (gravimetric methods) investigated showed the variability of various standard moisture loss on drying methods compared to the standard Karl Fischer method for moisture determination. A less rigorous moisture loss on drying method that used the Thermo-balance (drying 1 g sample at 105°C for about 5 min), an instrument commonly available in fuel ethanol plants gave the least variability among all the methods evaluated and was recommended as the most appropriate for DDGS.

Funding Sources

The Andersons Research Grant Program

Integrated Ethanol Co-product Research & Extension Effort; an Indiana State Department of Agriculture and Purdue College of Agriculture Funded Project

The Energy Center at Purdue's Discovery Park

Contacts

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Title

Heat treatment of empty storage structures for pest disinfestations.

Project Objectives

The goal of this project is to evaluate, under field conditions, the efficacy of heat treatment to disinfect empty storage structures from pests that are detrimental to stored grains.

By

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Botany and Plant Pathology²

Entomology³

Agricultural Economics⁴

Kansas State University, Grain Science & Industry⁵

USDA, ARS, GMPRC, Engineering Research Unit⁶

Results for 2007

This new project was initiated to expand on our preliminary research and quantify the necessary engineering, entomological and economic parameters to make heat treatment of empty storage structures such as steel bins and tanks a successful control technique to prevent residual stored product pest populations from contaminating high-value identity-preserved food and specialty grains as well as conventional commodity grains and oilseeds. Heat treatment trials were conducted at the Purdue University Post-Harvest Education & Research Center (PHERC) in West Lafayette, Indiana and the Southeast Purdue Agricultural Center (SEPAC) located in Butlerville, Indiana. Two 30 ft diameter and 25 ft high bins were heat-treated using the burner of an in-bin drying system for SEPAC and the MHT 1500 heating unit TempAir (Burnsville, MN) at PHERC. Before the start of the heat treatment, insect bioassays were prepared using PVC tubes. Species of adult maize weevils (MW), red flour beetles (RFB), and lesser grain borer (LGB) were used. Thirty insects were placed in each cage placed with either 300 grams of flour (for RFB), whole kernel corn (for MW), or wheat (for LGB). These cages were placed in the plenum and inside the augers near the door and away from the door. During the heat treatment using the in-bin dryer, the fan was covered halfway to restrict airflow through the bin and control of the burner was adjusted to provide inlet air close to 200°F. Temperature was monitored using twelve wireless sensors provided by TempAir and were placed in the three locations where the insect cages were placed and at four locations (North, East, South, and West) on the perforated floor and six feet above these points. The burner was turned off once the temperature inside the flour cage reached

130°F (55°C). Cages were collected and left for 24 hours before sieving and counting the dead and live insects. The sieved materials from each insect cage were kept in separate bottles and were observed weekly for two months for possible insect re-emergence. For the PHERC bins, monthly insect population were monitored using dome traps and cardboard rolls placed inside the plenum. Heat treatment at 55°C (131°F) for three hours was sufficient for controlling the insect's pests. The results of this study indicate that for heat treatment at any temperature, uniform distribution of the heated air has to be assured throughout the plenum. Additionally, the target temperature has to be reached and held sufficiently long to achieve 100% mortality.

Plans for 2008

The plan is to expand this project to include empty wheat bins in Kansas as well as larger storage structures at commercial elevators.

Publications

Moog, D.J. and Maier, D.E. 2007. Efficacy of heat treatment of empty storage bins on confined populations of maize weevil and red flour beetle. Paper No. 07-6224. ASABE, St. Joseph, MI.

Issues

This project is investigating the utilization of heat treatment to disinfest empty grain storage structures from pests that are detrimental to stored grains. Use of high temperatures is a proven alternative for effective pest control when compared to chemical fumigants. A self-contained, portable, propane-generated and propane-fired heating system was built and used to successfully demonstrate the efficacy of pest disinfestation in empty storage bins on several Indiana food corn and organic popcorn farms in preparation for the 2007 fall harvest.

Impacts

In this new project, researchers are addressing a major concern of growers, handlers and processors regarding the contamination of high-value identity-preserved food and specialty grains (as well as conventional commodity grains and oilseeds) due to residual insect populations below the perforated floor (plenum) of corrugated steel farm bins (as well as tanks, silos and flat storage buildings at grain elevators). Empty bin treatment with residual protectants such as inert diatomaceous earth dusts and cyfluthrin products have shown limited success because of the inherent inaccessibility of the plenum area. Similarly, the dousing of the perforated drying floor with cyfluthrin spray generally does not result in a uniform drip-through application of the hidden concrete floor and bin sidewalls. Disassembling the floor before filling a bin in order to clean and treat the plenum area is a labor-intensive and dangerous alternative. Fumigating under the floor is possible but is costly. Chloropicrin (tear gas) has been the product of choice for under-the-floor fumigation of farm and elevator bins, but it is no longer available to licensed fumigators because the manufacturer will no longer allow shipment of small bottled product quantities through normal commercial channels. The use of phosphine as the only other legal fumigant product is generally limited to grain applications rather than empty bin treatment. Due to resistance concerns, it is primarily reserved for the control of primary stored product insect outbreaks above the economic threshold level in the grain mass. Therefore, a more effective method is needed to prevent contamination due to residual insect populations in empty bins. One such

alternative is using heat to control insects and molds. Heat treatment of processing facilities and other structures to kill stored product pests is a widely used pest control technique.

Funding Sources

Private industry.

Contacts

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Title

Ozonation of Corn, Wheat and Barley for the Control of Pests and Spoilage Agents, and the Removal of Off-Odors in Commercial Grain Storage Structures.

Project Objectives

The goal of this project is to test the ozonation technology in commercial silos and/or bins for three grains (corn, wheat, and malting barley) at three grain elevator locations (Indiana, Kansas, and North Dakota) during two consecutive storage seasons (2005-06, 2006-07). Specific objectives are:

To quantify the key performance parameters for ozonation (including airflow distribution) of stored grains in commercial silos, bins tanks, buildings and/or ground piles. (*Year 1*)

To determine the efficacy of ozone in controlling stored-product insects and spoilage agents (molds, bacteria) in grain stored in commercial silos and/or bins without affecting end-use quality. (*Years 1 & 2*)

To determine the efficacy of ozone in removing off-odors from out-of-condition grain. (*Year 1 & 2*)

By

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Results for 2007

Unfortunately, the commercial project collaborator was unable to make the promised 1 kg/h ozone generator available so the proposed field trials in Kansas and North Dakota could not be initiated. However, a semi-continuous flow ozone treatment system was designed and tested at Purdue University with a smaller ozone generator (250 g/h maximum capacity). Although it was a preliminary trial, the concept was proven successful. Computer modeling and scale-up design was initiated in preparation for additional testing in 2008.

Plans for 2008

Scale-up the semi-continuous flow ozonation treatment systems to quantify its effectiveness in objectionable odor removal from grain, fungi sterilization, and insect control. Utilize larger ozonation units to be made available from the commercial project collaborator that can generate 1 kg of ozone per hour and initiate our proposed field trials this year.

Publications

Campabadal, C.A., Maier, D.E. and Moog, D.J. 2007. Engineering design parameters for recirculation, flow of ozone through grain storage structures. Paper No. 07-6168. ASABE, St. Joseph, MI.

Issues

This project focuses on expanding the application of grain ozonation to large scale commercial grain storage systems including bins, tanks, silos, buildings and ground piles. An important part of this effort is the analysis and prediction of the non-uniform airflow through the grain mass in these large scale systems.

Impacts

There is a substantial interest in the application of ozone by the U.S. grain industry. Ozone is a powerful oxidant that has regulatory acceptance by the FDA (FDA 2001). EPA's MSDS defines it as "pure air". Numerous beneficial applications have been developed, such as water treatment to disinfect and eliminate odors, taste, and color, as well as to remove pesticides, inorganic and organic compounds. Ozone (O₃) is an allotrope of oxygen, which can be generated by electrical discharges in air. Ozone has a half-life of 20-50 min, and rapidly decomposes to diatomic oxygen, a natural component in the atmosphere. Because ozone can be easily generated at the treatment site using only electricity and air, it offers several safety advantages over other post-harvest treatments such as conventional pesticides. First, there are no stores of toxic chemicals, chemical mixing hazards, or disposal of left over insecticides or containers. Second, with a short half-life, it reverts back to naturally occurring oxygen. Third, if needed it would be possible to neutralize ozone through techniques such as thermal activated charcoal, as well as catalytic and chemical abatement. Research on the efficacy of ozone on insect mortality indicated 92-100% mortality of larvae of adult maize weevils (MW), Indianmeal moth (IMM) and adult red flour beetles (RFB) in infested corn when fumigated with 50 ppm ozone for three days. The same treatment also significantly reduced the viability of *Aspergillus parasiticus* Speare and other fungi on the kernel surface as well as removed off-odors from sour/musty grain. Data also indicated that repeated ozone treatments did not decrease the end use quality of grains. A number of grain producers and handlers have expressed interest in ozonation technology and generators are becoming commercially available for use. Preliminary tests have been performed by several commercial grain companies. Thus, the time is right to conduct replicated trials at commercial grain facilities that test the efficacy of ozonation for the control of pests and spoilage agents, and the removal of off-odors. Ozonation serves as a preventative strategy against insect infestation and at the same time reduces/eliminates the microbial load (fungal and bacterial spores), as well as guards against off-odors. Researchers believe there are many producers and handlers of food and feed grains (including conventional and organic food corn, wheat and barley) who will be interested in utilizing this new technology throughout the NC-213 Region.

Funding Sources

Andersons Research Grant Program Team Competition 2005-2007

Contacts

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Title

Physical and chemical properties of shelled corn related to conditioning and processing.

Project Objectives

The overall goal of this project is to determine and quantify differences in physical properties and chemical composition among corn hybrids that are related to their processing characteristics. Specific objectives are: 1) to determine physical properties (kernel size and hardness, volume, shape, density, pericarp thickness, and color) and chemical composition (protein, starch, oil, and fiber) of various shelled corn hybrids; 2) to measure the absorption rate of water by corn kernels and relate this to kernel chemical and physical properties; 3) to determine the effect of high temperature drying on the properties of several selected corn hybrids; and 4) to determine whether single kernel NIR can be used to determine seed viability and whether NIR or NIR/Vis of bulk samples can distinguish differences in kernel properties such as hardness, fiber content, color and ratio of amylose to amylopectin.

By

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Results for 2007

There are currently more than 140 corn samples available for evaluation. The majority (30 to 40 per year) have been provided by the Southern Indiana Corn Performance Trials (2004, 2006 and 2007 crop years). Several were obtained from seed companies or grain processors. During the summers of 2006 and 2007, eleven and ten specialty hybrids respectively, were grown at the Purdue Agronomy Center for Research and Education. Waxy, high oil, highly fermentable, high lysine and white corn hybrids were included in the plots. Ears were harvested and shelled by hand and small kernels were removed using a round-hole sieve (18/64" diameter holes). Samples were conditioned to approximately 14% moisture, and the round kernels are being removed using a slotted sieve (13/64" wide by 3/4" long). Tests are being conducted primarily on the flat kernels.

This report presents preliminary results, based on tests on some of the samples collected in 2006. Table 1 gives the grams of water absorbed in 1 hr by 100 g samples soaked at room temperature. Tests conducted on several samples with widely varying absorption rates using water near the boiling temperature showed similar differences among hybrids.

Table 1. Water Absorption Rate, grams of water absorbed by 100 g of shelled corn after 60 minutes of soaking. HES indicates Highly Extractable Starch, EFV is Enhanced Feed Value; Amylose 5 is ~57% amylose; Amylose 7 is ~77% amylose.

Hybrid class or Hybrid	Number Hybrids Averaged	Average Moisture content (% w.b.)	Avg. Water Absorption (WA) Rate (g/100 g for 60 min.)	Range in WA Rate (g/100 g for 60 min.)
Yellow (regular & food)	35	14.1	21.6	18.8 – 26.0
White	12	14.6	20.4	19.2 – 21.7
Yellow (food grade)	13	14.1	20.5	19.2 – 21.6
Total (Yellow + White)	47	14.2	20.8	18.8 – 26.0
HES, Hard Endo (W8721)	1	13.8	19.7	-
HES, EFV (W8603)	1	14.1	23.2	-
High Lysine (C-SR472B)	1	14.1	19.8	-
Waxy (P-34N41)	1	13.8	19.6	-
Amylose 5 (National S)	1	14.4	23.9	-
Amylose 7 (National S)	1	14.8	25.4	-

Table 2 is a summary of pericarp thickness measurements. Although the measurements were made at 12 points on the removed pericarp, the only measurements shown are the averages of three points on the germ side of the kernel and three more on the abgerminal side. The pericarp was almost always thicker on the abgerminal side. The ranges shown for the individual hybrids indicate the variability in measurements on a given side.

Table 2. Average pericarp thicknesses in microns for kernels from various classes of hybrids or selected specialty hybrids. Values are averages of three points on the germ side and three on the abgerminal side. See Table 1 title for explanation of hybrid types.

Hybrid class or Hybrid	No. Hybrids Avg'd	Germ Side Thickness (μm)		Abgerminal Side Thickness (μm)	
		Avg	Range	Avg	Range
Yellow (regular & food)	9	92	64 – 145	113	80 – 140
White	3	90	73 – 92	105	94 – 126
HES, Hard Endo (W8721)	1	72	66 – 78	77	68 – 83
HES, EFV (W8603)	1	88	76 – 100	78	75 – 80
Waxy (P 34N41)		68	53–81	89	59 – 123
Amylose 5 (National Stc.)	1	62	58 – 66	82	74 – 96
Amylose 7 (National Stc.)	1	65	63 – 67	77	73 – 81

Kernel hardness was evaluated on the basis of time in seconds required to grind 17 ml of material from a 20 g sample using a grinder rotation rate of 360 rpm. Results are shown in Table 3 along with bulk density measurements, when available. Averages are for 3 replicates. Coefficients of variation of the 3 replicates varied from 1.8 to 16.8%.

Table 3. Stenvert Hardness (average of 3 replicates) and bulk density of corn hybrids.

Hybrid class or Hybrid	Number Hybrids Averaged Hardness/ Bulk Density	Stenvert Hardness (Grind time – sec)		Bulk Density (kg/m ³)	
		Avg.	Range	Avg.	Range
Yellow (regular & food)	14/8	20.0	14.6 – 28.0	770	745 – 794
White	11/6	27.4	23.1 – 35.3	792	776 – 806
HES, Hard Endo (W8721)	1/1	18.5	17.7 – 20.4	761	-
HES, EFV (W8603)	1/0	16.0	14.9 – 17.8	-	-
High Lysine (C-SR472B)	1/1	16.7	15.7 – 18.1	746	-
Waxy (P-34N41)	1/0	29.0	27.9 – 30.9	-	-
Amylose 5 (National S)	1/1	25.7	23.2 – 29.8	701	-
Amylose 7 (National S)	1/1	23.7	22.3 – 24.7	665	-

A summary of NIR tests for composition conducted by Rock River Laboratory, Inc. (Watertown, Wisconsin) is shown in Table 4.

Table 4. NIR Composition of corn hybrids (HES is Highly Extractable Starch; EFV is Enhanced Feed Value; Amylose 5 and 7 are ~57% and ~77% amylose; respectively.

Hybrid class (number in class) or Hybrid	Crude Protein % DM	Acid Det. Fiber % DM	Fat % DM	Starch % DM	Lignin % DM
Yellow (all- 14) - average	8.4	3.5	3.3	72.9	0.62
Yellow (all - 14) - range	6.4–9.9	2.8–4.0	3.1–3.6	69.4–75.5	0.54–0.70
White (11) - average	9.5	3.6	3.1	71.8	0.66
White (11) - range	8.8–10.3	3.0–4.0	2.5–3.6	68.9–76.0	0.59–0.70
HES, Hard Endo (W8721)	8.6	3.5	3.5	70.6	0.60
HES, EFV (W8603)	8.7	3.4	3.5	70.9	0.60
High Lysine (C-SR472B)	10.5	2.2	4.0	69.8	0.58
Waxy (P-34N41)	10.5	3.1	2.9	71.4	0.57
Amylose 5 (National S)	11.2	3.5	4.7	63.8	0.66
Amylose 7 (National S)	10.7	3.2	4.5	66.6	0.55

Results for several additional tests are also available. The average germ to endosperm ratio for yellow corn hybrids was 0.126 with a range of 0.099 to 0.182 and the average for white corn hybrids was 0.140 with a range of 0.112 to 0.183. Although no new single kernel density data are currently available, averages (with number of hybrids averaged) and standard deviations reported last year are as follows: White corn hybrids (9) – 1.245 ± 0.03; yellow food corn hybrids (4) – 1.229 ± 0.04; yellow “regular hybrids (19) – 1.211 ± 0.03.

Single kernel NIR tests using two different instruments were conducted at GMPRC on 192 kernels selected at random from samples dried at 24°C (ambient air), 52°C, and 88°C. Differences in seedling development, as determined using a modified paper towel germination test, were compared with NIR spectra. Poor prediction was observed in all cases. However, comparisons with drying temperature using binary assignment of values (0 = ambient, 1 = 52°C, 2 = 88°C) gave much better predictability with coefficients of determination (r^2) ranging from 0.72 to 0.96 depending on the machine and spectral range used.

Plans for 2008

Measurements on individual samples will continue and results will be summarized. Correlations among hybrid traits will be examined.

Issues

The typical “life time” of a corn hybrid 3 to 5 years. Over the past 20 years, many “specialty” hybrids have been developed for specific end uses, such as white corn for corn based foods, high oil and high lysine corn for feeding to livestock, and waxy hybrids for processing into starch with unique characteristics. For these reasons it seems possible that the diversity in corn hybrid properties has increased. This study was designed to determine variations in some of the physical and chemical properties of hybrids currently on the market.

Impacts

Quantification of kernel properties will document the extent to which various properties differ among hybrids. The results can be used to assess of potential impact of these differences on various aspects of processing. It may also help to identify hybrids with specific traits that are particularly desirable for specific end uses. Finally, it should provide seed corn companies with information that could help them develop hybrids with desirable traits. Tests on samples dried with air at higher temperatures will help to elucidate the effect of high temperature drying on kernel characteristics.

Contacts

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Title

Food Safety Practices in the Grain Industry.

Project Objectives

Develop science-based risk management technology and practices to mitigate food safety hazards.

By

Lee, K.M., Herrman, T.J.

Texas Agricultural Experiment Station, Office of the Texas State Chemist

Results for 2007

Corroborative study: A corroborative study was conducted on maize quality and dry- and wet-milling quality properties by six participating industry and university laboratories. The statistical results for maize physical properties showed acceptably low standard deviations of within-laboratory repeatability and between-laboratory reproducibility except for the two or three physical properties, verifying the suitability and reliability of the current test procedures commonly used in grain quality laboratories. Large variations in maize quality properties appeared to come from the effect of hybrid and laboratory. The yields of dry- and wet-milling products and their correlations with maize quality properties varied among participating laboratories, implying that the recommendation of hybrids in breeding programs relying on results from only one laboratory may induce a great economic loss in the grain industry.

Mycotoxin contaminated grains in Texas: A census was performed of all country elevators in TX to identify how many facilities were testing for and correctly labeling aflatoxin contaminated grain. Results revealed that 92% of the grain elevators licensed to handle and distribute aflatoxin contaminated grain were testing. The census also revealed that of these elevators, 73% of the facilities identified aflatoxin levels above the 20 ppb action level. The Office of the Texas State Chemist harvest samples (780) revealed that 62.5% of the grain harvest in 2006 contained mycotoxins (aflatoxin and fumonisin) over the action level compared to 2007, in which 12% of the grain contained more than 20 ppb aflatoxin and 40% of the grain contained over 5 ppm fumonisin. The OTSC census indicated that 71% of the grain industry was properly labeling grain containing mycotoxin.

Traceability system: An effort underway to develop a grain tracing system continues at Texas A&M. New formulations, manufacturing techniques, and testing criteria were developed, in collaboration with the Grain Marketing and Production Research Center of ARS in Manhattan, KS.

Spectroscopic techniques: Preliminary work to identify spectral techniques to identify contaminants in feed was initiated. Preliminary data from hyperspectral image analysis reveals that automated microscopy for the feed industry is possible.

Plans for 2008

Traceability system:

- 1) Develop tracing caplets with good manufacturing feasibility, appropriate hardness, and physicochemical properties that can be readily incorporated in grains during storage, handling, and end-use processing without affecting the functional properties of grains. With collaborating USDA-ARS in Manhattan, we will test various ingredients with different binding properties, compressional and shear strength, hygroscopic property, microscopic scoring of abrasion, flow properties and durability, and storage properties of tracing caplets.
- 2) Test different printing techniques, such as non-contact ink jet technology with edible ink and laser coding methods, to print bar codes on tracing caplets, and evaluate the feasibility of protective coating materials, mainly dextrans and modified starches, using different coating preparation methods.
- 3) Assess the cost of grain tracing implementation strategies and the impact on competitiveness of US grains in global markets.

Antibiotic residues in DDG: Develop a new detection method and protocol for antibiotic residues and illegal substances in distiller's dried grains using mass spectrometer aiming to increase the economic value of DDG in fuel alcohol production.

Spectroscopic technique: Explore the suitability of spectral technology including FTIR, RAMAN, and hyperspectral imaging on rapidly identifying chemical hazards in grains and their co-products.

Regulatory impact on bio-fuel co-products: Assess the impact of regulatory policies including defining acceptable methanol content in crude glycerin and sulfur in DDGS and other grain based feed ingredients on the competitiveness and supply of biofuel co-products.

Publications

K.M. Lee, T.J. Herrman, S.R. Bean, D.S. Jackson, and J. Lingenfelter. 2007. Multivariate Classification of Dry Milled Maize Grit Yield Groups by Quadratic Discriminant Analysis and Decision Tree Algorithm. *Cereal Chem.* 84: 152-161.

B. Ioegeger, S.R. Bean, M. R. Tuinstra, J. F. Pedersen, J. Erpelding, K. M. Lee, and T. J. Herrman. 2007. Characterization of polymeric proteins from vitreous and flourey sorghum endosperm. *J. Agric. Food Chem.* 55:10232–10239.

K.M. Lee, T.J. Herrman, L. Rooney, D.S. Jackson, J. Lingenfelter, K.D. Rausch, J. McKinney, C. Iiams, L. Byrum, C.R. Hurburgh, Jr., L.A. Johnson, and S.R. Fox. 2007. Corroborative Study on Maize Quality, Dry-Milling and Wet-Milling Properties of Selected Maize Hybrids. *J. Agric. Food Chem.* 55:10751–10763.

Issues

The corroborative study shows that a great source of variation in maize quality and milling properties largely comes from the hybrid effect, causing inconsistent and irreproducible results among laboratories and previous studies. However, the laboratory effect and other factors can be a greater source of variation in the test results if they are not carefully controlled.

Testing criteria for tracing caplets made of different ingredients needs to be developed to choose the caplets with good storability, manufacturing feasibility, suitable physicochemical properties, and no functionality in end-use grain products. Coating materials and printing techniques applied on the developed tracing caplets should be practically and economically feasible.

Mathematical treatments and procedures of Spectroscopic data and automated microscopic procedure need to be developed to help rapidly and accurately detect contaminants in feed ingredients and finished feeds.

What Was Done

The repeatability within laboratory and reproducibility between laboratories were estimated for maize physical properties and dry-and wet-milling properties by six participating industry and university laboratories.

A census of the grain industry in Texas was conducted to test labeling grains contaminated with mycotoxins properly.

Sugar-, starch-, and cellulose-based tracing caplets were developed and some preliminary tests for the selection of procedures were performed.

Hyperspectral image analysis effectively detected chemical and biochemical contaminants in feeds.

Impacts

The corroborative study results propose a need for collaboration among researchers, hybrid seed companies, and milling industries to develop and improve the test procedures and carefully interpret the results during breeding programs to maximize the economic gains in the grain industry.

Improving grain elevator testing and compliance with the TX Commercial Feed Control Act will enhance food safety and animal performance.

An outcome of this traceability works will be the development of an affordable and verifiable system of tracking grain to it's origin from any point in the grain handling system.

Automated microscopy will enable the feed industry to rapidly identify contaminant through the use of new spectral technology.

Contacts

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Title

Genetic variation in grain hardness of barley and its role in food processing.

Project Objectives

To determine the genotypic variation in kernel hardness of barley; to survey factors affecting hardness; and to explore the role of grain hardness in food processing of barley.

By

Baik, B.K.

Washington State University, Department of Crop and Soil Sciences

Results for 2007

Grains of 959 breeding lines of various classes contributed by ten major barley breeding programs in the USA were evaluated for kernel characteristics using a single kernel characterization system (SKCS). Average kernel weight and diameter of barley grain ranged from 24.9 to 53.7 mg and from 1.7 to 2.9 mm, respectively. Hulled barley lines exhibited wider variation in kernel weight and diameter than hulless lines. Spring and winter lines were similar in distribution of kernel diameter and average values. The proportion of hull, as determined by the abrasive removal rate, ranged from 10.2 to 20.8%. The proportion of hull was <15.5% in 99% of winter lines and in 80% of spring lines. Grain hardness ranged from 30 to 92 in hulled barley and from 42 to 91 in hulless barley. Eighty percent of winter and 30% of spring barley lines exhibited >67 in hardness. Average kernel hardness was 71 for winter types and 62 for spring types. Ten barley lines showing large variations in grain hardness were selected to determine the role of grain hardness in food processing of barley. Protein and beta-glucan content of 10 barley lines was 9.4% - 13.8% and 3.2% - 5.7%, respectively. Both of these biochemical parameters failed to show any consistent trend in grain hardness. The pearling rate negatively correlated with SKCS grain hardness, suggesting that pearling rate decreases as grain hardness increases. Grain hardness showed a significant positive correlation with proportion of particles greater than >106 μm , suggesting that particle size distribution is greatly affected by SKCS hardness. Water absorption of barley grains appeared to be independent of SKCS hardness. Kernel hardness, after 40 min of cooking, correlated significantly with water absorption of dehulled kernels after 8 hr soaking, while kernel hardness was not related to SKCS hardness. This suggests that cooked kernel hardness is influenced by water absorption, but is little affected by grain hardness.

Plans for 2008

Researchers will investigate genotypic and environmental influences on grain hardness of barley and explore factors responsible for variations in grain hardness.

Publications

S. Nair, S. E. Ullrich, and B.-K. Baik. 2007. Variation in grain hardness and associated traits in USA barley breeding lines. AACCI Annual Meeting, San Antonio, TX, September 2007. Abstract.

Issues

Despite increasing interest in the nutritional benefits of consuming barley food products, we have limited experience in systematic breeding and cultivation of appropriate barley varieties for food uses. Barley grain hardness may influence pearling and milling properties, flour particle size and, eventually, processing and product quality, as is intensively documented for wheat. Identification of food use traits of barley and the establishment of screening methods are crucial for development of food barley varieties.

What Was Done

Researchers determined grain hardness, proportion of hull and kernel size of 956 barley breeding lines, including winter and spring types, as well as hulled and hulless types of barley, using an SKCS and the barleys' genotypic variation. Ten selected lines showing wide variations in grain hardness were further analyzed for protein and beta-glucan content, pearling rate, water imbibition rate, flour particle size distribution and cooked kernel hardness. These compositional and physical characteristics of barley were related to grain hardness.

Impacts

Large variation in hardness and other grain characteristics among barley classes and genotypes indicate the potential for the identification of genes or quantitative trait loci (QTLs) and of genetic markers for development of barley varieties possessing appropriate grain characteristics for food uses. Identification of grain hardness as a food use trait of barley and establishment of proper screening methods will also be beneficial for development of barley varieties suitable for processing and food uses.

Funding Sources

USDA-ARS Barley CAP project and Agricultural Research Center - WSU

Contacts

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Title

Improved Handling and Storage Systems for Grain Quality Maintenance and Measurement.

Project Objectives

Develop and evaluate automatic grain aeration control strategies for maintaining stored grain quality and develop best management practices for heat treatment as pre-filling grain storage bin sanitation.

Evaluate grain commingling during handling in elevators and develop a decision support system to facilitate segregation operations.

By

Casada, M.E., Arthur, F.H., and Armstrong, P.R., USDA, ARS

Maghirang, R.G., Kansas State University

USDA, ARS – GMPRC, Engineering Research Unit, Biological Research Unit, Manhattan, Kansas

Kansas State University, Biological and Agricultural Engineering Department

Results for 2007

Monitoring Moisture Content of Stored Grain: A low-cost moisture sensor was designed for measuring moisture content and temperature of agricultural commodities. The 3.5 in long by 0.7 in diameter sensor was mounted on the end of hand-held probes and in 1.5 liter canisters and tested in wheat and corn over a range of moisture contents from approximately 1% to 20%. The sensor response was a consistent and sensitive function of moisture content in these applications indicating it will be effective for measuring the moisture content of grain during storage. The sensor is water-tight and constructed with corrosion resistant materials, which will also allow moisture content and temperature measurements to be made of industrial materials, chemicals, and fuels. The sensor may also be supported on cables in grain storage bins to acquire continuous, in situ data for stored grain management and the control of aeration and low-temperature drying systems.

Monitoring Equilibrium Moisture Content of Stored Grain: An instrument probe was developed to measure the equilibrium moisture content (EMC) of grain using a relative humidity (RH) and temperature (T) sensor. The probe was designed for insertion into the top of grain bulks. Advantages of this method of moisture measurement are that the sensor is inexpensive and is interchangeable. Disadvantages are that moisture measurements rely on the accuracy of ERH and T predictions of moisture and the response time of the sensors are slow to equilibrate to the grain environment. Instrument response time was substantially improved by forcing airflow over the sensor and using prediction models to determine the equilibrium value of the sensor. Measurement time was reduced to approximately five minutes or less.

Monitoring Relative Humidity, Temperature, and Carbon Dioxide in Stored Grain: A simulated grain storage was monitored during aeration to determine if a high-moisture grain in the bin top could be detected using relative humidity (RH), temperature (T), and carbon dioxide (CO₂) sensors. RH and T sensors data were combined to indicate the equilibrium moisture content (EMC) of the grain. Sensors were placed at different depths in the bin. The wet grain produced high amounts of CO₂, which, in most cases, was easily detectable during aeration. Lowering grain temperature with aeration diminished the amount of CO₂ produced making it more difficult to detect unless the CO₂ sensor was located very close to the wet grain. The moisture content of the grain increased downstream of the high-moisture grain during aeration as indicated by the EMC data. Simultaneous monitoring of stored grain with these sensors should improve storage management by detecting problematic conditions quickly so corrective measures could be taken.

Handling Pelleted Animal Feed: An estimated 80% of non-ruminant animal feed in the U.S. is pelleted — a form that improves the efficiency of feeding and the convenience of handling. Feed pellets need to be durable and of high quality to withstand the handling and transportation process after production. The corn-meal-type feed pellets were repeatedly transferred between two storage bins in the USDA-ARS, Grain Marketing and Production Research Center research elevator at Manhattan, Kansas and results were compared with shelled corn. The size of feed pellets decreased with repeated transfers, whereas the amount of broken pellets increased, but by significantly different amounts than with shelled corn. Both feed pellets and shelled corn withstood eight repeated elevator handlings without a significant change in durability as measured by the standard tumbling box test, although the accumulated breakage of feed pellets was 50% after eight transfers as compared to 6.2% for shelled corn. Analysis of dust removed by the cyclone separators showed that these feed pellets generated less dust emissions per unit mass of material handled than did shelled corn. These results will be valuable for feed and grain handlers for evaluating and improving their handling and transportation procedures.

Plans for 2008

Develop 2-d particle model for grain commingling and obtain needed physical property data; begin revising decision support system. Develop calibration for moisture sensor in wheat and evaluate use of the sensor for deep bin moisture monitoring. Evaluate T and RH sensors in field tests. Determine heat treatment efficacy for all life stages of selected stored grain insects.

Publications

Boac, J. M., R.G. Maghirang, M.E. Casada. 2007. Durability and breakage of feed pellets during repeated elevator handling. (In Italian). *TECNICA MOLITORIA*. 58(5): 499-512.

Ingles, M.E., M.E. Casada, R.G. Maghirang, T.J Herrman, and J.P. Harner 2007. Effects of grain receiving configuration on commingling in a country elevator. (In Italian). *TECNICA MOLITORIA*. 58(6): 609-625.

Tilley, D.R., M.E. Casada, and F.H Arthur. 2007. Heat treatment for disinfestation of empty grain storage bins. *Journal of Stored Products Research*. 43(3): 221-228.

Tilley, D.R., M.R. Langemeier, M.E. Casada, and F.H. Arthur. 2007. Cost and risk analysis of heat and chemical treatments. *Journal of Economic Entomology*. 100(2): 604-612.

Issues

Worldwide grain markets are changing and customers are now demanding grain that meets their specific needs for end use properties and that is purer, safer, and more wholesome. They are demanding grain with fewer insects, diseases, and pesticides and either no genetically modified (GM) grain or strictly controlled levels of GM grain. The introduction of transgenic crops into the U.S. grain handling system has shown that the infrastructure is largely unable to preserve the identity of specialty grains to the desired level of purity. Fundamental data are needed on commingling during handling, along with methods to minimize or eliminate this problem to effectively separate grains with special desirable characteristics, which adds value compared to commodity grains.

Aeration is an underused tool for controlling insects and other risks in stored grain without the use of chemical pesticides, particularly in small grains in warm climates, a significant omission that contributes to storage losses of 5 to 10% in stored grain in some U.S. climates. Appropriate improved control strategies and improved monitoring systems are needed so that aeration will be more widely used to reduce pesticide use in stored grain. Even when aeration is used to reduce or eliminate pesticide use in stored grain, pesticides are still used to sanitize bins before storage; thus, a chemical-free method of pre-filling sanitation of grain storage bins is also needed.

Impacts

The potential to reduce energy consumed for grain cooling is estimated at 25-50 percent. The greatest impact is the assurance of timely grain cooling and prevention of grain quality losses from deterioration and insect infestations. Results from this project may lead to the development of new insect pest management and temperature management strategies for stored wheat. The portable propane heat treatment systems provide low-cost, low-risk disinfestation of empty bins, while eliminating the concerns that arise with using chemicals. New sensors and related technological developments can provide increased accuracy for stored grain condition monitoring and help prevent grain quality losses.

The decision support system (DSS) will assist grain elevator operators with resolving grain commingling problems. The computer simulation model will provide input to the DSS and will be a valuable tool to enable researchers and designers to gain a deeper understanding of the particle physics involved in grain commingling in elevator equipment that may lead to modifications and new designs that can be applied to mitigating unwanted commingling.

Funding Sources

Horizon Technology, Inc.

Grain Industry Alliance

USDA-CSREES-PMAP

Contacts

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Management of Grain Quality and Security in World Markets

NC-213 (The U.S. Quality Grains Research Consortium)

Objective 3

**Create and disseminate scientific knowledge that will
enhance public confidence in market-driven quality
management systems for grain.**

Title

Operate quality analysis testing/instrument calibration services to support research and marketing activities.

Project Objectives

The Iowa Grain Quality Initiative has developed expertise in creation of multi-media training materials and in software based decision aids. Training materials for various operations affecting purity will be developed and shared with distance learning/professional training programs. Interpretive materials for databases and economic decision-making will be distributed. The offering of high school and community college curricular materials relative to quality management systems/data interpretation will be expanded.

By

Hurburgh, Jr., C.R.

Iowa State University, Department of Agricultural and Biosystems Engineering

Results for 2007

From the 2006 crop, 22,450 samples were analyzed for compositional factors. For soybeans, a standardized database format was developed to facilitate the pooling of data across sources, locations, and data collection organizations. NIRS calibrations demonstrated to be in agreement with USDA-GIPSA references, and harmonized across instrument brands were distributed to 12 public collaborators. In all cases, standardization data showed that the calibration transfer target of having 50% or less of the standard error of prediction relative to reference chemistry was being met.

A web-based grain storage decision making and training module is under construction. Producers are the target audience; the needs/buying patterns of the ethanol, and to a lesser extent biodiesel (through soybean processing) industries are the management targets. A survey of producers indicated that 12-15% was currently adding on farm storage. Less than 25% of producers were familiar with the stringent quality acceptance standards of the biofuels industries.

Plans for 2008

Continue the analysis and calibration sharing programs, as a means of promoting uniformity among data sources. Bring the web module on-line in early 2008.

Publications

Hurburgh, C.R., Jr. 2007. Current Storage and Handling Issues for the 2007 Crop. Proc. 19th Annual Integrated Crop Management Conference, Agribusiness Education Program, Iowa State University, Ames, Iowa. November 28, 2007.

Issues

Analytical consistency across data sources is very important for accurate interpretation or comparison of grain quality results, and for reliable forecasting or pricing based on those results. Harmonized results also provide groundwork for legal metrology applied to grain factors beyond moisture and weight.

Biofuels require nearly all US grain to be stored in production areas, for use throughout the marketing year. Biofuels industries have stringent quality standards and cannot accept poor quality for either their fuel or feed products.

Impacts

In Iowa, we expect that 500-700 million additional bushels will be stored in-state, with less tolerance for deterioration than was previously acceptable in the grain market. An overall reduction of 1% in damaged kernels on the 2.2 billion bushels of corn grown in Iowa represents approximately \$60-100 million. The cost of achieving this is balanced by the more than doubling of corn value within the last 18 months, as a result of ethanol production.

Contacts

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Title

Assessing the Susceptibility of Shelled Corn to Invasion by Storage Fungi.

Project Objectives

The overall objective of this project was to identify methods of measuring the susceptibility of shelled corn to invasion by storage fungi. The specific objectives were: (1) to evaluate the use of a Test Kit that measures CO₂ production (Woods End Research, Mt. Vernon, Maine), for determining shelled corn fungal susceptibility; (2) to identify several rapid (< 15 min) tests that can be used together to screen for susceptibility to fungal invasion; and (3) to examine the correlations among the various tests conducted.

By

Stroshine*, R.L. and Moog, D.J.P. - Purdue University

Seitz, L.M. - Retired from USDA, ARS, GMPRC, Manhattan, Kansas

Purdue University, Agricultural and Biological Engineering

Results for 2007

During 2007 results collected during previous years were summarized and papers were prepared for publication. A paper covering data collected during the first two years of the project was recently published in *Cereal Chemistry* (Moog et al., 2008) and a second is being prepared for publication.

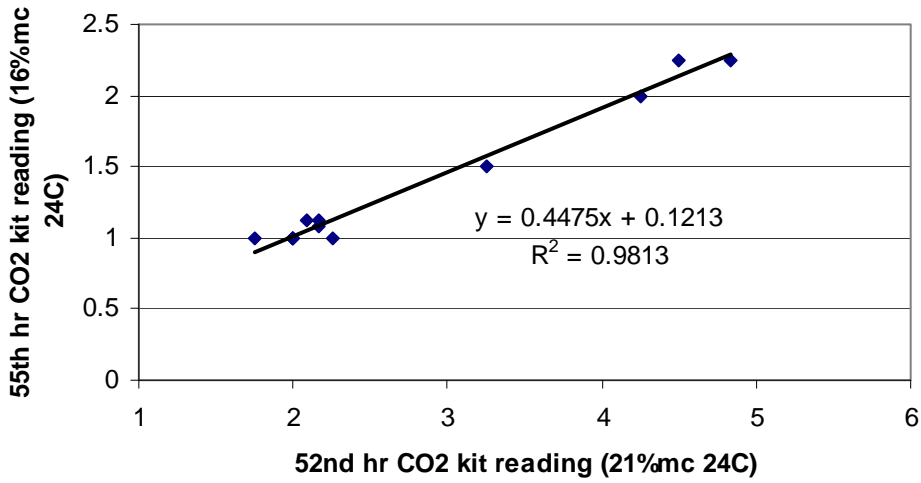
The following is a summary of results of tests begun during the fall of 2005 and continued in 2006. Most of these results were not presented in previous reports. For this series of tests, five samples were chosen to provide a wide range of fungal susceptibility and were incubated at either 16% or 21% moisture content (mc) and either 24°C or 30°C. This gave four possible moisture-temperature combinations. The test strips containing the color indicator were inserted at hours 48 and 72 after re-wetting and color numbers were determined hourly for up to 8 hours. This study included an evaluation of a Digital Color Reader (DCR), developed by Woods End Laboratories for the purpose of obtaining more accurate and consistent color number measurements. For some samples, Color Number was determined by both visual comparison to a color card (VR) and using the DCR. For the remaining samples, only the DCR was used.

In general, fungi grow more rapidly at higher mc's and warmer temperatures. As expected, fungal growth was slowest at 16% mc and 24°C and fastest at 21% mc and 30°C. For a given sample, the rankings of the color numbers taken on the 75th hr were similar. However, differences in DCR readings among samples were more evident in samples incubated at 21% mc. The coefficients of determination (r^2) for the regression of DCR reading with initial ppm ergosterol and difference in ppm ergosterol (final minus initial) were 0.97 and 0.81, respectively. Graphs of DCR color number versus time were smoother than graphs of VR versus time and the DCR was better able to

distinguish differences in CO₂ evolution among samples. Correlation with ergosterol difference was slightly higher with the DCR ($r^2 = 0.75$) than the VR ($r^2 = 0.73$).

Linear regression analysis of results from the same samples incubated under the four conditions revealed correlations among hourly readings obtained from each incubation condition. The best correlation was for tests conducted at 24°C, where the readings taken on the sample at the 52nd hr after re-wetting to 21% mc were well correlated with the readings taken on the 16% mc sample at the 55th hr ($r^2 = 0.98$, Figure 1). Note that the sample was incubated for 4 hours (hours 48 to 52) at the higher mc (21%) and for 7 hours at the low moisture content. This is a reflection of the slower growth rate at the lower mc. Values of r^2 for correlations among the other samples (16% vs. 21% mc) tested at 24°C ranged from 0.91 to 0.97. Correlations were poorer for comparisons of samples tested at 30°C and 16% mc versus 21% mc ($0.47 < r^2 < 0.52$). The best correlation among comparisons of the 2nd day and 3rd day readings, was for the 79th hour at 16% mc and 24°C with the 50th hour at 21% mc and 24°C ($r^2 = 0.93$). Note that the sample at the lower mc (16%) was incubated five hours longer. The values of r^2 for the other comparisons among 2nd and 3rd day readings ranged from 0.38 (21% mc 30°C vs. 16% mc 24°C) to 0.54 (16% mc 30°C vs. 21% mc 24°C).

Figure 1. Regression of 55th hr CO₂ kit reading at 16% mc & 24°C vs. 52nd hr reading at 21% mc & 24°C.



Plating of the samples revealed that kernels were infected by *Eurotium*, *Fusarium*, and *Penicillium*. There were also differences in the numbers and kinds of fungi that grew at the different incubation conditions. For many of samples, both the time of previous storage of the corn lot from which the incubated sample was taken, and the incubation conditions (moisture, temperature) affected which type of fungus predominated.

Plans for 2008

A manuscript summarizing the results of the DCR and temperature-moisture content tests will be submitted to a journal for review. Woods End Laboratory and Titus Grain Testing (W. Lafayette, IN) are exploring the possibilities of using the kit to evaluate shelled corn samples from commercial facilities.

Publications

Moog, D.J.P. 2006. Assessing the Susceptibility of Shelled Corn to Invasion by Storage Fungi. Ph.D. Thesis, Purdue University, West Lafayette, IN.

Moog, D.J.P., R.L. Stroshine, and L.M. Seitz. 2008. Relationship of Shelled Corn Fungal Susceptibility to Carbon Dioxide Evolution and Kernel Attributes. *Cereal Chemistry* 85(1):19-26.

Issues

When shelled corn is placed in storage, there is usually very little information on duration and conditions of previous storage. Managers of storage facilities must rely on experience and the average moisture content of the corn when assessing risk of long term storage. A test that quantifies the likelihood of fungal invasion would assist them in their decisions regarding moving grain out of storage.

What Was Done

Results of a study on the use of CO₂ test kits for measuring susceptibility of shelled corn to invasion by storage fungi were published. A manuscript summarizing results of a second study, in which the effects of temperature and moisture content on the CO₂ test kit shelled corn measurements, will be submitted to a journal for review in the near future. This second study involved incubation of the same samples at two different temperatures and moisture contents. Results were similar for incubation at all four possible temperature-moisture combinations. However, it may be possible to achieve a better indication of fungal susceptibility by adjusting incubation conditions to more closely align with the anticipated conditions to which the corn will be exposed. Use of a digital color reader improved the consistency and reliability of test results and it should therefore facilitate the use of the test by the grain industry.

Impacts

Managers of facilities could use the results of 3-day CO₂ kit tests to more accurately determine the risk of spoilage during continued storage. Test results could also be used to evaluate shelled corn destined for shipment to tropical

climates where conditions are more conducive to fungal growth. The investigators believe that use of the kit could reduce losses and improve the overall quality of shelled corn marketed in the United States or sold overseas.

Contacts

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Title

Sorghum Utilization Research.

Project Objectives

Conduct basic and applied research in the biochemistry and technology of grain sorghum to identify and evaluate the biochemical components that govern processing, functionality, and susceptibility to mold. The information is used to improve sorghum quality and utilization for increasing domestic and export markets.

By

Bean, S.R.

USDA, ARS, Grain Quality and Structure Research Unit
U.S. Grain Marketing Research Laboratory, GMPRC - Manhattan, Kansas

Results for 2007

Analysis of polymeric proteins in hard and soft endosperm was completed and the binding of gamma kafirins to tannins was investigated. The safety of sorghum foods for celiac patients was evaluated and sorghum showed no toxicity.

Plans for 2008

Investigate the formation of visco-elastic dough from non-wheat cereals and isolated proteins and the formation of sorghum polymeric proteins in developing sorghum grains.

Publications

Taylor, J., Bean, S. R., Ioerger, B., and Taylor, J. R. N. 2007. Preferential binding of sorghum tannins with gamma-kafirin and the influence of tannin binding on kafirin digestibility and biodegradation. *J. Cereal Sci* 46:22-31.

Higiro, J., Herald, T.J., Alavi, S., and Bean, S.R. 2007. Rheological study of xanthan and locust bean gum interaction in dilute solution: Effect of salt. *Food Research Int.* 40:435-447.

Corredor, D. Y., Bean, S. R., and Wang, D. 2007. Pretreatment and Enzymatic Hydrolysis of Sorghum Bran. *Cereal Chem.* 84:61-66.

- Kyung-Min Lee, Timothy J. Herrman, Scott R. Bean, David S. Jackson, and Jane Lingenfelter. 2007. Classification of Dry-Milled Maize Grit Yield Groups Using Quadratic Discriminant Analysis and Decision Tree Algorithm. *Cereal Chem.* 84:152-161.
- Wu, X., Zhao, R., Bean, S. R., Seib, P. A., McLaren, J. S., Madl, R. L., Tuinstra, M., Lenz, M. C., and Wang, D. 2007. Factors impacting ethanol production from grain sorghum. In the dry-grind process. *Cereal Chem.* 84:130-136.
- T. J. Herald, F. Aramouni, S. Bean, and S. Alavi J. Influence of Deacetylation on the Rheological Properties of Xanthan-Guar Interactions in Dilute Aqueous Solutions H.A. Khouryieh, 2007. *J. Food Sci.* 72:C173-C181.
- Schober, T. J., Bean, S. R., and Boyle, D. L. 2007. Gluten-free sorghum bread improved by sourdough fermentation: biochemical, rheological, and microstructural background. *J. Agric. Food Chem.* 55:5137-5146.
- Ciacchi, C., Maiuri, L., Caporaso, N., Bucci, C., Giudice, L. D., Massardo, D. R., Pontieri, P., Fonzo, N. D., Bean, S. R., Ioerger, B., and Londei, M. 2007. Celiac disease: in vitro and in vivo safety and palatability of wheat-free sorghum food products. *Clinical Nutrition.* (In press, Accepted 5/18/07).
- Pearson, T.C., Wilson, J.D., Gwartz, J., Maghirang, E.B., Dowell, F.E., McClusky, P. and Bean, S.R. 2007. The relationship between single wheat kernel particle size distribution and the Perten SKCS 4100 hardness index. *Cereal Chem.* 84:567-575.
- Ioerger, B., Bean S. R., Tuinstra, M. R., Pedersen, J. F., Erpelding, J., Lee, K., Herrman, T. Characterization of polymeric proteins from vitreous and floury sorghum endosperm. *J. Agric. Food Chem.* 55:10232-10239.
- Park, Arthur, F. H., Bean, S. R., and Schober, T. 2007. Susceptibility of sorghum to *Rhizopertha dominica* F. and their effects on the physicochemical properties of sorghum kernel and flour. *J. Stored Product Research.* (In press).
- Zhao, R. Bean, S. R., Ioerger, B. P., Wang, D., and Boyle, D. L. 2008. Impact of mashing on sorghum proteins and its relationship to ethanol fermentation. *J. Agric. Food Chem.* In press
- Wang, D., Bean, S., McLaren, J., Seib, P., Tuinstra, M., Lenz, M., Wu, X., Zhao, R. 2008. Grain sorghum is a viable feedstock for ethanol production. *J. Industrial Microbio and Biotechnol.* In press.

Issues

Sorghum is a drought resistant, low input crop currently used as animal feed in the U. S. However, there is great potential for human food uses and bio-industrial uses for sorghum (such as ethanol). To fully utilize sorghum as a renewable resource, basic research into the functionality of sorghum proteins and other biomolecules is needed.

What Was Done

Analysis of polymeric proteins in hard and soft endosperm was completed and the binding of gamma kafirins to tannins was investigated. The safety of sorghum foods for celiac patients was evaluated and sorghum showed no toxicity.

Impacts

The production of wheat-free foods from sorghum provides persons with celiac disease new food choices. Developing high quality wheat-free food products from sorghum provides new markets for the U.S. sorghum crop and may improve the food choices available to persons with celiac disease. Ethanol production is a growing area for sorghum utilization. Processing of sorghum grain before fermentation is one way to improve ethanol yields and thereby the value of sorghum to the ethanol industry.

Contacts

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Title

Effect of high molecular weight glutenin subunits (HMW-GS) on wheat flour tortilla quality.

Project Objectives

Investigate the contribution of high molecular-weight glutenin subunits (HMW-GS) on wheat flour tortilla quality.

By

Tilley, M.

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U.S. Grain Marketing Research Laboratory, GMPRC, Manhattan, Kansas

Results for 2007

Flours with HMW-GS 5+10 produced tortillas with significant smaller diameter than the corresponding pairs 2+12 or 3+12 in near isogenic lines.

Tortillas with subunits 5+10 had better overall texture profile (better rollability score, larger rupture force and stretchability) than 2+12 if the complementary pair was 7+8 pair. Tortilla's texture with the pair 5+10 did not differ from 2+12 if the complementary pair was 7+9.

Larger tortillas were inversely related to superior texture profiles.

Tortillas with subunits 6+8, 3+12 showed significant lower rollability scores than other flours in that group, but the other texture measurements did not distinguished differences between the pairs 5+10 and 3+12 and 6+8 and 7+9.

The results indicated better tortillas with a longer shelf-life were obtained with higher protein content flours containing HMW-GS 5+10.

Plans for 2008

Determine the effects of over-expression of different HMW-GS on wheat flour tortilla quality.

Publications

Mondal, S., Tilley, M., Alviola, J.N., Waniska, R.D., Bean, S.R., Glover, K.D., Hays, D.B. 2008. Use of Near-Isogenic Wheat Lines to Determine the Glutenin Composition and Functionality Requirements for Flour Tortillas. *J. Agric Food Chem* 56; 179-184.

Akdogan, H., Tilley, M., and Chung, O.K. 2006. Effect of emulsifiers on textural properties of whole wheat tortillas. *Cereal Chemistry*. 83(6):632-635.

Tilley, M., Pierrucci, V.R.M., Tilley K.A., Chung, O.K. 2006. Effects of Processing on Wheat Tortilla Quality: Benefits of Hard White Wheat. *Chinese J. Food Science* 11:152-158.

Tilley, M., F.E. Dowell, B.W. Seabourn, J.D. Wilson, S.R. Bean, E.B. Maghirang, O.K. Chung, S.H. Park, T.C. Pearson, F. Xie, T.J. Schober, H. Akdogan, G.L. Lookhart, M.S. Caley, S.Z. Xiao, F.H. Arthur, M.E. Casada, D.B. Bechtel, D.L. Brabec, D.R. Tilley, R.K. Lyne, and R.C. Kaufman. 2007. Wheat research in the U.S. Grain Marketing and Production Research Center. *Annual Wheat Newsletter* 53:119-130.

Akdogan, H., Tilley, M., Bean, S.R., and Graybosch, R.A. 2007. Differentiation of allelic variations of the HMW glutenin subunits of wheat flours by use of mixing parameters and polymeric protein content. In *Gluten Proteins 2006, Proceedings of the 2006 Gluten Workshop*.

Tilley, M., Akdogan, H., and Chung, O.K. Effect of ingredients on tortilla quality. *Proceedings of the First International Symposium on Cereal Science, October 18 -21 2006, Wuxi China*.

Issues

Flour used in tortilla production has been typically optimized for bread making and thus the flour properties that determine good quality bread do not necessarily provide good quality tortillas.

What Was Done

Tortillas were made from unique wheat biotypes with variations in HWM-GS composition supplied by Dr. Robert Graybosch – ARS Lincoln NE, and near-isogenic HMW-GS deletion lines. Quality parameters included dough properties and tortilla quality measurements including texture analysis and tortilla rollability over the course of 14 days.

Impacts

The tortilla industry is one of the fastest growing segments of the U.S. baking industry with annual sales surpassing \$6 billion. Identification of protein composition for ideal tortillas will provide wheat breeders with targets for development of tortilla or multi-use wheat lines and decrease the addition of additives to adjust flour quality in the tortilla industry.

Contacts

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