
NC-213

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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.

*Retired 2006. Listed for historical reference only.

++A replacement can be determined at the Annual Meeting.

Objective 1

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



NC-213 Objective 1

Title

Expanding the capability and use of near infrared spectroscopy.

Project Objectives

Iowa State has developed laboratory capability to calibrate a wide range of near infrared instruments and to collect very large spectral databases for these instruments. 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. Image analysis technology will be further refined for more precise applications in single seeds and low-concentration food safety/biotechnology factors.

From

Department of Agricultural and Biosystems Engineering
Iowa State University

By

Hurburgh, Jr., C.R.
Yang, C.
Kovalenko, I.
Rippke, G.R.
Igne, B.
Hardy, C.L.

Results for 2006

Calibration equations for soybean oil fatty acid profile in whole soybeans were developed using partial least squares (PLS), artificial neural networks (ANN), and support vector machines (SVM) regression methods. Validation results demonstrated that (1) equations for total saturates had the highest predictive ability ($r^2 = 0.91 - 0.94$) and were usable for quality assurance applications, (2) palmitic acid models ($r^2 = 0.80 - 0.84$) were usable for certain research applications, and (3) equations for stearic ($r^2 = 0.49 - 0.68$), oleic ($r^2 = 0.76 - 0.81$), linoleic ($r^2 = 0.73 - 0.76$), and linolenic ($r^2 = 0.67 - 0.74$) acids could be used for sample screening. SVM models produced significantly more accurate predictions than those developed with PLS regression. ANN calibrations were not significantly different from the other two methods. Reduction of number of calibration samples reduced predictive ability of all types of NIR equations. The rate of performance degradation of SVM models was the lowest.

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 after being 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 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.

Near-infrared (NIR) spectroscopy has been applied to amino acid measurement by several researchers with various degrees of success. NIR calibrations were developed for whole soybean amino acid profiles using partial least squares (PLS), artificial neural networks (ANN), and support vector machines (SVM) regression methods and for five models of NIR spectrometers. Validation of models resulted in coefficients of determination r^2 ranging from 0.04 (tryptophan) to 0.91 (leucine and lysine). Most of the models were usable for research purposes and sample screening, however, no sufficient correlation was found between spectral data and concentrations of such important

amino acids as cysteine and tryptophan. The predictive ability of NIR models was directly determined by how well a certain amino acid correlated to reference protein. Comparison of calibration methods demonstrated that (1) performance of PLS and LS-SVM was significantly better than that of ANN, and (2) choice of preferred modeling method was spectrometer-dependent.

A procedure was then developed to evaluate the amino acid models by statistical comparison to regression models of amino acids versus protein. If the NIR model outperformed the protein regression then there was value in the NIR model. If not, then the protein regression was the best prediction of the amino acids. No NIR soybean amino acid calibration outperformed the protein regression. A sample set that would break the protein correlation may improve the models so they can be validated as true calibrations, rather than as calculations. This principle can be extended to any grouping of factors that are correlated with each other.

A limitation of the ANN calibration method is that the ratio of available training samples to a number of neuron interconnection weights and biases (unknown regression parameters) must be large (i.e. many calibration samples, typically 1000s). Traditionally, this ratio is increased by reducing dimensionality of ANN input space by compressing X data using principal component analysis (PCA). An attractive data compression method (local PCA) that combines two multivariate data analysis techniques, namely clustering and PCA, has been described in the literature. Global and local PCA compression was evaluated using soybean protein and oil test set, in an instrument known to work well with ANN calibrations. The results demonstrated that local PCA could significantly outperform traditional global PCA compression, but performance of local PCA-based calibrations degraded rapidly as compression rate increased, while global PCA allowed achieving higher compression at minimal cost of prediction accuracy.

The decision of when to update a calibration is one of the most problematic issues in the management of a near-infrared calibration. Based on the development of a triticale protein calibration over four years, validation scenarios (cross validation, a validation set coming from the calibration set with two sizes (10 and 25%) and a validation set containing only next crop year samples) were evaluated with 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 validation.

Multiple-model soybean moisture and protein calibrations were done for two transmission-type instruments operating in the same wavelength range (850-1048 nm in 2nm increments). A new Robust Calibration Method gave excellent results both within and among brands. Pooled calibration accuracy was equal to or better than calibrations for units individually. The best known optical matching procedure for NIRS units (Piecewise Direct Standardization) was able to make instrument brand 1 calibrations transfer to brand 2 without loss in accuracy, but not vice versa.

Spectra from different reflection instruments were also aligned with Support Vector Machines. Extrapolation of spectra from smaller range instruments to larger range calibrations appears to be possible. This optical alignment technique will also be tested with the transmission instruments.

The ability to simultaneously align and expand spectra from multiple brands would be a major step toward both harmonization of results and the creation of universal databases that would allow rapid introduction of new technologies/instruments.

Several new grain calibrations were developed for general use:

- soybean moisture, protein, oil calibrations for the Perten DA7200
- corn moisture, protein, oil, starch and density for the Bruins/Dickey-Omega G (NTEP)
- soybean moisture, protein, oil, and fiber for the Bruins/Dickey-Omega G (NTEP)
- soybean linolenic acid and saturated fats for the Foss Infratec and the Omega G.
- corn moisture, protein, oil, starch and density for the Zeiss Corona
- soybean moisture, protein, oil, and fiber for the Zeiss Corona

Plans for 2007

Continue calibration development applications for manufacturers and other users.

Modify the fatty acid calibration strategy to improve discrimination between 1%, 2% and 3% linolenic acid samples. Add oleic acid calibrations. Expand the germplasm base of the fatty acid database.

Develop concept calibrations on a sample set that has been assembled to break the correlation between protein and amino acids in soybeans.

Continue spectral modifications to improve agreement within and across NIRS brands.

Test a low cost measurement strategy to predict ethanol yield from corn.

Publications and Presentations

Hurburgh, C.R., Jr. 2006. Measurement of amino acid content with near infrared spectroscopy. 97th AOCS Annual Meeting, American Oil Chemists Society, Champaign, IL. May 2-6, 2006, St. Louis, Mo. (abstr)

Kovalenko, I.V., G.R. Rippke and C.R. Hurburgh, Jr. 2006. Determination of amino acid composition of soybeans (Glycine max) by near-infrared spectroscopy. *Journal of Agricultural and Food Chemistry*, 54 (10):3485-3491.

Kovalenko, I.V., G.R. Rippke and C.R. Hurburgh, Jr. 2006. Measurement of Soybean Fatty Acids by Near-Infrared Spectroscopy: Linear and Nonlinear Calibration Methods. *Journal of AOCS*, 83(5): 421-427.

Kovalenko, I., G.R. Rippke, and C.R. Hurburgh, Jr. 2006. Measurement of soybean fatty acids by near-infrared spectroscopy: Linear and nonlinear calibration methods. 97th AOCS Annual Meeting, American Oil Chemists Society, Champaign, IL. May 2-6, 2006, St. Louis, Mo. (abstr, oral presentation)

Kovalenko, I. and C.R. Hurburgh, Jr. 2006. Dimensionality reduction of NIR spectral data using global and local implementation of PCA for neural network calibrations. *JNIRS*. Accepted December 2, 2006

Benoit I., L.R. Gibson, G.R. Rippke, and C.R. Hurburgh, Jr. 2006. Evaluation of preprocessing methods in the development of near-infrared models for triticale protein and moisture. *World Grains Summits: Foods and Beverages*. American Association of Cereal Chemistry. Annual meeting, San Francisco, CA. October 17-20, 2006. Poster.

B. Igne, G.R. Rippke, L.R. Gibson, and C.R. Hurburgh. 2006. Does your grain calibration need to be updated? *Proc. 25th International Diffuse Reflectance Conference*, Chambersburg, PA. August 7-10, 2006. Poster.

Rippke, G.R., I.V. Kovalenko, and C.R. Hurburgh. 2006. Calibration Development When Reference Values are Correlated: Soybean Amino Acid Case Study. *Proc. 25th International Diffuse Reflectance Conference*, Chambersburg, PA. August 7-10, 2006. Abstract.

Issues

Measurement systems need to be consistent across brands of instruments so that new technologies can be introduced easily without invalidating the results of existing technologies.

Often brands of test instruments that are well matched to the reference methods, will have unacceptably large variations with respect to each other on individual samples.

Measurements of secondary or subunit factors that are correlated with their respective major units are misleading if the test instrument cannot exceed the accuracy of correlation equation(s).

Improper validation of instrument calibrations (not on truly new samples) can lead to large errors, especially when the product is undergoing genetic as well as environmental changes.

Impacts

The requirement of only one instrument model in a given trading system may be eliminated, which will reduce testing costs, and provide incentives for new technology development.

True calibrations (beyond correlations) will have a major impact on genetic screening programs for secondary factors, by identifying unique samples that would have otherwise been missed.

Calibration monitoring systems can be simplified, and the cost of calibration maintenance can be reduced by more effective targeting of truly unique or independent samples.

Contacts

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NC-213 Objective 1

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. A secondary objective is to develop protocols for performing the laboratory experiments to allow for evaluation of drying and storage effects on dry mill ethanol production.

Summary

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.

By conducting research at the University of Kentucky on hybrids grown in Kentucky, using techniques similar to those employed by Commonwealth Agri-Energy, we can determine what hybrids are best suited to ethanol production in the state.

From

Biosystems and Agricultural Engineering
Plant and Soil Sciences
University of Kentucky

By

Montross, M.
Crofcheck, C.
Lee, C.

Results for 2006

Samples during corn harvest from Fall 2005 have been analyzed. Samples have been collected during the Fall 2006 harvest. We expect to begin analyzing those samples soon. Protocols have been developed to consistently convert the starch to glucose and ferment to ethanol. There have been some issues with measurement of ethanol. 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.

Figure 1 shows the variation in ethanol production from the eleven hybrids. There were statistically significant differences between some of the hybrids. However, maximizing ethanol yield for a processing plant or producer also depends on the corn yield and test weight. Figure 2 takes these variables into consideration and the ethanol yield per acre was calculated. There were significant differences in the ethanol yield per acre, however it was a different ranking than shown in figure 1. A high ethanol yielding variety (SC 11B45) did not result in the highest ethanol production per acre due to the low grain yield and test weight. The same hybrids were sampled in 2006 and will be analyzed and compared to the 2005 data.

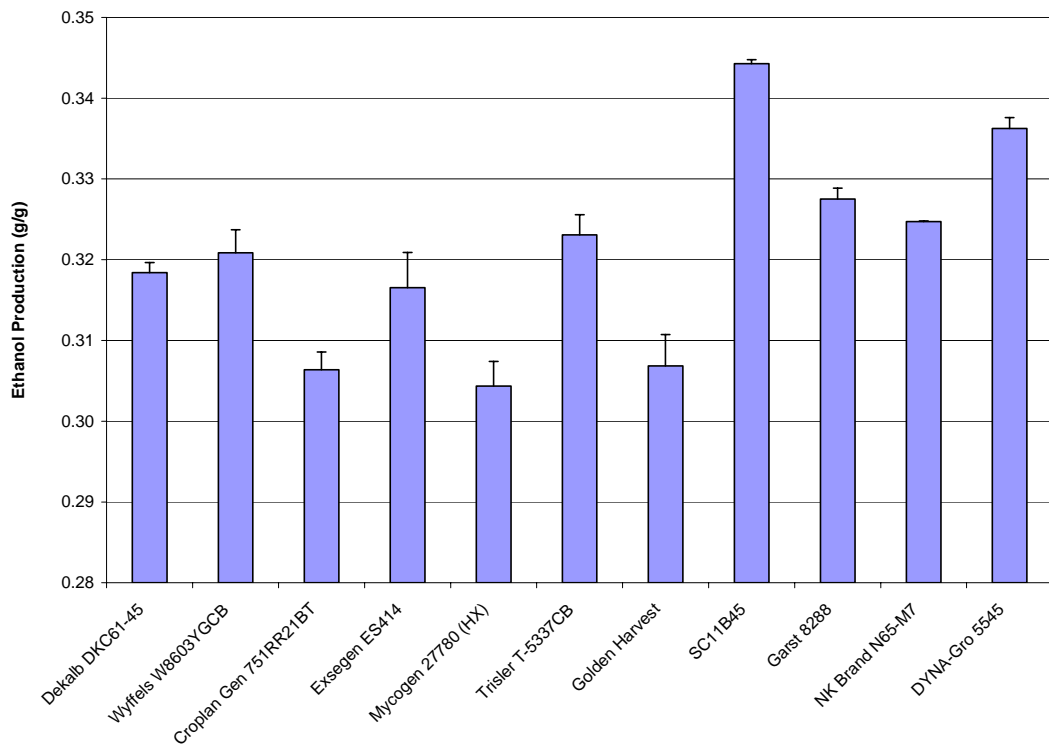


Figure 1. Ethanol production (g/g dry corn) and standard error from eleven corn hybrids from 2006.

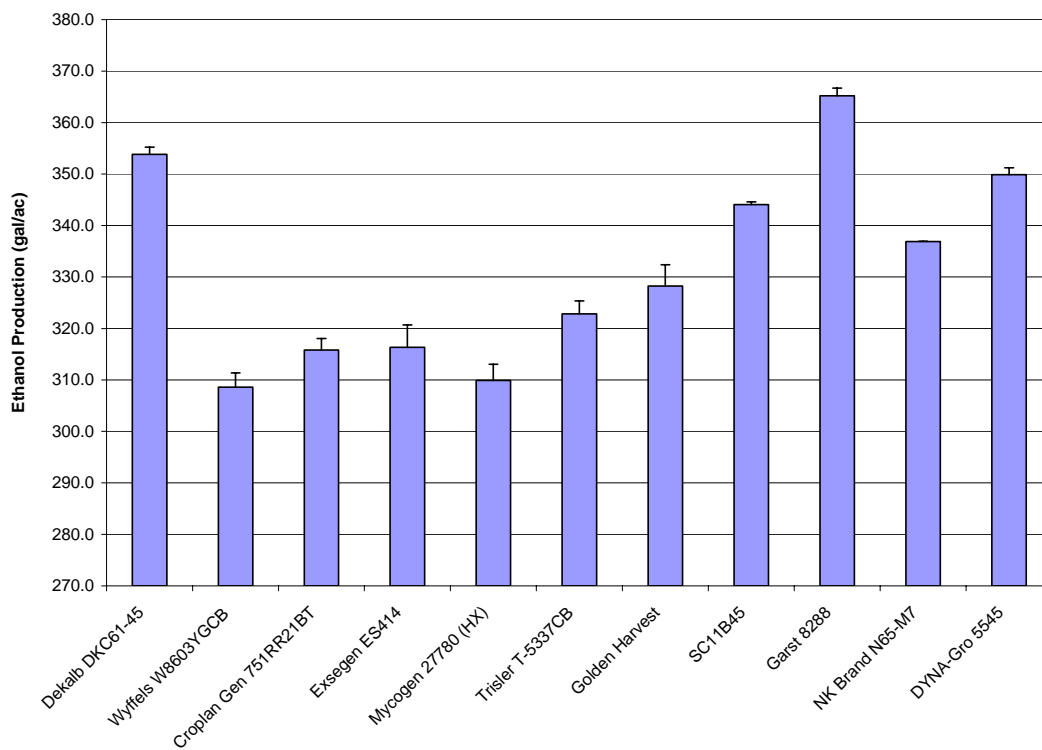


Figure 2. Ethanol yield (gal/ac) and standard error from eleven corn hybrids from 2006.

Plans for 2007

Additional hybrids have been collected during 2006 and will be tested for ethanol production. Preliminary tests on the effect of drying and storage on dry grind ethanol production will also be conducted.

Issues

Seed companies are selling corn that is labeled as high fermentable starch. However, data and protocols to support the claims have not been published. This project will develop protocols and data that are independent of commercial companies.

What Was Done

Laboratory procedures that were accurate and repeatable have been developed to simulate a commercial dry grind ethanol plant. Further experiments can now be conducted.

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.

Funding Sources

USDA/CSREES Special Grant on New Crop Opportunities

Contacts

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NC-213 Objective 1

Title

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

Project Objectives

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

From

Department of Food Science & Human Nutrition
Michigan State University

By

Ng, Perry K.W.

Results for 2006

We have continued to examine soft wheat varieties for milling and baking qualities. Quality evaluation of selected wheat crops harvested in 2006 has been completed. Data are being analyzed. In addition, biochemical studies on flour proteins have 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. Results revealed that TG has more beneficial effects on weaker protein flours than strong protein flour samples. Furthermore, TG increased the water-holding capability of the flour samples. The functional and thermal properties of the cross-links formed among flour proteins via TG were different than those of control samples, and present new opportunities for the food industry. Another area of focus in 2006 was the examination of effects of various antioxidants 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 the antioxidants decreased the maximum resistance of fermented dough samples. The change in rheological properties by the addition of the studied antioxidants would be important in the baking industry, especially during dough processing.

Plans for 2007

Our plans are to continue evaluating 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 on dough rheology and baking properties will be studied.

Publications and Presentations

Ng, P.K.W., Ward, R., Tanhehco, E. MSU Wheat Quality Testing of Advanced Lines: Report on Milling and Baking Test Results for Selected Michigan-Grown Soft Wheats Harvested in 2005. January 2006. 32 pp.

Kim, J.H., Tanhehco, E.J., and Ng, P.K.W. 2006. Effects of extrusion conditions on resistant starch formation from pastry wheat flour. *Food Chemistry* 99(4): 718-723.

Rhim, J.W., Mohanty, A.K., Singh, S.P., and Ng, P.K.W. 2006. Effect of processing methods on performance of polylactide (PLA) films: Thermocompression vs. solvent casting methods. *J. Applied Polymer Science* 101:3736-3742.

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. In addition, 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.

Funding Sources

Michigan State Millers' Association; Cereal Industry; USDA-NRI

Contacts

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NC-213 Objective 1

Title

Environmental and genetic impacts on quality.

Project Objectives

Evaluate postharvest insect resistance of Montana organic producers' most popular wheat varieties and of African varieties of cowpeas. Explore farmer-acceptable postharvest management methods for cowpeas postharvest and other means of improving protein in diets of people in material resource poor communities.

From

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l'Institut d'Economie Rurale, Bamako, Mali²

By

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Biglethand, R.¹

Coulibaly, K.²
Assa Kante, A.²

Results for 2006

Our study this year concluded the testing of three hypotheses regarding Montana wheat that:

A rapid assay (10 day instead of 63 day) can be developed to locate within the wheat seed, factors conferring postharvest resistance to the lesser grain borer, *Rhyzopertha dominica*.

Using this rapid resistance / sensitivity bioassay, we can show that significant differences in levels of insect resistance in seven currently grown varieties was due primarily to genetic factors.

Because of the unique feeding behavior patterns of *R. dominica* and the Indian mealmoth, *Plodia interpunctella*, genetic factors could be demonstrated to be primarily expressed in the kernel pericarp.

We found no significant effect of growing region or of dryland versus irrigated production within location on feeding damage (measured in frass production) by *R. dominica*. It is now clear that *P. interpunctella* feeding activity can make kernels of hard wheat up to 7.5 times more vulnerable to feeding damage by *R. dominica*. For *R. dominica*, there seems to be a bran and /or aleurone factor that confers resistance to feeding in Northern Great Plains Hard Wheat varieties. Once the bran and /or aleurone layer containing this factor is gone, such as in the specific feeding done by *P. interpunctella* larvae, *R. dominica* is much more destructive to hard wheat. This was particularly noticeable in the variety McNeal. In the soft white wheat Penawawa, *R. dominica* resistance seems to be localized in the endosperm.

We initiated this year the testing of three hypotheses regarding postharvest protection of cowpeas. We hypothesized that:

Among bruchid varieties from the Mali cowpea breeding program (Cinzana Research Station, l'Institut d'Economie Rurale), significant resistance to Malian strains of the cowpea bruchid, *Callosobruchus maculatus*, the main cause of postharvest loss can be found.

A concentration (percent weight per weight) of freshly prepared neem kernel powder, *Azadirachta indica*, can be found that will both prevent the second generation of *C. maculatus* and leave the cowpeas after washing and cooking in a sensory-acceptable condition to a trained panel of Malians, and ultimately to villagers who will use the postharvest procedure with neem kernel powder.

We acquired samples of 11 varieties of cowpeas, *Vigna unguiculata*, grown at the Cinzana research station of l'Institut d'Economie Rurale (IER), Mali. In preliminary studies 3 varieties showed bruchid resistant tendencies, T11-Korobalen, T4-T97 586-18, and T6- 97 1034-94. These varieties were compared with organic US black-eyed pea variety of cowpea in glass Supelco vials with screw tops and brass screen inserts. Stock cultures of *C. maculatus* were obtained from these varieties at IER-Sotuba. Test conditions were the same as the stock culture, 12:12::light dark, temperature 28 ± 0.5 °C, R.H. 40 ± 5.0 percent. There were 4 replicates, 5 males and 5 females 0 to 48 hours post adult emergence, 10 sound cowpeas per vial equilibrated to test conditions. Parent adults were removed after 10 days. First generation adults began emerging 19 days after inoculation and were removed every 24 hours and gender recorded.

For all test varieties except for T-4, adult bruchid emergence began on day 19 and peak emergence (mean = 83; n=4) occurred on Day 21. Emergence of adult bruchids on T-4 began day 20 and peaked (mean = 55; n=4) on 26. Total F-1 (generation 1) adult emergence per female parent was: US black-eyed peas 37.2; T6 29.5; T11 26.4; and T4 21.4. Therefore, not only was total emergence for T4 variety was 58 percent of the control, black-eyed peas, but peak emergence was delayed by 6 days. Clearly, the greatest potential for postharvest bruchid resistance traits exists in the Malian variety, T4.

To obtain a local solution to cowpea infestation in Bamako, cowpeas in the market closest to the American International School of Bamako were obtained for the experiments along with neem kernels harvested from beside the school building. Neem kernel powder was prepared as traditional medicine would be prepared in the neighborhood, with a wooden mortar and pestle. Cowpeas (moisture content 4.63 percent) were treated with the locally produced neem kernel powder in concentrations of 0, 2.5, 5.0 and 7.5 percent weight per weight). Each of 5 replicates consisted of a glass jar with screw top in which a brass mesh was inserted and contained 50 grams cowpeas treated with one of the neem kernel powder concentrations. Each replicate was inoculated with 5 male and 5 female bruchids 0 to 24 hours post adult emergence. On days 0, 2,3,5,7,11,20,24, 25, 28, and 31 post inoculation, 10 cowpeas were randomly selected from each replicate for analysis. For each aliquot of each replicate, these data were taken: number of live bruchids; number of eggs; embryonic development of each egg; and number of emergence windows.

On Day 2 post inoculation, mean number of eggs per 10 cowpeas were 7.8 in the control, 6.6 at 2.5% neem kernel powder, 3.4 in 5.0% neem kernel powder, and 3.0 in 7.5 % neem kernel powder. By day 20 postinoculation in the control, there were hundreds of bruchid per replicate in each replicate with windows forming (behavior characteristic of late instar larvae just prior to pupation) as observations were made, meaning there was a very large bruchid population. In 2.5% there were no live bruchids or eyespots at day 20. Results were similar in 5.0% neem kernel powder at day 20 and in the 7.5% concentration. Neem did not kill the parent bruchids, not even at 7.5% w/w, but it did disrupt the life cycle of the F-1 generation with a combination of developmental disruptions, beginning in the embryo stage.

The first trial of sensory evaluation was completed March 2007 at IER-Sotuba by food scientist Assa Kante with cowpeas treated with 0.05 and 5.0% neem kernel powder. Treatments prior to cooking were washing the cowpeas and not washing the cowpeas. Treatment after cooking was to decorticate and not to decorticate. Evaluation by the trained panel of these 4 treatments nested within each concentration of neem kernel powder concentration indicated that sensory differences (taste, odor, color, texture) could not be detected.

We also initiated hypothesis tests of the sensory acceptability for Americans and Malians, nutritional benefits, and shelf-life effect in sourdough bread on replacing yeast with a high lysine producing bacterium, *Lactobacillus fermentum*, from traditional bread products in Egypt. We used 4 treatments: bread made with no Baker's yeast or *L. fermentum*; bread made with only yeast; bread made with only *L. fermentum*; and bread made with 50:50 yeast and *L. fermentum*. We determined that loaf volume was not affected by *L. fermentum* and that although the taste was different with *L. fermentum*, it was preferred by the Malian evaluator. Samples were obtained for quantitative gas chromatography to determine the effect of these treatments on lysine content of the bread.

Plans for 2007

Repeat bioassays to obtain LC₉₀ and probit analyses of Malian neem kernel powder used to manage the cowpea bruchid, *Callosobruchus maculatus* on Malian cowpeas. Determine by splitting the cowpeas, precisely how much damage was done by the bruchid larvae at each concentration, even though adult emergence was significantly decreased even at 2.5% neem kernel powder.

Repeat and publish resistance in Malian cowpea varieties and recent releases of cowpea varieties from IITA (Ibadan, Nigeria) to the cowpea bruchid, *Callosobruchus maculatus*.

Complete studies on the sensory acceptability of cowpeas treated with an effective level of neem (*Azadirachta indica*) kernel powder.

Continue to explore use of high lysine yeast replacement to improve shelf life of bread and other grain products in Malian villages. Prepare initial results for publication.

Publications and Presentations

Broughton, M.J., and F.V. Dunkel. 2006. Interactions of wheat variety, production environments, and prior insect damage on postharvest resistance to the lesser grain borer. *Journal of Economic Entomology*. 99:1826-1834.

Biglethand, R., K. Coulibaly, and F. Dunkel. 2006. Postharvest resistance to *Callosobruchus maculatus* in Malian cowpea varieties. Poster presented at the Montana American Indian Research Opportunities annual conference, July 2006, Bozeman, Montana, and at the national Leadership Alliance Symposium, July 30, 2006, Chantilly, Virginia.

Issues

Hard wheat is grown mainly in northern temperate areas of the world and is considered easy to store due to its resistance to insect attack. Some alarming recent research results now may negate this statement. Recently, the lesser grain borer, *Rhyzopertha dominica* (F.), a southern temperate/tropical insect that thrives on hard red wheat has

been moving north (Fields and Phillips 1995). *Rhyzopertha dominica* is able to survive Montana conditions, probably due to its ability to locate refugia (microhabitats with the right conditions for survival) in or near the grain mass. *R. dominica* was officially unknown in Montana before 1987. In 1996, this insect was uncommon. In 2001, *R. dominica* was ranked second most frequently encountered insect by elevator operators in Montana. Unfortunately, wheat varieties are not developed for their ability to resist postharvest insect attack.

The purpose of the cowpea project was to improve the availability of cowpeas throughout the year for villages in Mali. Cowpeas are high in protein and so are called “the meat of the poor” in Mali. Cowpeas are planted in June and harvested in October and November. Villagers can produce a sufficient amount of cowpeas to keep a family sustained for an entire year. The problem with cowpeas is that villagers find it difficult to maintain cowpea quality during storage due to ideal reproductive conditions for the cowpea bruchid, *Callosobruchus maculatus* in Mali. These infestations destroy the cowpeas after several months of storage, leaving farm families with no cowpeas to consume for the remainder of the year. July through September is the hunger period for the people of Mali. Solving the cowpea storage quality problem would maintain adequate protein levels for parents and young children as well as provide a high value cash crop to sell during the hunger period.

What Was Done

In our wheat research this year, we focused on statistical analyses and publication preparation of our many years of *R. dominica* sequential feeding damage bioassays and simultaneous wheat evaluation methods, including SDS-PAGE protein analyses. Before analysis of variance (ANOVA), variances of means were tested for homogeneity using Levene’s test for homogeneity with PROC GLM (SAS, version 9.01). Analyses were performed using SAS one-way ANOVA to detect significant differences among all wheat varieties. All wheat varieties at all sites and production modes, both sound and previously damaged by *P. interpunctella*, were inoculated at the same time and repeated twice. For each run, 150 observations were analyzed with PROC GLM factorial in all possible combinations of the following main effects: geographical location of wheat sample production, kernel treatment (sound or previously damaged), and variety. We used SAS (SAS Institute 2002) to obtain means and standard deviations within varieties. Differences among bioassay means were tested for significance using one-way ANOVA and Student-Newman-Keuls means separation test ($\alpha = 0.05$). Means and standard deviations were also determined for protein and hardness of each sample. We also did a factorial analysis with PROCGLM (SAS, version 9.01 to compare frass production across all main effects of treatment, location, agronomic condition (dryland versus irrigated), and variety. We used Spearman’s rank coefficient PROC CORR to compare parametric data (frass production) and nonparametric data (visual index of feeding damage).

With cowpeas, we determined that there is one variety with potential for postharvest bruchid resistant traits that cause a reduced generation one and a lengthening of the preadult stages of the bruchid, both factors contributing to a reduction in bruchid attack. We also determined that local neem kernel powder can also contribute significantly to decreasing bruchid populations and that this level of effective neem kernel powder treatment was acceptable after processing and cooking.

With the high lysine yeast replacement, we developed an acceptable experimental protocol and determined that sensory factors (loaf volume and taste) were acceptable to continue with nutritional studies and shelf-life evaluation.

Impacts

There are small differences among current U.S. varieties of wheat, but this research should lead to the increased investigation of these traits by breeders. For many decades, wheat breeding programs have focused on field characteristics. Varieties released and published literature indicate no consideration has been given to postharvest issues other than end-use qualities. Conventional systems have a quick fix to insect infestation with fumigation, but organic operators do not have that option due to a lack of registered organic fumigants.

This wheat research provides a methodology to analyze all lines of wheat in order to detect novel gene expression related to postharvest resistance, which could lead to new strategies for postharvest protection. These strategies become more important as *Rhyzopertha dominica* seems more frequently encountered farther and farther north, due to its increasing its range through commerce and possibly through hypothesized wind-borne dispersion (Fields et al.

1993). For example by 1983, this tropical insect was found as far north as the Canadian border (Storey et al. 1983). By 1990, *R. dominica* was found flying outside grain-handling facilities in all Canadian prairie provinces (Fields et al. 1993). Increased postharvest host plant resistance would increase the storability of wheat, particularly organic wheat, and increase food safety by decreasing the need for chemical application in conventional markets.

Both the cowpea research results and the results with *Lactobacillus fermentum* are issues of food security for material resource poor communities in Mali and throughout the world. We have determined that for subsistence farmers and their children who survive on cereal-based diets, low in certain essential amino acids necessary for protein production, cowpeas and *L. fermentum* provide useful, year-round dietary supplements to provide protein. Particularly for growing children, the correct amount of protein is essential for ideal physical and mental development, and for better resistance to disease.

Funding Sources

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Contacts

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URL: <http://scarab.montana.edu/people/flodunk.htm>

NC-213 Objective 1

Title

Effect of pre-harvest production practices on end-use quality of durum wheat.

Project Objectives

To determine the effect of pre-harvest production practices on end-use quality of durum wheat.

From

Department of Plant Sciences
North Dakota State University

By

Manthey, F.A.

Results for 2006

Yellow pigment content in the endosperm of durum wheat is a very important quality characteristic. During kernel development, carotenoid pigment content/kernel increased until physiological maturity, after which it declined. Lutein and zeaxanthin are the main carotenoids found in durum wheat. Lutein content decreased 38% while zeaxanthin content/kernel remained constant.

Cultivars were found to vary in carotenoid pigment content. Compared to untreated kernels (11-12% mb), kernels tempered to 15-40% mb for six days had increased free fatty acid and conjugated diene contents, which indicates enhanced lipid oxidation. Pigment content declined significantly in grain that had a moisture content of at least 25%.

Plans for 2007

Experiments will be conducted to continue characterizing the deposition and composition carotenoid pigments during kernel development. Experiments will be conducted to determine how pre-harvest conditions affect the oxidative stress associated with kernel desiccation after reaching physiological maturity.

Publications and Presentations

Sandhu, K. 2006. Effect of weathering on vitreousness of durum wheat. M.S. Thesis. North Dakota State University: Fargo, ND.

Issues

Kernel appearance (vitreousness) and endosperm color (yellow carotenoid pigment content) are very important quality characteristics of durum wheat. Pasta/couscous industry is demanding better color. Untimely rainfall and/or prolonged damp conditions before harvest can result in kernel bleaching. Bleached kernels are often designated as nonvitreous, which reduces the value of the grain. Bleached kernels are often associated with low carotenoid pigment content. Limited information is available concerning the effects of genotype and environment on carotenoid pigment deposition and composition during kernel development.

What Was Done

Spikes from five durum cultivars were harvested every 5 days for 35 days beginning 7 days after anthesis from plants grown in field plots. For each sampling time, content and composition of carotenoid pigments were determined using HPLC techniques. In a separate experiment, grain was tempered to 15-40% mb and incubated at room temperature for up to 6 days. For each sampling time, grain was assayed for free fatty acid, conjugated diene, and carotenoid pigment contents.

Impacts

Data indicate that the association between bleached kernels and low carotenoid pigment content is probably due to enhanced lipid oxidation promoted by rehydration of kernels during damp conditions. Lutein content declined during kernel desiccation. Lutein is important for aesthetic quality and also for healthfulness of durum wheat and durum wheat based products. Lutein has been shown to protect humans against age degenerative diseases such as macular degeneration, cataracts, and certain cancers. Thus, research directed towards 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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NC-213 Objective 1

Title

Corroborative study on physical properties and milling processes in maize.

Project Objectives

To compare determinations of maize quality and physical properties evaluated by several university and industrial laboratories aiming to provide information about the variance structure of the methods within and between laboratories as well as hybrids.

From

Texas Agricultural Experiment Station
Office of the State Chemist
Texas A&M University

By

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

Collaborators: Jackson, D.S., Bean, S.R., Lingenfelter, J., Rooney, L., Rausch, K.D., McKinney, J., Iiams, C., Hurburgh, C.R., Jr., Johnson, L.A.

Results for 2006

Eleven maize hybrids with broad genetic and environmental backgrounds were selected for physical (test weight, time to grind in Stenvert Hardness Tester, kernel distribution, TADD, true density, and 100 kernel weight), spectroscopic (oil, protein, and starch contents), and milling (dry and wet) processing tests from four clusters created by using 40 maize hybrids and multivariate statistical techniques. Well-equipped laboratories that have demonstrated considerable works and great capability of the tests participated in this study. Eleven samples were blind-duplicated and sent to collaborators with suggested standard operating procedures for tests. Data was duplicated or triplicated within each laboratory. Results on the eleven samples were tested for outlying and staggering laboratories by using Cochran repeatability (to detect a laboratory with extreme individual values) and Grubb reproducibility (to detect a laboratory with extreme averages) tests to assure the absence of outliers. Analysis of variance of a corroborative study data with and without outliers was performed on each test to determine repeatability (agreement between successive results under same conditions) standard deviation, reproducibility (agreement between individual results under different conditions) standard deviation, repeatability value, reproducibility value, repeatability relative standard deviation, and reproducibility relative standard deviation.

The repeatability and reproducibility parameters appeared to be satisfactory with exceptions for two methods (Table I). Two-factor ANOVA on pooled data showed that significance of main effects (laboratory and maize hybrid) for all physical properties tested in this study was strong. A significant laboratory by maize hybrid interaction was also observed except for kernel distribution. The within-laboratory repeatability was acceptable, but the standard deviation of between-laboratory reproducibility was more than 2 or 3 times that of the within-laboratory repeatability. Repeatability relative standard deviation (RSD_r) varies ranging from 0.38% to 15.11%, while reproducibility relative standard deviation (RSD_R) ranging from 1.06% to 49.83%, indicating the significant variation among laboratories. Of physical properties, TADD and TTG produced rather unacceptable repeatability and reproducibility parameter values compared to others because only 3 laboratories participated in these tests and the values obtained from such laboratories significantly differed from each other for unknown reasons. After removing outliers by Cochran repeatability and Grubb reproducibility tests, the repeatability and reproducibility parameters could be slightly improved, with overall mean of RSD_r from 4.11 to 2.98% and overall mean of RSD_R

from 13.28% to 12.62%, respectively. With determinations of oil, protein, and starch contents by NIR or NIT, RSD_r and RSD_R ranged from 0.97 to 4.56% and from 2.27 to 11.38%, respectively. As expected, the between-laboratory variability was higher than the within-laboratory variability. A significant portion of variation among laboratories in physical properties could be ascribed to one or two deviant laboratories. Such laboratories with more outliers detected seem to have the least chance to practice tests for physical properties in maize samples and thus the least experience.

In this corroborative study, standard deviation of within-laboratory repeatability and between-laboratory reproducibility for physical properties were acceptably low except for TADD and time to grind in Stenvert Hardness Tester. The within-laboratory and between-laboratory variations in this study may be attributed to a data collection under diverse environments, equipment, operators, and instrumentation. Large between-laboratory variability is likely caused by failures to follow the operating procedure correctly by collaborators and inadequately specified procedure. The acceptable repeatability and reproducibility in the methods may enhance the confidence of such methods while there is a need to propose a new procedure suitable to determine precisely and accurately physical properties in maize.

Plans for 2007

Physical and processing test procedures will be carefully reviewed and discussed to improve more precision of the methods based on the results. The manuscript for the journal publication will be sent to all participants for their review and if necessary, adequate explanation for extreme values from their laboratories would be required.

Publications and Presentations

Lee, K.M., Herrman, T.J., Lingenfelser, J., and Jackson, D.S. 2005. Classification and prediction of maize hardness-associated properties using multivariate statistical analyses. *J of Cereal Sci.* 41(1):85-93

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Issues

The physical, spectroscopic, and biochemical methods for the evaluation of maize quality have been developed and provided researchers with great simplicity, speed, and reliability of the methods. However, little standard procedure and various correlations of physical and analytical measurements with end-use processing performance between laboratories have constrained the development of a standardized set of criteria used for the research and industrial use.

What Was Done

A corroborative study data was collected from all participants and statistically analyzed to determine within-laboratory repeatability and between-laboratory reproducibility of the methods.

Impacts

Results from the corroborative study would enable us to compare laboratories' measurements of maize quality to provide the variance structure of within and between laboratories as well as hybrids. This study may assist in establishing universal standard test procedures and data interpretation to help future research and industry partners.

Funding Sources

The Andersons Research Fund (Ohio State University)

AgraMarket Quality Grains

Frito Lay Inc.

Contacts

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Table I. Repeatability and reproducibility for physical properties.

Physical Property ^a	Outlier ^b	Mean	s_r ^c	s_R ^d	r^e	R^f	RSD_r (%) ^g	RSD_R (%) ^h
Moist, %	0	13.93	0.94	1.59	2.64	4.46	6.78	11.43
	3	13.97	0.39	1.46	1.09	4.08	2.80	10.44
TW, kg/hl	0	58.96	0.95	1.30	2.66	3.63	1.61	2.20
	3	59.12	0.34	1.05	0.95	2.95	0.57	1.78
TADD, %	0	29.29	1.54	10.98	4.33	30.74	5.27	37.47
	2	29.58	1.10	10.96	3.08	30.69	3.71	37.05
TTG, second	0	13.53	2.04	6.74	5.73	18.88	15.11	49.83
	2	13.46	1.58	6.21	4.43	17.38	11.76	46.11
Pycno, g/cm³	0	1.274	0.00	0.01	0.01	0.04	0.38	1.06
100 KW, g	0	36.25	1.09	1.71	3.06	4.78	3.02	4.71
	2	36.27	0.76	1.60	2.14	4.48	2.10	4.42
Ker Dist., %	0	91.17	1.12	5.61	3.13	15.70	1.23	6.15
NIR/NIT Oil	0	3.44	0.16	0.39	0.44	1.10	4.56	11.38
NIR/NIT Protein	0	7.15	0.15	0.40	0.42	1.12	2.09	5.62
	1	7.15	0.12	0.40	0.33	1.12	1.67	5.58
NIR/NIT Starch	0	61.71	0.64	1.81	1.78	5.08	1.03	2.94
	3	61.54	0.60	1.40	1.67	3.91	0.97	2.27

^a TW = test weight; TADD = Tangential Abrasive Dehulling Device; TTG = time to grind in Stenvert Hardness Tester; pycno = true density; 100KW = 100 kernel weight; Ker Dist.= kernel distribution; NIR/NIT = near-infrared reflectance or transmittance.

^b Number of outliers removed by Cochran repeatability (1-tail, $p = 0.01$) and Grubb reproducibility (1-tail, $p = 0.01$) tests.

^c Repeatability standard deviation (pooled standard deviation within laboratories).

^d Reproducibility standard deviation (pooled standard deviation within and across laboratories).

^e Repeatability value ($2.8 \times s_r$).

^f Reproducibility value ($2.8 \times s_R$).

^g Repeatability relative standard deviation (coefficient of variation within laboratories).

^h Reproducibility relative standard deviation (coefficient of variation within and across laboratories).

NC-213 Objective 1

Title

Evaluate the baking quality of Texas wheat breaders' samples.

Project Objectives

Define the attributes of wheat flours with excellent quality for flour tortillas. Evaluate the baking quality of Texas wheat breeder samples.

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

Improve aflatoxin tolerance and nutritional and processing quality of corn through breeding.

From

Soil & Crop Sciences Department
Texas A&M University

By

Rooney, L.W.
Betran, J.
Waniska, R.D.
Jones, E.

Results for 2006

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 is 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.

Nearly three thousand 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.

Sorghum Quality: Red, lemon-yellow and white pericarp sorghums without pigmented testa vary significantly in composition and quantities of anthocyanins and related compounds. Some sorghum extracts have significantly inhibited in-vitro human colon and breast cancer cell cultures. In cooperative trials, rats fed tannin and black sorghum brans had significantly less colon cancer cells than those fed cellulose or white sorghum brans. Rats fed tannin sorghum bran had significant levels of metabolic products from tannins than rats fed control diets. Black

sorghums containing pigmented testa vary in tannin content and in relative levels of luteolinidin and apigeninidins. Thus, sorghums with high levels of unique anthocyanins plus condensed tannins can be produced to optimize health benefits and improve functionality in foods. The black sorghum hybrids produce large quantities of grain. Comparison of tannins, total phenols and antioxidants among different cereal grains demonstrated that the special sorghums have significantly higher antioxidant levels than other cereals. The quantity of anthocyanins and tannins of sorghum are affected by variety, environment and their interaction. Mold attack during and after maturation produces phytoalexins which significantly increased anthocyanins. Several products containing bran from white, black and tannin sorghums had excellent flavor and color with high levels of antioxidants and dietary fiber. Additional experiments have confirmed that tannin sorghum bran is an effective antioxidant in cooked, ground-meat patties. Significant reduction in measurable antioxidant activity occurs when grain is processed, probably because of interactions among the tannins, proteins and carbohydrates. The tannin sorghum extrudates and porridges were more slowly digested using in-vitro assays for the estimated glycemic index. Some processes such as high-friction extrusion may depolymerize the condensed tannins. Identity preserved white, tan plant sorghum grain continue to be marketed in Japan in snacks, baked items and other products. The bland flavor of the white sorghum is an advantage for oriental snacks and competes with rice. 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.

Impacts

Sorghums developed in the TAMU sorghum improvement program continue to be used commercially to provide identity preserved grain for a wide variety of human and animal foods. There is increasing interest in use of special sorghums in healthy foods. Sorghum is used in processed high value foods for sophisticated markets, i.e., gluten-free products, natural, dark-colored, whole-grain products with high dietary fiber and increased antioxidant levels. Sorghum use in processed foods and beverages is increasing. A major US brewer is using sorghum in gluten-free beer; South Africa and other breweries in Africa use white, identity-preserved sorghum in commercial, malt-free, lager beer.

Improved understanding of the unique anthocyanins and other phenols in different genotypes of sorghum should lead to new products containing sorghum grain or sorghum extracts for use in nutraceuticals and natural coloring agents.

Corn Quality: Several blue and red corns have excellent processing properties. There were differences in cooking time, pericarp removal and other properties. The new corn lines may produce deep-red alkaline cooked products. Quality protein maize (QPM) inbreds released by the corn improvement program have good alkaline processing properties and higher lysine and tryptophan content. There are differences in cooking times and pericarp removal among the QPM hybrids.

Another goal is to identify and develop corn inbreds with factors 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.

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

Plans for 2007

Continue to evaluate wheat flours and other ingredients for tortilla quality.

Confirm the unique types and levels of anthocyanins in special sorghum cultivars with different genetics grown under different environmental conditions. Determine what happens to the unique anthocyanins of sorghum during processing.

Evaluate factors affecting processing quality of corn and sorghum, especially changes in anthocyanins and procyanidins of special sorghums. Continue efforts to develop aflatoxin-resistant corn lines with improved nutritional value.

Publications and Presentations

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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 tentatively identified sorghums that produce high levels of apigenidin and luteolinidin that have good color stability, and may have anticancer activities as well. More information is required, but special sorghum varieties are 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.

Combinations of soy flour, guar gum, CMC and amylases were optimized to produce tortillas with optimum shelf stability. Other additives from soy were evaluated and some products had improved functionality in corn and flour tortillas.

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.

Impacts

The PI has presented information on food products from sorghum in workshops in South Africa, Brazil, Central America and the USA. The new sorghums are especially important as a new grain for use in gluten-free and ethnic

foods. A source of good-quality sorghum is available for use in food and feed products which has allowed production on new products.

The high levels of tannins in special sorghums have led to effective use of special sorghum bran fractions as preservatives for ground-beef patties. Natural brown or black breads are also made from selected sorghums with high levels of antioxidants.

The understanding of what happens during tortilla staling has led to improved flavor and texture of tortillas which could significantly increase their consumption since they are low in fat and contain significant levels of calcium and fiber. A combination of maltogenic amylases, hydrocolloids and soy flour give tortillas longer shelf life in terms of rollability.

Usefulness of Findings

The potential to produce aflatoxin-resistant corn hybrids exists. More work is required to determine if this is practical.

Corns with improved nutritional quality and processing properties have been released.

Snacks from U.S. identity preserved food sorghums are being sold in Japan.

Food sorghums have excellent extrusion properties and produce bland, light-colored extrudates equivalent to rice.

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

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

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

Objective 2

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



NC-213 Objective 2

Title

Quality management system applications for agriculture.

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.

From

Department of Industrial and Agricultural Technology
Iowa State University

By

Hurburgh, Jr., C.R.
Laux, C.

Results for 2006

The ISO 9000 standard has established itself as a prominent, formal quality management system for companies to pursue. However, despite the advantages that certification brings, there are few case studies on the impact of ISO 9000 on a company's external customer quality. Specifically, the commodity grain handling business in the agriculture sector is a growth area for ISO adoption with few organizations certified to ISO 9001. However, as the number of certifications grows in agribusiness, there will be more demand to demonstrate the effectiveness of ISO 9001 in this marketplace for increasing practitioner knowledge and application. This case study examines the impact of implementing the ISO 9000 quality management system on shipped product quality at Farmers Cooperative; a multi-location, elevator business which handles commodity and specialty grain in the food supply chain. Based on a mixed model approach, the case is divided into a qualitative, or inquiry phase of study, and a quantitative phase analyzing results. Utilizing business process management techniques, a system of measurement investigation was used in developing important metrics that measure the performance of the core processes and in turn, the product, in this study. Both multiple site comparison and in-depth analysis was utilized where: (a) sites without the ISO system were compared to sites operating ISO, and (b) sites operating ISO 9000 were compared by time before and after implementation of the quality management system. The results demonstrate a significant effect of the ISO 9000 system on product quality where human judgment was a significant source of variation in the process of inspecting and designating an official quality classification, or grade, of the product. Company elevator locations that used QMS scored significantly better in key indicators of profitability and success than locations that were not using QMS.

ISO also brings additional benefits in meeting new, domestic, federal mandates, namely, the registration of food companies and records maintenance sections of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (known as the Bioterrorism Act). This case study examines how a Farmer's Cooperative of Iowa utilized its quality management system, based on ISO 9000, to implement a traceability system to meet the requirements of the Bioterrorism Act. Utilizing the quality management system (QMS), the organization implemented grain identification and traceability procedures under the structure of the Farmer's Cooperative (FC) quality management system. The company then held 21 mock recall events across eight FC locations. These tests

demonstrated both the potential and the problems of grain traceability in a typical, bulk commodity grain elevator operation. Traceability ratios ranged from 5 to 200.

Plans for 2007

Expand and publish the methods used for measuring business success from quality management systems.

Refine the product tracking system and add statistical probabilities to the tracking of specific inbound grain lots.

Apply the ISO 9000 and 22006 standards to the agricultural input supply component of the cooperative firm.

Publications and Presentations

Hurburgh, C.R., Jr. 2006. Traceability in bulk agricultural products. International Conference on Food Traceability, IdTechEx, Norwich, UK. February 1-2, 2006, Dallas, Tx. Invited Presentation

Hurburgh, C.R., Jr. 2006. Food Safety and Security: A Bulk Commodity Perspective. Iowa State University National Events Lecture Series. February 9, 2006.

Hurburgh, C.R., Jr. 2006. The impact of FDA recordkeeping rules on bulk grain handling. Proc. 77th International Conference, Grain Elevator and Processing Society, GEAPS, Minneapolis MN. February 25-28, 2006. Nashville, TN.

Hurburgh, C.R., Jr. 2006. Traceability of Bulk Grains: The New FDA Rules and a Case Study Response. Annual Technical Meeting, NC-213 Multistate Project, OARDC, Wooster, OH. March 1, 2006. Nashville, TN.

Hurburgh, C.R., Jr. 2006. Food Traceability: A US Perspective Based on Bulk Commodities. Second annual meeting of TRACE, EU 6th Framework project. Prague, Czech Republic, April 24-26, 2006

Hurburgh, C.R. Jr. 2006. The Impact of FDA Recordkeeping Rules on Grain Handling. Operations and Management Seminar, Grain Elevator and Processing Society, Minneapolis, MN. August 2, 2006. Invited Presentation.

Laux, C. and C.R. Hurburgh, Jr. 2006. The Impact of an Auditable Quality Management System in an Agribusiness. National Association of Industrial Technology, 39th Annual Meeting, Cleveland, OH. November 14-18, 2006. Abstract.

Issues

Agriculture is finding new industrial markets for traditionally food commodities. These markets have altered distribution patterns, have increased farm income, and have created the need for industrial supply chains rather than commodity trading.

Raw materials are not exempt from the increasing traceability and biosecurity needs of world markets. Recent food safety issues will bring supply management and tracking to the producer.

Quality management systems have created substantial efficiencies in manufacturing industries; agriculture will need to discover and implement these benefits as well.

Impacts

The company involved in the study has reorganized its management structure to facilitate the ISO system. Three facilities are ISO certified, and six have private certification in preparation for ISO implementation. Internal auditor and quality manager jobs have been created. Site security and food security needs have been easily added to the ISO system.

Iowa grain firms have utilized the web based bioterror recordkeeping module to begin compliance with the FDA regulations.

The grain tracking system has demonstrated significant income potential created by more precise inventory management.

The ISO22006 Standard, ISO 9000 Application to Production Agriculture is now in its third committee draft. Advancement to Draft International Standard is expected in Summer 2007.

Contacts

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NC-213 Objective 2

Title

Ethanol yield with FT-NIR.

Project Objectives

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

From

Illinois Agricultural Experiment Station
Agricultural and Biological Engineering Department
University of Illinois at Urbana

By

Paulsen, M.R.
Rathore, S.

Results for 2006

The objective of this work was to investigate the feasibility of developing calibrations for ethanol yield based on ground corn samples using a Fourier-Transform Near Infrared (FT-NIR) Perkin Elmer Model 6750 Spectrum One NTS spectrometer. Calibration models using PCA, PLS, and discriminant PLS were investigated. Fourier-Transform NIR calibrations were made based on HPLC tests of fermented corn slurries. The wavenumbers (wavelengths) of 5170 cm^{-1} (1934 nm), 4764 cm^{-1} (2100 nm), 4518 cm^{-1} (2210 nm), 5782 cm^{-1} (1729 nm), and 5938 cm^{-1} (1684 nm) were found to be important for the classification of corn hybrids for ethanol values.

The Discriminant PLS model with five factors had a correlation coefficient of 0.82 and RMSEP of 2.04. One principal component was able to explain 60% of the variation in ethanol among samples. Discriminate PLS analysis for each group had a population overlap with adjacent groups; but the highest ethanol group could be separated from the lowest ethanol group. The PLS model with five factors had a correlation coefficient of 0.67 and RMSEP of 0.6 % v/v. The calibration model using the PCR method had a higher RMSEP as compared to that of PLS1; thus, it provided no advantage in terms of prediction. The model using the PLS1 method usually gave a lower RMSEP than those built using PCR. However, with more samples at the upper and lower range of ethanol values, there is a possibility of obtaining improved results. Fermentability of corn not only depends on the starch constituents, but also on the process parameters such as pH and temperature. Factors such as variation in yeast nutrients, and activity of saccharification enzymes can also greatly affect yield of ethanol.

Plans for 2007

Plans for 2007 are to investigate factors affecting fermentables and DDGS in the dry-grind corn ethanol process.

Publications and Presentations

Rathore, S.S., Paulsen, M.R., Singh, V, and Graeber, J. 2006. Ethanol yield of corn hybrids in dry-grind corn processing using Fourier-transform near-infrared spectroscopy. ASABE Paper No. 06-3047. St. Joseph, MI 49085.

Issues

Ability to quickly measure fermentables in corn and products of fermentation in dry-grind ethanol processes.

What Was Done

Calibrations for measuring fermentables in corn with FT-NIR spectroscopy were developed.

Impacts

U.S. ethanol production capacity was 4.4 billion gallons per year in February of 2006 and is expected to reach 7 billion gallons by the end of 2007, creating a huge surplus of DDGS. Value of DDGS can be improved by modified processes that reduce fiber and increase protein, but rapid measurement and monitoring of fermentation processes and variability in DDGS quality is needed.

Contacts

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NC-213 Objective 2

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.

Summary

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

From

Bioproducts and Biosystems Engineering Department
Entomology Department
University of Minnesota

By

Morey, R.V., Bioproducts and Biosystems Engineering Department
Wilcke, W.F., Bioproducts and Biosystems Engineering Department
Kells, S.A., Entomology Department

Results for 2006

Accomplishments and results for 2006 include:

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

Published a paper on mortality of Indianmeal moth in southern Minnesota and prepared a paper which has been accepted for publication.

Published a paper on effect of broken corn on Indianmeal moth survivability.

Developed and validated 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.

Plans for 2007

Finalize Publications and Presentations on our work.

Publications and Presentations

Carrillo, M.A., R.D. Moon, W.F. Wilcke, R.V. Morey, N. Kaliyan, and W.D. Hutchison. 2006. Overwintering mortality of Indianmeal moth (Lepidoptera: Pyralidae) in southern Minnesota. *Environmental Entomology* 35(4): 843-855.

Kaliyan, N., R.V. Morey, W.F. Wilcke, M.A. Carrillo, and C.A. Cannon. 2006. 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* (in press).

Kaliyan, N., M.A. Carrillo, R.V. Morey, W.F. Wilcke, and S.A. Kells. 2006. Mortality of Indianmeal moth under changing temperatures: Model development and validation. ASABE Meeting Paper No. 066200. ASABE St. Joseph, MI 49085.

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 2006 was to complete work on the effects of low temperatures on mortality of Indian meal moth [*Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae)].

We published results on the effect of broken corn on survivability of *P. interpunctella* larvae fed a standard laboratory diet, whole corn with 0% broken kernels, whole corn with 5 to 7% broken kernels, and 100% broken corn kernels. A conventional low-oil yellow dent corn (3.9% oil) and a high-oil corn hybrid (7.7% oil) were tested at 28°C, 65% RH, and 14 h light: 10 h day photo period cycle. Larval survival rates increased with increasing amounts of broken kernels. Larval growth rate for high-oil corn was greater than for low-oil corn. Results indicate that cleaning corn before storage could reduce Indianmeal moth problems.

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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NC-213 Objective 2

Title

Naturally occurring antifungal agents from lactic acid bacteria.

Project Objectives

Search for food grade lactic acid bacterial cultures that inhibit fungal (mold) growth.

Determine the effect of the antifungal activity on mycotoxin production.

Determine if the antifungal activity can be developed to prevent mold invasion and growth in grains.

Determine if any of the bacterial cultures can degrade or remove mycotoxins from solutions and foods.

Summary

Lactic acid bacteria were isolated from several fermented food products and sourdough bread cultures. The bacterial isolates and sourdough bread cultures were tested for antifungal activity. A total of ten lactic acid bacterial isolates and two sourdough cultures were found to be strongly inhibitory to *Fusarium graminearum*. This fungus was used as a test organism because it was found to be most sensitive to the antifungal activity of the lactic acid bacteria.

From

Department of Food Science and Technology
University of Nebraska-Lincoln

By

Bullerman, L.B.

Results for 2006

The best mold used as an indicator of antifungal activity of lactic acid bacteria was shown to be *Fusarium graminearum*. Using this mold as an indicator of antifungal activity, lactic acid bacteria isolates from fermented plant foods were shown to be more strongly antifungal and better able to inhibit growth of this mold than isolates from dairy products. From those isolates that showed antifungal activity against *Fusarium graminearum*, the best ones were used in a broader study involving a wider variety of spoilage and toxigenic species of fungi. The isolates inhibited completely the growth of *Cladosporium sp.*, *Cladosporium cladosporioides*, *Alternaria sp.*, *Alternaria alternata*, and *Phoma sp.*, during the observation period. When *Aspergillus* and *Penicillium* species were used as test organisms, all isolates significantly inhibited the growth of *Aspergillus niger*, *Penicillium sp.*, and *Penicillium roqueforti*, except the isolates from cottage cheese and cultured buttermilk. The best results were obtained with the strains isolated from a kimchi sample. For the spoilage yeasts tested, *Kluyveromyces marxianus* var *lacticus*, *Kluyveromyces marxianus* var *marxianus*, and *Saccharomyces cerevisiae* were not inhibited by any of the isolates tested, while *Rhodotorula sp.* was inhibited by all the isolates tested, except for the isolates from cottage cheese and cultured buttermilk. Intact sourdough bread cultures were also shown to have antifungal activity.

Plans for 2007

Cultures of the lactic acid bacteria isolates and sourdough bread cultures will be grown in different food grade liquid fermentation media and fermentation conditions to attempt to develop the best substrate and conditions for maximum production of cells and antifungal activity. The fermentation media/substrates will be composed of ingredients that are or can be obtained as food grade such as glucose, lactose, sucrose, yeast extract, beef extract,

peptones, soy protein, various salts, and other ingredients. Fermentation conditions, including temperature, atmosphere (presence or absence of oxygen and CO₂) and agitation will be studied. Milk and cheese whey will also be studied. The inhibitory activity of the lactic acid bacteria isolates in these media will be tested in the presence and absence of the bacterial cells. The inhibitory activity of the intact bacterial cultures (cells and supernatant) will be determined by measurements of mold colony diameter in a dual agar, where the bacterial isolates will be grown in the bottom layer and the mold in the top layer of the agar. For those experiments using the cell-free supernatant, the isolates will be grown in the test media, the cells removed by centrifugation and/or filtration, and the supernatant tested using an agar prepared with the cell free supernatant mixed with double strength Potato Dextrose Agar. The inhibitory activity of the isolates will be determined by daily measurements of mold colony diameter, compared to controls. Cultures will also be studied as intact “fermentates”, (fermented substrates) added directly to solid substrates such as grains for ability to inhibit mold growth. For these solid substrates mold growth will be evaluated by measuring ergosterol production and by visual observations.

Issues

Concern over chemical food additives and preservatives including grain preservatives and fungicides has prompted searches for more natural antifungal agents, such as naturally occurring safe biological agents. One source of safe naturally occurring biological agents with antifungal potential are lactic acid bacteria found in fermented foods and sourdough bread cultures. This work is an attempt to find and develop antifungal lactic acid bacteria cultures that can be used as safe, natural food and grain preservatives.

What Was Done

Lactic acid bacteria and intact sourdough bread cultures were tested for antifungal activity against *Fusarium graminearum* and other mold cultures. Strong antifungal activity was found in ten lactic acid bacteria isolates and two sourdough bread cultures.

Impacts

This work may lead to development of safe, natural, biological antifungal preservatives for use in stored grain as a replacement for chemical fungicides.

Funding Sources

Nebraska Agricultural Research Division (ARD)

USDA Multistate Regional Research Funding administered through the Nebraska ARD

Contacts

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NC-213 Objective 2

Title

Biological evaluation of reduction of Fumonisin B₁ toxicity in corn grits by extrusion processing.

Summary

Corn grits, contaminated with fumonisin B₁ (FB₁) were produced by direct addition of FB₁ (spiking) and by fermentation of the grits with a fumonisin producing strain of *Fusarium verticillioides* M2552. Spiked and fermented corn grits were extruded with and without 10% added glucose at 160°C and 60 rpm screw speed. The extruded grits were then analyzed by enzyme linked immunosorbent assay (ELISA), high performance liquid chromatography (HPLC) and by high performance liquid chromatography linked to a mass spectrometer (LC-MS). Extruded grits were also tested for fumonisin toxicity using a rat feeding bioassay. Analyses by ELISA indicate that fumonisin concentrations in extruded corn grits plus 10% glucose were reduced by 79 to 86% by the extrusion process. This result was also observed (75-85% reduction) when the extruded corn grits plus 10% glucose were analyzed by LC-MS. The rat feeding bioassay gave somewhat inconclusive results, but generally showed lowered toxicity of fumonisin contaminated corn grits extruded with 10% glucose.

Project Objectives

The overall objective of this project is to assess reduction of the toxicity of FB₁ during extrusion cooking of contaminated corn grits using *in vivo* bioassay methods. Specific objectives include:

Extrude corn grits contaminated with FB₁ to obtain maximum destruction of FB₁.

Determine reduction of FB₁ by ELISA and HPLC methods.

Determine identity of any degradation products by LC-MS.

Determine residual toxicity of FB₁ in the extruded product with bioassay methods.

From

Department of Food Science and Technology
University of Nebraska-Lincoln

By

Bullerman, L.B.

Results for 2006

Contaminated corn grits were produced by direct addition of purified FB₁ (spiking) and by fermentation of the grits with a fumonisin-producing strain of *Fusarium verticillioides* M-2552 which was obtained from the *Fusarium* Research Center of the Pennsylvania State University, University Park, PA. A limited amount of purified FB₁ was obtained from Dr. Lauren Jackson of The National Center for Food Safety and Technology, FDA, Summit-Argo, IL. Analyses of the spiked corn grits by ELISA showed that the unextruded spiked grits contained 29.2 µg/g (ppm) of FB₁. Corn grits were extruded in a Single Screw Extruder (Model 2003 GR-8, C.W. Brabender, South Hackensack, NJ). The temperature of the first (feed) zone was set to 100C, while the second (metering) and third (compression) were set at 160C, the screw speed was 60 RPM. The extruded spiked grits contained 6.0 µg/g of FB₁ and extruded spiked grits with 10% added glucose contained 4.0 µg/g of FB₁ for reductions of 79.4 and 86.3% respectively. Fermented unextruded corn grits contained 60.1 µg/g (ppm) of FB₁, extruded fermented grits contained 10.2 µg/g (ppm) of FB₁ and extruded fermented grits with 10% added glucose contained 10.9 µg/g (ppm) of FB₁ for reductions

of 83.0 and 81.9% respectively. Analyses by HPLC and mass spectrometry (LC-MS) confirmed the results and showed that extrusion of corn grits with 10% added glucose resulted in 75-85% reductions in FB₁ levels. Levels of FB₂ and FB₃ were also reduced by 84% in extruded corn grits with 10% glucose. A mass balance analysis was used to estimate the contribution of the various FB₁ reaction products, hydrolyzed FB₁ (HFB₁), N-(1-Deoxy-D-fructos-D-1-yl) FB₁ (NDF-FB₁) and N-(Carboxymethyl) – FB₁ (NCMFB₁). Mass balance analysis indicated that 73-78% of the FB₁ species detected in the corn grits extruded with 10% glucose was NCMFB₁. However in spiked corn extruded with glucose, 90% of the FB₁ originally in the corn was converted to NDF-FB₁. However in fermented corn samples extruded with glucose only about 50% of the FB₁ present was converted to NDF-FB₁. Results of the rat feeding trial were rather inconclusive, but tended to indicate that extrusion of contaminated corn grits with 10% glucose reduced the toxicity of fumonisin.

Plans for 2007

The project is completed. A final report will be submitted and a manuscript will be developed and submitted to a peer reviewed scientific journal for possible publication.

Issues

The mycotoxin fumonisin is produced by the molds *Fusarium verticillioides* and *Fusarium proliferatum* which are common contaminants of corn. These organisms are found in all corn growing regions and fumonisins, particularly FB₁, FB₂ and FB₃, are common and frequent contaminants of corn, including apparent good quality No. 2 corn. Fumonisin has the potential to cause or contribute to human diseases such as cancer, atherosclerosis, neural tube defects in developing embryos and weakened immune systems. Fumonisin has been shown to be fairly heat stable compounds that survive most food processes to contaminate processed corn based foods. However, processing, especially extrusion processing, appears to reduce the concentrations of fumonisin in extruded and other processed corn based foods. Unfortunately, there is also evidence that fumonisins may not be as completely destroyed as it might appear because the toxin can bind to the corn matrix during thermal processing and become non-recoverable and non-detectable by analyses that require extraction, resulting in so called “hidden” fumonisin. This work attempted to correlate the apparent loss of fumonisin in the extrusion process, as determined by ELISA and HPLC analyses, with actual losses as determined by detection of breakdown products using LC-MS and loss of toxicity as determined by a rat feeding bioassay.

What Was Done

We conducted an experiment in which we artificially contaminated some corn flaking grits with fumonisin B₁ by spiking the grits with purified FB₁ and also by growing a fumonisin-producing mold on other flaking grits to get fumonisins produced directly in the grits. We then processed the contaminated grits in a Brabender Model Type 2003 GR-8 single screw laboratory scale extruder at a temperature of 160°C and a screw speed of 60 rpm, with and without 10% added glucose. We then collected and dried the extruded contaminated corn product for analyses by ELISA, HPLC, LC-MS and a bioassay based on feeding the extruded contaminated corn to rats. The ELISA analyses showed that extrusion gave an apparent reduction of FB₁ in the spiked extruded grits of 79.4% without added glucose and 86.3% with 10% added glucose. In the fermented grits the reductions were 83% without added glucose and 82% with 10% added glucose. LC-MS showed that reaction products of FB₁, notably HFB₁, NDF-FB₁ and NCMFB₁ were formed. Rat feeding trials showed lowered toxicity of corn grits extruded with 10% glucose.

Impacts

This research produced evidence of reduction in toxicity of fumonisins in corn after extrusion processing with 10% added glucose. Some less toxic breakdown products were identified and there appeared to be lowered toxicity in rats. This helps to answer the question of whether the extrusion process actually destroys the toxins or simply masks them by causing reactions with the corn matrix and making them non-detectable but still toxic. There appears to be a reduction in toxicity, though further studies are in progress to confirm this. This information is needed by the food industry and regulatory agencies and it is also valuable to consumers of corn based food products. The results of this research can be used to develop extrusion processes that will give better reductions of fumonisins resulting in safer food products. The results of this work were also used to prepare a USDA/CSREES Competitive Grants

research proposal that was funded and allows the work to continue on a larger scale to extend and confirm the findings of this Andersons Grant.

Funding Sources

Andersons Research Fund (Ohio State University)

Nebraska Agricultural Research Division (ARD)

USDA Multistate Regional Research Funding administered through the Nebraska ARD

Contacts

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NC-213 Objective 2

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.

From

Department of Cereal and Food Sciences
Department of Veterinary and Microbiological Sciences
North Dakota State University

By

Hall III, C.
Wolf-Hall, C.

Results for 2006

A wet noodle model system was developed to determine the antifungal activities of flaxseed flour (FF). Sub-samples were taken to screen the antifungal activity. Noodle samples were stored in plastic bags at room temperature and checked daily for visual observation of mold growth. A spot inoculation method was used to further assess the antifungal activity of FF against specific fungal species. *Penicillium chrysogenum*, *Aspergillus flavus*, *Fusarium graminearum*, and a *Penicillium* isolate from the dominant spoilage micro flora in the noodle system were used as test microorganisms. Eight FF of two cultivars from four locations of Minnesota and North Dakota were used to determine the effect of cultivar and sources. To determine the effect of concentration, 5 levels of FF concentration (0, 6, 9, 12, and 15%) were added into the noodle formula. FF was heated at 121°C for 15 min before addition to the noodle sample to determine the effect of heat treatment. Results showed that addition of FF delayed the mold growth from day 6 to day 11. Both omega and brown FF had antifungal activity in the noodle model system regardless of location, although differences in the degree of mold inhibition were found among FF due to the location and cultivar. It was also found that a concentration of 9% FF or higher was needed to inhibit the growth of the *Penicillium* isolate and *P. chrysogenum*. In addition, 15% FF addition had the same effect as 0.2% propionic acid against the growth of *P. chrysogenum*. Heat treated FF had the same pattern as the control sample, and therefore it was concluded that heat destroyed the antifungal activity of FF.

Plans for 2007

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).

Publications and Presentations

Hall III, C.A., Tulbek, M.C. and Xu, Y. 2006. Flaxseed. In: Advances in Food Science and Human Nutrition. Edited by S. Taylor. Elsevier Inc. Volume 5 pp 1-97. (Book chapter with a section devoted to antifungal activity.)

Xu, Y., C.A. Hall III, and C. Wolf-Hall. Antifungal activity of flaxseed flour and flaxseed flour extracts. Session 052, Antimicrobials. Annual Meeting and Expo of the Institute of Food Technologists. Orlando, FL., June 24-28, 2006. (Oral presentation 052-7)

Xu, Y., C.A. Hall III, C. Wolf-Hall and F. Manthey. 2006. Antifungal Activity of Flaxseed Flours. The Proceedings of the 61st Flax Institute of the United States. Edited by J. Carter. Published by North Dakota State University, Fargo, ND. pp 177-185. (Results presented at the 61st Flax Institute of the United States. Fargo, ND. March 22-24)

Impacts

This project demonstrated the feasibility of flaxseed as an antifungal agent. It also provided details about the antifungal activity of different varieties and that the stability was influenced by heat. The data reported suggests that flaxseed could be useful as an antifungal agent in food with minimal heat application.

Funding Sources

North Dakota Agricultural Utilization Commission.

NC-213 Objective 2

Title

Investigation of methods to improve the flowability of distillers dried grains with solubles (DDGS) during processing, handling, storage and transport.

Project Objectives

The focus of this research will be to determine the physical and flow properties of DDGS for designing handling, transport and storage systems to ensure smooth flow. It will also cover the determination of conditions during processing, handling, storage and transport that cause poor flowability of DDGS.

Additional objectives of the project are:

Determine the physical, flow, hygroscopic and chemical properties of DDGS relevant to solving its flowability during processing, handling, storage and transport,

Determine and quantify corn-to-ethanol process conditions that affect the flowability of DDGS, and

Develop practical solutions to ensure smooth flowability of DDGS.

From

Agricultural and Biological Engineering Department
Purdue University

By

Ileleji, K.E.
Stroshine, R.L.
Maier, D.E.
Clementson, C.
Prakash, K.

Results for 2006

The significant findings of the study on Segregation during gravity-driven discharge of DDGS are summarized as follows:

One-way ANOVA for geometric mean particle diameter for the segregated bulk classified as inner core, outer core, inner periphery and outer periphery, respectively were significantly different for piles formed by gravity-driven discharge, without and after vibration.

The geometric mean particle diameter for segregated bulk classified as inner core, inner periphery and outer periphery were significantly different from the non-segregated bulk, except for the outer core.

Chemical compositional analyses for crude protein, crude fat, crude fiber and ash for the segregated bulk classified by particle size distribution and segregation during gravity-driven discharge indicated some differences. However, this was not statistically tested.

Preliminary analysis of the morphology of particles sizes within the classified segregated bulk portions showed clear differences in particle shape and size.

For the particle size distribution of DDGS samples tested (i.e. from an “old generation” ethanol plant), segregation of bulk particles during gravity-driven discharge is likely to occur during bulk handling. Syrup balls formed by caramelization of residual sugars were the largest sized particles and they are likely to segregate during gravity discharge as was observed in this study.

In addition, physical properties such as bulk density, particle density and the angle of repose were determined. It was also established that DDGS exhibit funnel flow during gravity-driven discharge from a hopper with circular orifice and behaves like a cohesive bulk solid.

Plans for 2007

Segregation during gravity-driven discharge of DDGS will be investigated by sampling piles of DDGS in flat storages of five ethanol plants in the Midwest. In particular, DDGS samples from more ethanol plants to capture the variability of DDGS in the industry will be included in this study. The results will provide a better understanding of the occurrence of segregation in piles and its effect on nutrient variability. This will enable the development of sampling protocols for DDGS in ethanol plants.

We plan to collaborate with five ethanol plants to sample DDGS for physical and flow property determination. During sampling, data on the process variables and corn feedstock that produce the DDGS will be collected for correlation with the results from the physical and flow properties tests. In addition, the chemical characteristics of the DDGS samples will be determined. The primary goal of our effort will be (1) characterize the fundamental particles consisting DDGS bulk, (2) to understand what factors affect poor discharge of DDGS from a hopper, (3) the effect of process variables on flowability, and (4) strategies to mitigate against DDGS poor flow behavior.

Publications and Presentations

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

Issues

Flowability of DDGS has been cited as one of the major hurdles to expanding existing markets and developing new markets for DDGS. As part of the overall goal to mitigate against flowability of DDGS, segregation during gravity-driven discharge of DDGS was investigated in 2006. This is because feed manufacturers avoid using DDGS sources that have a high average micron size (which is due to the presence of "syrup balls") because ingredient segregation can occur in complete feed due to large variation in particle size of the feed mixture. Size segregation that occurs during bulk handling in feed preparation will lead to uneven nutrient distribution in the material stream and thus cause inconsistent feed formulation. Particle segregation could also cause bridging of the bulk in gravity discharge from a hopper bin or sampling error caused by sampling from localized segregated regions.

What Was Done

The major objectives of this study were to: (1) determine if particle segregation occurred during gravity-driven discharge of DDGS and (2) determine if the occurrence of particle segregation during gravity-driven discharge of DDGS could lead to chemical composition differences within the segregated portions of the bulk. We conducted studies to determine (1) segregation in a pile without vibration, (2) segregation in a pile after vibration, and (3) segregation in a container after vibration. The segregated pile was divided into four portions with concentric rings designated as inner core, outer core, inner periphery and outer periphery. These portions were analyzed for particle size analysis and chemical composition (moisture, crude fat, crude protein, crude fiber and ash).

Impacts

The results of this research will improve the quality consistency of DDGS especially with respect to better flowable product during processing, handling, transport and storage. In general, we will use the results to develop quality assurance protocols for DDGS co-products that will guide ethanol plant managers on what to monitor and how to

improve the quality of their DDGS during production. The outcomes of this research will be transferred to the industry through workshops, extension Publications and Presentations, website, peer-reviewed journal papers and industry trade magazines.

Funding Sources

The Andersons Research Grant (primary support)

The Energy Center, Discovery Park at Purdue University

Duke Energy

Contacts

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NC-213 Objective 2

Project Title

Monitoring stored grain quality.

Project Objectives

The goal of this project is to evaluate, under field conditions, the use of carbon dioxide detectors to monitor for bio-activity in stored corn prior to the time that spoilage would be detected by traditional methods. Our hypothesis is that CO₂ monitors can efficiently detect grain in the early stages of spoilage. The specific project objectives are:

To determine the parameters for monitoring changes in CO₂ concentrations within a grain bin.

To determine the relationship between a fungal biomass growing in a grain bin and the early detection of CO₂.

To determine the impact of fungal feeding insect infestations on detection of CO₂ from spoiling grain.

To determine scale-up parameters through modeling in order to implement the CO₂ monitoring technology in commercial-sized storage structures.

To develop robust CO₂ sensors and a prototype CO₂ monitoring system that could be commercially implemented.

Summary

This project is investigating the utilization of carbon dioxide detectors to monitor for the spoilage of stored corn prior to the time that spoilage would be detected by traditional methods. An automatically controlled water drip apparatus was built and used to simulate the development of a hot spot in stored grain. In-lab and pilot bin experiments as well as tests in large commercial storage structures and outdoor grain piles have been conducted and indicate the effectiveness of CO₂ detection.

From

Agricultural and Biological Engineering¹
Botany and Plant Pathology²
Entomology³
Purdue University

Engineering Research Unit⁴
USDA-ARS-GMPRC
Manhattan, Kansas

By

Maier, D.E.¹
Moog, D.J.¹
Bin, Q.¹
Ileleji, K.E.¹
Woloshuk, C.P.²
Mason, L.J.³
Armstrong, P.⁴

Results for 2006

The first objective of this research project was completed in 2000, and has been previously reported on. The in-lab experiments of the second objective were completed in 2001, and were previously reported on. The pilot bin trials of the second objective were completed in 2002, and were previously reported on. The impact of fungal feeding insect infestations on detection of CO₂ was monitored as part of on-going stored grain insect pilot bin studies during the summer of 2003, and were previously reported on. The feasibility of CO₂ detection was further explored by intermittently monitoring the exhaust air of several 500,000 bushel steel tanks at one commercial elevator between January and June 2003. These tests were continued in 2004 (which was previously reported) and again in 2005. USDA-ARS-GMPRC designed and custom-built CO₂ sensors that were equipped to communicate via a wireless monitoring system. The successful installation and utilization of that system was reported on in last year's report. Additionally, 16 CO₂ sensors were installed in 2005 in the pilot bins of the Purdue University Post-Harvest Education & Research Center, and monitored beginning in May 2005 as part of a long-term storage experiment to detect any grain quality problems due to molds and/or insects early., which continued throughout 2006 and is on-going. Progress was made on the completion of a simplified mathematical model for the generation and movement of low CO₂ levels due to biological activity (fungi, insects) in a stored grain mass using a Computational Fluid Dynamics package called Fluent. The CO₂ movement model will be validated using data collected from the in-lab and pilot bin experiments as well as the field test of CO₂ detection undertaken for objectives 2 and 3 of the project. The fifth objective of this research project was initiated in 2005 through funding from a USDA-SBIR grant and involves the cooperation with two companies. For the 2005-06 storage season, the wireless CO₂ monitoring network was installed on two large ground piles at a commercial grain elevator facility in Indiana (one round pile with 1.8 million bushel capacity; one oblong pile with 1.5 million bushel capacity). Fixed CO₂ sensors were installed in the exhaust air streams of the downdraft aeration fans for early detection of spoilage in stored corn. The effect of external wind velocity and direction outside one 500,000 bushel capacity steel storage tank and the air movement in the headspace of that tank was quantified using a weather station placed outside and a 3D anemometer placed above the grain surface inside the tank.

Plans for 2007

We expect to finish this project with the completion of a second M.S. thesis by middle of this year, and transition into a new project that will include commercialization of CO₂ sensors and the associated intelligence needed for the automated monitoring system.

Publications and Presentations

Bhat, C.G. 2006. Early detection of grain spoilage and prediction of movement of low levels of CO₂ in a storage tank. Unpublished M.S. thesis, Purdue University.

Maier, D.E., K.E. Iteleji, C. Bhat and C.P. Woloshuk. 2006. Detection by a CO₂ sensor of a simulated hot spot in stored corn. *Transactions of the ASAE*. 22(2):275-289.

Hulasare, R.B., Maier, D.E., Qian, B., and Armstrong, P. Monitoring carbon dioxide levels for early detection of spoilage in corn stored in large tanks and ground pile. Paper No. 06-6039. ASABE, St. Joseph, MI.

Issues

In the United States close to 20 billion bushels of grain are stored every year. Insects and fungi create numerous quality problems in these stored grains that cause millions of dollars in losses. It is essential for the grain storage industry to have effective pest management programs to protect against economic loss due to contamination from insects, fungi and mycotoxins. A major contributor to the spoilage of grain is the growth of various fungal species, including several that produce mycotoxins. Although quality of harvested grains can never be improved with storage time, the rate of deterioration can be slowed with an integrated systems approach that combines engineering, biological and economic principles.

What Was Done

Monitoring the condition of thousands of bushels of grain is a difficult task with only the technology of temperature sensors. Our research has presented evidence that CO₂ monitoring technology can be effectively used in stored grain management.

Impacts

The impact of this research will help solve grain storage problems by applying an available technology that can detect spoilage before it gets out-of-hand. If spoilage is detected early by an increase in CO₂ concentration, the problem can be corrected by simple management practices such as applying aeration to cool and dry the grain mass.

Funding Sources

Anderson Research Grant Program 1999-2001, 2002-2003, private industry, USDA-SBIR

Contacts

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NC-213 Objective 2

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). Our 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*)

Summary

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.

From

Agricultural and Biological Engineering¹
Botany & Plant Pathology²
Entomology³
Purdue University

Grain Science & Industry⁴
Kansas State University

Veterinary and Microbiological Sciences⁵
North Dakota State University

By

Maier, D.E.¹
Moog, D.J.¹
Campabadal, C.A.¹
Woloshuk, C.P.²
Mason, L.J.³
Subramanyam, Bh.⁴
Wolf-Hall, C.⁵
Schwarz, P.⁵

Results for 2006

Numerous aeration system designs exist to aerate large outdoor grain piles (up to 50,000 tonnes) in North America. Suction airflow is used to hold tarps covering these piles in place. Airflow through the peaked grain mass is presumed to be non-uniform. A computational fluid dynamics package (CFD), FLUENT, was used to model non-uniform suction airflow in one commercial outdoor maize pile. The material properties of maize including moisture content, porosity and bulk density were specified and boundary conditions of air mass inflow rates based on an airflow rate of 0.085 m³/min/tonne were used. A procedure was established to estimate the percentage of grain volume having a flow velocity above a critical value needed for ozonation. A comparison between airflow distributions with varying ratios of mass inflow rates between the central tower, flexible perforated air ducts under the tarp and the perforated side wall was made. The velocity profile of the air movement and absolute pressure exerted by the airflow inside the grain pile and between the tarp and grain surface interface were also studied. For each mass flow case, the velocity magnitude and the absolute pressure exerted by the airflow increased near each of the three air inlets. The mass flow ratio of 1:1:1 had the highest percentage (77%) of flow velocity above the critical velocity of 0.03 m/s needed for ozonation. Additionally, using a 3D CFD approach to evaluate aeration system design for large storage structures such as outdoor grain piles proved useful.

Plans for 2007

Now that a larger ozonation unit is available from the commercial project collaborator that can generate 1 kg of ozone per hour, we will be able to initiate our proposed field trials this year.

Publications and Presentations

Maier, D.E., Khandelwal, S., Lawrence, J., and Campabadal, C.A. 2007. Modeling airflow in outdoor grain pile aeration systems using computational fluid dynamics software. Paper No. 06-6085; ASABE, St. Joseph, MI.

Issues

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.

What Was Done

During the first project year, the velocity profile of the air movement inside a grain pile and between the tarp and grain surface interface were studied. A mass flow ratio of 1:1:1 had the highest percentage (77%) of flow velocity

above the critical velocity of 0.03 m/s needed for ozonation. Additionally, the performance of a new ozone generator was tested and deemed feasible for the research proposed in this project.

Impacts

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. We 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

Anderson Research Grant Program Team Competition 2005-2007

Contacts

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NC-213 Objective 2

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 amylase/amylopectin.

From

Agricultural and Biological Engineering
Purdue University

Grain Marketing and Production Research Center
USDA, Agricultural Research Service
Manhattan, Kansas

By

Stroshine, R.L.
Ramos, O.F.

Armstrong, P.

Results for 2006

Corn samples for testing have been provided by the Southern Indiana Corn Performance Trials (both white and yellow food grade corn from 2004, 2005, and 2006 crop years). Additional samples were obtained from seed companies, processors and other collaborators. During the summer of 2006, twelve specialty hybrids (waxy, high oil, highly fermentable, high lysine) were grown at the Purdue Agronomy Center for Research and Education. Ears from each of the plots were harvested and shelled by hand. There are currently more than 100 hybrid samples available for evaluation. The small kernels have been removed from these samples using a round hole sieve (18/64" diameter holes) and the samples are being conditioned to 14% moisture. Once conditioning is completed, flat kernels will be separated from the round kernels using a slotted sieve (13/64" wide by 3/4" long).

Moisture content, kernel and bulk density measurements have been conducted on some of the corn hybrids collected during 2004 and 2005. Results are shown in Table 1. Note that these samples were not conditioned to uniform moisture content prior to evaluation.

Table 1. Average values of bulk and kernel density for classes of hybrids grown during the 2004 or 2005 crop season.

Hybrid class	% Moisture content (range)	Number of hybrids averaged	Average Kernel density (g/cm ³) and std. dev.	Average Bulk density (kg/m ³) and std. dev.
White Corn Hybrids	9.5-11.5%	9	1.245 ± 0.03	805.8 ± 13.6
Yellow Food Corn Hybrids	9.8-11.2%	4	1.229 ± 0.04	794.2 ± 31.4
Yellow “Regular” Hybrids	10.0-11.5%	19	1.211 ± 0.03	783.4 ± 21.7

Therefore the moisture is low and there are differences in moisture content of up to 2 percentage points among the samples. Nevertheless, the trends are consistent with expectations. The white corn hybrids, which are usually selected for hardness during breeding programs, had the highest average kernel and bulk densities, while “regular” yellow hybrids had the lowest averages.

Once the samples have been conditioned and rounds kernels have been removed, the density tests will be repeated and the following additional measurements will be made: pericarp thickness, kernel hardness, kernel size and shape, germ to endosperm ratio, color as a proxy for carotenoid content, and chemical composition (hardness, oil, protein, starch, fiber and ratio of amylose to amylopectin).

Three of the hybrids grown on the Purdue plots were dried in the laboratory using a thin layer dryer. These samples will be evaluated for the purpose of determining the effects of drying temperature on kernel physical properties along with chemical composition and water absorption rate. In addition, the viability of the embryos of these kernels will be determined and they will be used for evaluating whether single kernel NIR measurements can be used for assessing seed viability.

Plans for 2007

We will continue to develop and standardize our procedures for measurement of water absorption rate, pericarp thickness, and germ to endosperm ratio. We will conduct measurements on many, if not all, of the hybrid samples that have been collected. Results will be summarized and reported and also used for selecting hybrids that will be grown during 2007.

Issues

New corn hybrids are continually being introduced and then phased out within 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. It seems likely the diversity in corn hybrid properties has increased. This study will help to determine the extent of variations in some of the physical and chemical properties of current hybrids.

What Was Done

The project was begun in June of 2006 and initial efforts have focused on growing hybrids or obtaining hybrid samples from various sources and then preparing the samples for evaluation, as described above. Preliminary results for kernel density and bulk density of some of the hybrids grown during 2004 and 2005 have been reported above.

Impacts

Quantification of kernel properties will document the variations in these properties that have developed and should facilitate assessment of whether these differences could have an impact upon certain aspects of processing. It may also identify hybrids with specific traits that are particularly desirable for specific end uses. Finally, it should provide information that could help seed corn companies develop hybrids with desirable traits. The tests with samples dried with air at higher temperatures will help to elucidate the effect of high temperature drying on kernel characteristics.

NC-213 Objective 2

Title

Trapping as a means of monitoring stored product insects in buildings.

Project Objectives

To develop trapping and contour analysis of trap catch as a method for monitoring stored product insect pests in warehouses, processing plants, and retail stores, and for locating foci of infestation or points of entry.

From

Center for Medical, Agricultural and Veterinary Entomology
USDA, Agricultural Research Service
Gainesville, Florida

By

Arbogast, R.T.*
Chini, S.R.

Results for 2006

Investigation of trapping as a means of monitoring stored product insects in buildings continued with further study of trap efficiency using red flour beetles. The traps used were Trécé Dome traps, baited with red flour beetle pheromone and an attractant food oil. An array of 14 traps was set up in a 3.2 x 9.0-m shed, and 500 pupae were placed in a pan containing a small amount of flour. The pan was placed at the center of the shed and the number of insects captured in each trap was determined at daily intervals. The source of insects at the center of the shed was equidistant from the two closest traps, which captured the most insects, but one has consistently captured more than the other. The experiment is still in progress.

Plans for 2007

Trap efficiency and numbers of insects dispersing from a source will be investigated further with emphasis on the environmental factors that influence efficiency and contour pattern.

Publications and Presentations

Arbogast, R.T., Chini, S.R. and McGovern, J.E. 2006. Use of contour analysis in monitoring stored-product insects. *J. Econ. Entomol.* 99 (3): 601-603.

What Was Done

Trapping experiments were done in an attempt to estimate the efficiency of a particular type of pitfall trap and the effectiveness of contour analysis in locating foci of red flour beetle infestations. The red flour beetle was selected for research because of its importance as a pest of flour mills and other food processing plants.

Impacts

The use of contour analysis in mapping trap catch to locate foci of infestation in buildings has proven effective, although anomalous results occasionally occur. Contour maps of trap catch have proven to be powerful tools for communicating insect problems to management, maintenance, and sanitation personnel, and its use by pest control companies is increasing.

Funding Sources

USDA, Agricultural Research Service

Contacts

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NC-213 Objective 2

Title

Improved handling and storage systems for grain quality maintenance and measurement.

Project Objectives

Develop and evaluate automatic grain aeration control strategies for maintaining grain quality and controlling insects during storage.

From

Grain Marketing and Production Research Center
Engineering Research Unit, Biological Research Unit
USDA, Manhattan, Kansas

By

Casada, M.E.
Arthur, F.H.
Armstrong, P.R.

Results for 2006

Summer aeration of stored wheat in the hard red winter wheat belt: It is difficult to aerate wheat immediately after harvest as part of an integrated pest management (IPM) strategy in much of the hard red winter (HRW) wheat belt due to high ambient temperature as well as high nighttime relative humidity. The high ambient temperatures are well known, but the complicating effect of high humidity has not been well documented. Using 50 years of historical weather data, we developed maps showing contours of average hours when summer aeration is effective after accounting for the complicating effect of high humidity. The actual hours available for effective grain cooling were reduced by an average of 68% for 12% moisture content wheat and by 88% for 10% moisture content wheat compared to the hours suggested by ambient temperatures when neglecting the humidity effect. These results indicate that previously published design data suggested fan sizes less than one-half that actually needed for effective summer aeration. These maps allow engineers to properly design aeration systems with correct fan sizes for summer aeration and clarify where the climate makes summer aeration impractical.

Our previous research has shown that heat treatments are effective as a non-chemical method for disinfestation of empty grain storage bins. We developed an empirical economic risk model to compare variable costs for five tested heating systems for disinfestation of empty, 5000 bu grain storage bins with fitted drying floors. The high-output, 29 kW, propane heating system had the lowest cost and risk level of all heating systems and achieved the target temperature of 50°C within 2 hours at all test locations. Lower power systems requiring complex heat distribution or recirculation were not cost effective and exhibited higher risk levels of insect survival. These results indicate that properly-sized portable propane heat treatment systems are equal to chemical applications for low-cost, low-risk disinfestation of empty bins, but without the concerns that arise with using chemicals.

Monitoring Moisture Content of Stored Grain: Grain temperature and moisture content (MC) are fundamentally important for safe grain storage. Temperature monitoring of grain is relatively easy, but there are no commercially available sensors for directly monitoring MC. Relative humidity (RH), however, can be an indirect way to measure MC by measuring the RH of the air surrounding the grain. The air RH comes into equilibrium with the grain depending on the grain MC and temperature (T). MC can thus be predicted from equations that are experimentally

derived and use RH and T. Unfortunately these equations are not perfect and, thus, have inherent equation error in addition to the error of the RH and T sensing. This research found that RH and T sensor error did not influence grain MC prediction as greatly as the equation error. With development of better equations, accuracy could be increased for grain moisture content monitoring in bins.

Plans for 2007

Revise basic procedures and recommendations for IP handling operations in the decision support system and obtain additional data. Begin development of 2-d particle model for grain commingling. Complete third year of aeration field trials and complete the simple physical model. Develop calibration for moisture sensor in wheat and evaluate use of the sensor for deep bin moisture monitoring.

Publications and Presentations

Akdogan, H., and M.E. Casada. 2006. Climatic humidity effects on controlled summer aeration in the hard red winter wheat belt. *Transactions of the ASABE*. 49(4): 1077–1087.

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Gonzales, H., P.R. Armstrong, and R.G. Maghirang. 2006. Monitoring Grain Storage with Relative Humidity, Temperature, and Carbon Dioxide Sensors. Presented at ASAE Annual International Meeting, July 9-12, Portland, Ore.

Tilley, D.R., M.E. Casada, and F.H Arthur. 2006. Heat treatment for disinfestation of empty grain storage bins. *Journal of Stored Product Research*. In press.

Tilley, D.R., M.R. Langemeier, M.E. Casada, and F.H. Arthur. Cost and risk analysis of heat and chemical treatments. *Journal of Economic Entomology*. In press.

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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 leading to continued 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. With typical grain losses of 5 to 10% to stored grain insects, total losses in the U.S. exceed \$1 billion.

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. With development of better equations, the T and RH based sensors can provide increased accuracy for grain moisture content monitoring in bins and help prevent moisture-related grain quality losses during storage.

Funding Sources

Horizon Technology, Inc., Grain Industry Alliance, USDA-CSREES-PMAP

Contacts

Strong collaborations are maintained for this project, including the following:

USDA-ARS-Biological Research Unit for projects with stored grain aeration and heat treatments

Kansas State University, Biological and Agricultural Engineering Department for IP grain handling project

Kansas State University, Grain Science and Industry Department for heat treatment project

Oklahoma State University, Entomology Department for heat treatment project

Objective 3

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

NC-213 Objective 3

Title

Outreach programs for supply-chain agriculture.

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. The basis and impact of supply-chain based agriculture will be developed. 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.

Operate quality analysis testing/instrument calibration services to support research and marketing activities. Achieve ISO 17025 certification with related statistical control of data management.

From

Department of Agricultural and Biosystems Engineering
Value-Added Agriculture Program
Iowa State University

By

Hurburgh, Jr., C.R.
Hardy, C.L.
Shepherd, H.
Suryatmaadja, M.
Rippke, G.R.

Results for 2006

The rapid expansion of Iowa's ethanol industry has changed corn distribution patterns to support more local processing. As more corn is used locally in fuel production, less is available for export, feed applications, and other processing. This has led to changes in grain transport, on-farm grain storage, and the function of local grain elevators. Interviews with representatives of twenty Iowa ethanol plants revealed information about sourcing corn, processing capacity, corn storage capacity, corn quality specifications, truck and rail access, and co-product storage capacity and marketing. At this time, twenty-three dry grind plants and four wet mills are expected to produce 1.5 billion gallons of ethanol in Iowa in 2006. Ten new dry grind plants, one new wet mill plant, and six expansions are under construction. In addition, dry grind plants immediately across Iowa's borders draw corn from Iowa farms. The current plants and those under construction will use 1.61 billion bushels of corn annually. Thirty-three new plants or expansions have been announced. If all announced facilities are built and operating at capacity by 2010, fuel ethanol production of 7.5 billion gallons per year in and near Iowa would consume 2.68 billion bushels of corn. Construction of all announced plants would be an aggressive projection dependent on continued favorable economic conditions; this report does not evaluate the likelihood of their construction.

Dry-grind ethanol plants also produce distillers grains feed products (DGS) in various forms. Iowa ethanol plants currently produce about 4.3 million tons of DGS, which could grow to 22.5 million tons if all announced ethanol plants come online. Distillers grains can substitute for other ingredients in cattle rations (up to 50% of ration), and can also be used in swine and poultry rations at a lower rate (up to 10%.) Ethanol plants located close to cattle feedlots are able to save energy costs by selling wet distillers grains, but on average only 25% (range 6% - 100%) of

distillers grains is sold wet at an average of 56% moisture (range 50% - 65%). Nearly 60% (range 0% - 93%) of DGS is shipped by rail to users outside of Iowa and is shipped as dried distiller's grains.

Ethanol plant managers recognized that new plants and existing livestock markets would compete for corn. Sixty-two percent (range 5% - 100%) of the corn currently used by ethanol plants is purchased directly from farmers. Operators expressed a desire to source corn directly from farmers. However, most had absolute limits (typical 18% moisture, 10% damage) on acceptable quality, unlike the general acceptance policies of traditional elevators. Stored grain quality will need to be maintained more closely, over a longer period, than current markets require.

Plants had onsite storage for about 5% (range 2% - 12%) of annual corn use and 2.5% (range 1.6% - 4.7%) of annual distillers' grains production, which makes consistent logistics a major need. Some expressed concern about adequate rail service for both ethanol and distillers grains. The need for ongoing training for current and future ethanol plant workers was stressed by managers, pointing to Iowa's regents universities, community colleges, and Extension to take this responsibility.

The Iowa State University Grain Quality Laboratory (ISU-GQL) provides instrument calibration and measurement services for composition of agricultural products. ISU-GQL is pursuing ISO 17025 accreditation which require lab to have a quality control program. The NIRS quality control program includes data from NIRS daily check, duplicate differences, and NIRS comparison to references. The activities include setting tolerances, developing appropriate control charts, handling and documenting data, writing Standard Operating Procedures (SOP) of quality control activities, and implementing quality control program. The tolerance setting of NIRS based on the Standard Error of Prediction (SEP) as described in AACC Method 39-00 appears to give better control than traditional shewhart control charts. Supporting equipment quality control improved the consistency of data generated by the lab.

A quality control program for calibration for calibration was also developed. The reference data consists of internally generated tests (oven moisture and corn density) and externally outsourced tests (proximate analysis, amino acids and fatty acids). The quality control activities included setting tolerances, developing appropriate control charts, handling and documenting data, writing Standard Operating Procedures (SOP) of quality control activities, and implementing quality control program. The tolerance setting detected the consistency (or lack thereof) of reference data generated by ISU-GQL and external laboratories.

Plans for 2007

Develop grain storage and management training module for IGQI website. Producers will be the target audience. Commercial grain handlers are encouraged to participate in the GEAPS-Purdue distance education program.

Develop example supply chain and logistics management strategies for allocation of now-scarce grain supply to best end use at its best time.

Complete the laboratory qms process and identify its costs/benefits.

Publications and Presentations

Suryatmaadja, M. and C.R. Hurburgh, Jr. 2006. Ongoing Quality Control Program for NIRS-based Service and Research Laboratory. World Grains Summits: Foods and Beverages. American Association of Cereal Chemistry. Annual meeting, San Francisco, CA. October 17-20, 2006.

Hardy, C. and C.R. Hurburgh, Jr. 2006. Sourcing Iowa Corn for Ethanol: Impacts of Increased Local Processing. Proc. Integrated Crop Management Conference, Agribusiness Education Program, Iowa State University, Ames, IA. November 30, 2006

Hardy, C., M.S. Holz-Clause, H.E. Shepherd and C.R. Hurburgh, Jr. 2006. Sourcing Corn for Ethanol: Impacts of Local Processing. Report of Iowa Grain Quality Initiative. November 2006. www.iowagrains.org

Issues

The rapid increase of local processing demand has, within a year, created a scarcity of grain. Processors want to purchase from farmers, but have rigid quality requirements that must be met even after months of storage. Iowa will need 500-750 million new bushels of storage by 2008.

Processing plants operate best when their inputs are consistent in all ways. Lack of consistency in grain inputs is now being shown by variable DGS quality (corn) or variable meal quality (soybeans). Achieving consistency and high throughput without incurring the costs of identity preservation will require new management principles.

Impacts

Based on the results of the ethanol study, new Iowa State Extension efforts in grain storage training, and in supply chain evaluation were started. Programs will be operational in 2007.

Plants could increase ethanol output by about 0.1 gal/bu if inputs were more consistent. For a 100 MM gal/yr plant, this would be 4,000,000 more gallons of ethanol or about \$8 million per year. DGS quality would be more consistent as well.

Contacts

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NC-213 Objective 3

Title

Assessing the susceptibility of shelled corn to invasion by storage fungi.

Project Objectives

The overall objective of this project is to identify methods of measuring the susceptibility of shelled corn to invasion by storage fungi. The specific objectives are: (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.

From

Agricultural and Biological Engineering
Purdue University

Grain and Marketing and Production Research Center
USDA, Agricultural Research Service
Manhattan, Kansas

Agricultural Engineering
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By

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Moog, D.J.P.
Woloshuk, C.P.

Seitz, L.M.

Paulsen, M.R.

Results for 2006

Over the past four years, approximately 90 samples of shelled corn, obtained from a variety of sources, have been evaluated. The samples were tested for the following: ergosterol level, percent kernel infection, damage index, percent fine material (16/64 and 12/64 inch round-hole sieves), electrolyte leakage, NIR (reflectance, Fourier Transform-NIR), and CO₂ evolution using a test kit. The tests are described in the 2003 report, Moog et al. (2004), and Moog (2006). Table 1 gives the range, mean and standard deviation of the measurements. The characteristics of the samples were diverse. The mean value of ergosterol was only 2.18 ppm, while the upper limit was 12.5 ppm, indicating abundant mold growth in some samples. The germs or entire kernels of the samples with high ergosterol were usually discolored, and there was often visible mold growth on the kernels. A relatively high ergosterol level in several samples stored for only a short period of time can be attributed to ergosterol production prior to storage by field fungi. The mean percentage of the kernels infected by osmophilic storage fungi was 33%, indicating at least some of the kernels in most samples had been invaded. The average percent germination, 53%, was relatively low since many of the samples were from corn stored at least several years and/or corn dried in a high temperature dryer. The average damage index (DI) was 23.6 and it varied from 12 for hand shelled corn to 39.2 for a sample of white corn obtained from a Kansas grain elevator. The sample with a DI of 32 also had the highest percentage of fine material passing through the two sieves (12/64" [continued after Table #1]

Table 1. Mean values and ranges of the various measurements conducted on the samples. The number “n” is the number of samples on which the measurements were made.

Factor	N	Minimum	Maximum	Mean	Std. Dev.	C.V
Ergosterol Level (ppm)	94	0.04	12.54	2.18	2.54	1.116
% Kernel Infection	93 [^]	0.0	100.0	35.33	26.10	0.739
% Germination	94	0.0	99.0	52.72	34.07	0.646
Damage Index	91 [^]	12.0	39.2	23.6	5.03	0.312
% pass through 16/64” sieve	91 [^]	0.0	7.6	2.03	1.24	0.618
% pass through 12/64” sieve	91 [^]	0.0	5.17	1.14	0.81	0.716
Electrolyte Leakage(10min)	91 [^]	32.7	103.3	59.86	14.18	0.237
Electrolyte Leakage(15min)	91 [^]	36.8	122.2	67.32	16.82	0.250
CO ₂ Paddle readings:						
Slope 48-51 hr	51 ^{^^}	0.48	1.45	0.84	0.25	0.300
Slope 48-52 hr	51 ^{^^}	0.43	1.30	0.83	0.25	0.300
51 st hour reading	51 ^{^^}	1.25	4.25	2.43	0.77	0.317
52 nd hour reading	51 ^{^^}	1.50	4.83	3.21	0.98	0.306
Slope 72-75 hr	51 ^{^^}	0.40	1.65	0.88	0.31	0.351
Slope 72-76 hr	51 ^{^^}	0.40	1.40	0.87	0.29	0.330
74 th hour reading	51 ^{^^}	1.00	2.50	1.65	0.50	0.301
75 th hour reading	51 ^{^^}	1.00	5.00	2.59	0.98	0.378

[^] 93 or 91 samples were tested because some were small and was not enough corn was available.

^{^^} 51 of 91 samples, those with moistures within $\pm 0.5\%$ of the target m.c., were used for comparisons.

[continued from previous page] and 12/64”). Electrolyte leakage, a measure of cell integrity within the kernels, also varied widely from 36.8 to 103.3 mS/m (15 minute reading).

It was assumed that fungal growth on re-wetted samples of shelled corn was a good indicator of susceptibility of the corn to invasion by fungi during storage. The difference in ergosterol before and after the CO₂ kit test was conducted on the re-wetted shelled corn was selected as the best measure of fungal growth. The CO₂ kit readings were significantly ($P > 0.001$) correlated with difference in ergosterol ($0.439 < r^2 < 0.570$) and the highest correlation was for the CO₂ kit color number reading 75 hours after re-wetting. Correlations among the various attributes in Table 1 are given in Moog (2006).

A stepwise regression analysis was performed to determine which of the following attributes, that can be measured in 15 minutes or less, was best correlated with the difference in ergosterol vales: initial ergosterol (NIR), percent fines (12/64” sieve), percent fines (16/64” sieve), and electrolyte leakage (after removal of fines with a 12/64” sieve). It was assumed that the initial ergosterol could be accurately determined using NIR analysis, for the purpose of determining NIR’s maximum potential as an indicator of fungal susceptibility. After each analysis, the test that had the highest alpha value was removed and the analysis was repeated. When all of the tests were used, the value of R² was 0.500. However, the contributions of only two of the tests, initial ergosterol and electrolyte leakage, were statistically significant and at this point R² had decreased to 0.417. These results suggest that a rapid measurement of initial ergosterol using the NIR equipment could be used, if it were accurate, in combination with an electrolyte leakage test to screen samples for fungal susceptibility. Once samples with potentially high susceptibility have been identified, the fungal susceptibility of those samples could be more precisely determined using the three day CO₂ Kit test. It should be noted that NIR (continued after Figure 1)

Table 4.21. Coefficient of determination of selected hourly paddle readings at different temperatures and moisture contents (n=12).

Temperature & moisture	Time of reading(hr)	Temperature & moisture (time, hr) ^{^^}			
		16% 24°C	21% 24°C	16% 30°C	21% 30°C
SAME DAY CORRELATIONS					
21% 24°C	51 st hr	0.973*(56 th hr)		0.815* (50 th hr)	0.491* (49 th hr)
	75 th hr	0.954*(77 th hr)		0.512* (74 th hr)	0.679* (74 th hr)
16% 24°C	55 th hr		0.981*(52 nd hr)	0.887* (50 th hr)	0.404* (49 th hr)
	75 th hr		0.914* (74 th hr)	0.720* (74 th hr)	0.627* (74 th hr)
21% 30°C	49 th hr	0.576* (50 th hr)	0.671* (49 th hr)	0.518* (53 rd hr)	
	78 th hr	0.155* (76 th hr)	0.050 (79 th hr)	0.144 (76 th hr)	
16% 30°C	54 th hr	0.867* (55 th hr)	0.470* (49 th hr)		0.470* (49 th hr)
	74 th hr	0.720* (75 th hr)	0.479* (76 th hr)		0.479* (76 th hr)
CORRELATIONS OF DAY 2 VS DAY 3 READINGS					
21% 24C**	50 th hr	0.931* (79 th hr)		0.538* (76 th hr)	
21% 30C**	51 st hr	0.375* (79 th hr)		0.467* (73 rd hr)	

Note: * statistically significant at $\alpha=0.05$
^{^^} time selected with highest r^2 value

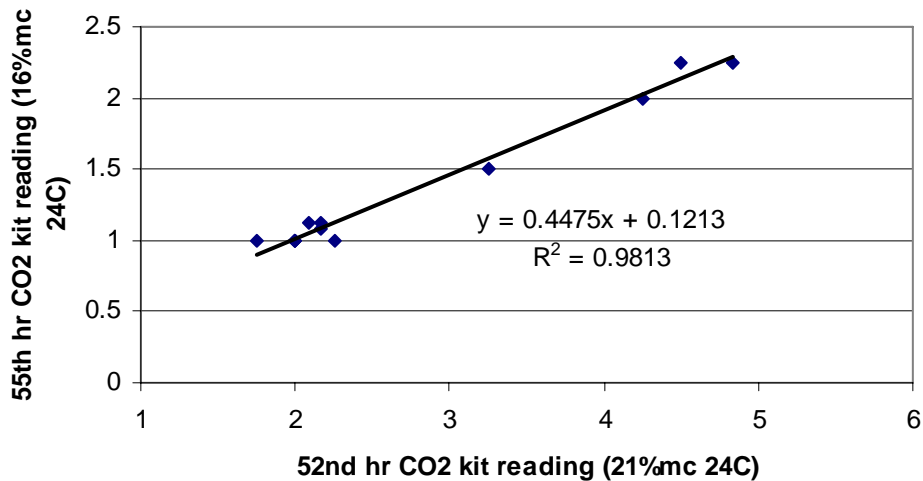


Figure 1. 52nd hr CO₂ kit reading at 21%& 24°C mc vs 55th hr reading at 16% mc & 24°C

[continuation from previous page] determination of ergosterol is not precise. For the samples on which CO₂ kit tests were conducted, it was estimated that prediction of ergosterol using either NIR or FT-NIR should be possible with a standard error of about 1.05 to 1.3 ppm.

During the fall of 2005 and in 2006, the effects of incubation temperature and moisture on CO₂ kit results were investigated. These two factors can affect the kinds of fungi that will grow on samples. Tests were conducted at two different moistures and temperatures and hourly readings from the CO₂ kit were compared using linear regression.

Tests with the highest r^2 values are summarized in Table 3. The strongest correlation was for tests conducted at 24°C, between the 52nd hr reading at 21% m.c. the 55th hr reading at 16% m.c. and 24°C ($r^2 = 0.98$; see Figure 1). Fungal analyses indicated differences in the numbers and kinds of fungi that grew at the different incubation conditions. Nevertheless, the results obtained at the various temperatures and moistures are, to varying degrees, correlated. Differences among samples emerge more slowly at the lower moisture. For example, the 50th hour reading at 21% and 24°C was well correlated with the 79th hour reading at 16% and 24°C ($r^2 = 0.93$). The best approach may be to select the time and temperature at which the CO₂ kit is conducted on the basis of the conditions to which the corn will be subjected in the future (e.g. storage in a temperate versus a tropical climate).

Plans for 2007

Manuscripts summarizing the research are being prepared for submission to journals. As a means of progressing towards the goal of making the test available to the grain industry, Titus Grain Testing (W. Lafayette, IN) will use of the CO₂ kit to evaluate samples from commercial facilities. When possible, these samples will also be evaluated at Purdue.

Publications and Presentations

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

Issues

When shelled corn is placed in storage at grain elevators and processing facilities, there is usually very little information on duration and conditions of previous storage. Managers 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

A series of quality tests that measure factors affecting storability were conducted and correlations among the test results were determined. The CO₂ kit results were well correlated with the standard measure of mold growth, difference in ergosterol content before and after incubation at 21% moisture content. The temperature and moisture content of the CO₂ kit test can be adjusted to suit the type of storage condition to which the corn will be exposed. Among the rapid quality tests, electrolyte leakage in combination with initial ergosterol was the best indicator of fungal susceptibility.

Impacts

Managers of facilities where shelled corn is being stored could use rapid tests (<15 min) for initial screening for fungal susceptibility. The 3-day CO₂ test kit results could then be used to more accurately determine the risk of spoilage during continued storage or shipment to tropical climates where conditions are more conducive to fungal growth.

NC-213 Objective 3

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.

From

Grain Marketing and Production Research Center
USDA, Agricultural Research Service
Manhattan, Kansas

By

Bean, S.R.

Results for 2006

The quality of wheat-free sorghum bread was improved through the use of sourdough fermentation and addition of enzymes and additional gums. Relationships between protein, fiber, and starch chemistry on fermentation of cereal grains were determined. Improved methods for the extraction and analysis of ergosterol in sorghum were developed.

Plans for 2007

Continue research on improving the quality of wheat-free sorghum bread. Research on the role of protein cross-linking on grain hardness and ethanol fermentation in sorghum will be conducted. Improved methods for extracting and analyzing cross-linked proteins in sorghum will be developed.

Publications and Presentations

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Wu, X., Wang, D., Bean, S.R., and Wilson, J.P. 2006. Ethanol production from pearl millet using *Saccharomyces cerevisiae*. *Cereal Chem.* 83:127-131.

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- Higiro, J., Herald, T.J., Alavi, S., and Bean, S.R. 2006. Rheological study of xanthan and locust bean gum interaction in dilute solution: Effect of salt. *Food Chem. (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

Improved methods for analyzing ergosterol were developed. Wheat-free sorghum bread quality was improved. Effects of protein, starch, and fiber contents on ethanol production were investigated.

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.

NC-213 Objective 3

Title

Objective 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.

Summary

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. Also, a method was developed 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. An NIR system was developed that is 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 other are listed below.

From

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By

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Results for 2006

Applications developed for the automated NIR sorting technology commercialized through a CRADA with Perten Instruments in Stockholm, Sweden. The system was demonstrated at several international conferences and is being publicly marketed. The system automatically scans individual wheat kernels, and then sorts kernels based on specific attributes such as protein content, hardness, amylose content, etc. The system is now being used by breeders to select specific traits from early generation breeder samples. This will significantly reduce the time and expense required to develop cultivars with specific end-use traits. The system is also being evaluated for use in detecting food safety attributes such as vomitoxin during routine grading. Although it was developed for wheat, it is also finding applications in sorghum and millet.

Fast Single-Kernel NIR Measurement of Grain and Oil-Seed Attributes. Fast single kernel analysis using near-infrared spectroscopy (SKNIR) can significantly improve many areas where single kernel analysis is presently used, such as in grain and oil-seed breeding programs. Current rates of SKNIR systems are around 1 kernel/s. For this work, instrumentation was designed and tested on corn and soybeans at rate of 10 kernels/s. The design allows measurement of kernels in near free-fall conditions to realize the faster rate. Results show the instrument worked well for predicting corn and soybean moisture and soybean protein. Future work will focus on the mechanical feeding and sorting of kernels and methods to bring corn measurement accuracy to the level of soybean measurements.

Rapid Methods for Predicting Grain, Flour, and End-Use Quality. Eight quality variables that can be measured rapidly were chosen for predicting various bread making quality parameters (bake water absorption, bake mix time,

proof height, loaf weight, crumb score, and loaf volume, and loaf volume regression) of hard red winter (HRW) and hard red spring (HRS) wheat samples. The variables used in the predictions were: test weight; average hardness, weight, length, and diameter as measured by the SKCS 4100; and protein content, mixograph water absorption, and average total wet gluten as measured by near-infrared spectroscopy. Based on the eight-variable model obtained separately for HRW and HRS wheat, loaf volume and loaf specific volume can be predicted with a model R² greater than 0.80; bake water absorption, bake mix time, and proof height with R² ranging from 0.58 to 0.78; loaf weight, crumb score and loaf volume regression can be predicted only with R² ranging from 0.27 to 0.39. For loaf volume and loaf specific volume, which has the highest potential of being predicted using rapid measurement techniques, the single highest partial R² that accounted for 98% of the model R² of both HRW and HRS wheat was flour protein content. Additionally, flour protein content was a significant variable for predicting bake mix time, loaf weight, and loaf volume regression for HRW wheat and bake water absorption and bake mix time for HRS wheat.

Detecting Durum Wheat Quality. Durum wheat production accounts for approximately 8% of the wheat production worldwide, and is mainly used to make semolina for macaroni, spaghetti, and other pasta products. The best durum wheat for pasta products should appear hard, glassy and translucent, and have excellent amber color, good cooking quality, and high protein content. Nonvitreous (starchy) kernels are opaque and softer, and result in decreased yield of coarse semolina. Thus, vitreousness of durum wheat has been used as one of the major quality attributes in grading. Traditionally, grain grading has been primarily done by visual inspection by trained personnel. This method is subjective and tedious. It also produces great variations in inspection results between inspectors. We used digital imaging technology for determining durum vitreousness. Results showed that 100% of non-vitreous kernels and 92.6% of mottled kernels, which is one of the hardest defect categories to consistently detect visually, could be correctly classed.

Improving the Quality of White Wheat through Rapid Sorting. White wheat is gaining acceptance throughout the Midwest as a class that can improve our competitiveness in export markets. All breeding programs in the Midwest are developing white wheat cultivars. We are able to improve the quality of white wheat cultivars being used in breeding programs by removing wheat of other classes, such as red wheat, from samples using high speed sorting procedures developed through an agreement with Satake, Inc. There is no other technology available to remove these contaminating kernels. Almost all white wheat being developed in the Midwest and Pacific Northwest is now shipped to our research unit for purification through our sorter. Our sorting has reduced the development time for these new cultivars by several years, has saved the breeders hundreds of hours, and has salvaged some cultivars that would have been terminated if our technology was not available.

Reducing mycotoxins in corn. A high-speed single-kernel sorter was used to remove mycotoxins from white corn. It was found that using spectral absorbance at 500nm and 1200nm could distinguish kernels with aflatoxin-contamination. When these two spectral bands were applied to sorting corn at high speeds, reductions in fumonisin averaged 82% for corn samples with an initial level of aflatoxin over 10 ppb. Most of the fumonisin is removed by rejecting approximately 5% of the grain. This technology will help insure the safety of the US food and feed supply.

Detecting insect fragments in flour. Primary pests of stored cereals that develop and feed inside grain kernels are the main source of insect fragments in wheat flour. The Food and Drug Administration (FDA) has set a defect action level of 75 or more insect fragments per 50 gram of flour. The current standard flotation method for detecting insect fragments in flour is very labor intensive and expensive. We investigated the potential of near-infrared spectroscopy (NIRS) to detect insect fragments in wheat flour at the FDA defect action level. Fragments counts with both the NIRS and the standard flotation methods correlated well with the actual number of fragments present in flour samples. However, the flotation method was more sensitive below the FDA defect action level than the NIRS method. Although the flotation method is very sensitive at the FDA action level, this technique is time consuming (almost 2 h/sample) and expensive. Although NIRS currently lacks the sensitivity of the flotation method, it is rapid, does not require sample preparation, and could be easily automated for a more sophisticated sampling protocol for large flour bulks. Therefore, this method should be reexamined in the future because NIRS technology is rapidly improving.

Properties of Corn Kernels Infected by Fungi. Near infrared spectra, x-ray images, color images, near infrared images, and physical properties of single corn kernels were studied to determine if combinations of these measurements could distinguish fungal infected kernels from non-infested kernels. Kernels used in this study were inoculated in the field with eight different fungi: *Acremonium zeae*, *Aspergillus flavus*, *Aspergillus niger*, *Diplodia*

maydis, *Fusarium graminearum*, *Fusarium verticillioides*, and *Penicillium* spp. *Trichoderma viride*. Results indicate that kernels infected with *Acremonium zeae* and *Penicillium* were difficult to distinguish from non-infested kernels while all of the other severely infected kernels could be distinguished with greater than 91% accuracy. A neural network was also trained to identify infecting mold species with good accuracy, based on the near infrared spectra. These results indicate that this technology can potentially be used to separate fungal infected corn using high speed sorter; and, automatically and rapidly identify the fungal species of infested corn kernels. This will be of assistance to breeders developing fungal resistant hybrids as well as mycologists studying fungal infected corn.

Relation of single wheat kernel particle size distribution to Perten SKCS 4100 hardness index. Material from single kernels crushed on the SKCS 4100 was collected and milled in a fabricated mill, which simulates the last two rolls of a Quadramat Jr. The PSD of each single kernel was then measured using a laser particle counter. It was found that the difference between the maximum and minimum slope of the PSD below 55 μm could distinguish most of the hard and soft kernels. These slopes correspond to a peak in the PSD between 20 to 30 μm . Particle size distributions from soft kernels normally have a peak in this particle size range while hard kernels have a small, or no, peak. SKCS low level data, as well as the raw crush profile, were analyzed to find a correlation with this slope. After stepwise selection, HI, and three normalized crush profile values were used to predict the PSD slope. The predicted slope correctly classified 95% of the hard and soft kernels. These results indicate that a calibration for the SKCS based on single kernel particle size is possible and this may give a better indication of end use quality of a wheat sample.

Low-cost bi-chromatic image sorting device for grains. A low-cost linescan imaging system was developed to inspect and sort grains and other products at high speeds (40 kernels/s). The device captures bi-chromatic images from opposite sides of each kernel and processes the images in real time using high speed microcontrollers. Detection of scab-damaged wheat kernels was used in this study to establish system feasibility and limits. Simple image statistics and intensity histograms were used as features and were able to distinguish good kernels from scab-damaged kernels with 95% accuracy. For each kernel, image acquisition required approximately 15 ms, while 5 ms were required for image processing and classification. The controller can output a signal to divert (sort) kernels or save the images on a compact flash card for transfer to a personal computer for off-line analysis. All parts for the system cost less than \$2000.

Camera attachment for automatic measurement of single-wheat kernel size on a Perten SKCS 4100. Wheat kernel size any shape is an important quality factor and characteristic for adjusting milling processes. Measuring kernel size is tedious and time consuming so it cannot be done as often as some wheat millers would like. Automated machines for measuring kernel size suffer from inaccuracies and/or high cost. The Perten Single Kernel Characterization System (SKCS 4100) is an automated instrument which measures several single kernel quality characteristics such as weight, moisture content, hardness, and diameter. Of all of these measurements, the diameter measurement is the least accurate. A low cost color camera was attached to an SKCS 4100 to enable more accurate kernel size determinations. Using image data combined with SKCS data, errors in estimating kernel length and diameter were reduced by 56% and 66%, respectively.

Detection of damaged wheat kernels by impact-acoustic emissions. A system was built that is able to distinguish good wheat kernels from a variety of damaged kernels by dropping kernels, one at a time, onto a steel plate and digitally analyzing the resulting sounds from the impact. The types of damage studied were insect damaged kernels with exit holes, hidden insect damaged kernels without exit holes, sprout damage, and scab damage. It was found that 98% of the good kernels and 87% of the insect damaged kernels with exit tunnels can be distinguished from each other. Accuracy for scab and sprout damaged kernels was 70% and 45% for hidden insect damaged kernels. The device should be capable of inspection rates exceeding 40 kernels/s, or $\sim 70\text{g}/\text{min}$. It is non-destructive and can be made to sort kernels into one of three different groups. This technology should help grain inspectors and millers better ascertain the quality of a wheat load under consideration.

Applying NIR sorting technology to other disciplines. The NIR spectroscopy procedures developed for determining single kernel attributes were found to apply to determining characteristics of single insects and other commodities. Thus, we applied NIR spectroscopy to detecting insect parasitoids, insect species, insect age grading, and fig quality in cooperation with the Biological Research Unit, ARS USDA, Manhattan, KS; the Dept. Entomology at KSU, Manhattan, KS; the CDC, Atlanta, GA; and the Horticultural Crops Research Laboratory, Fresno, CA. Results showed we could detect parasitized weevils and flies, fly and mosquito age, stored grain insect

species, and fig quality using NIR spectroscopy. This information can be used to develop control strategies for various pest insects and to automate fig grading.

Plans for 2007

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 relating single wheat kernel particle size distributions to SKCS 4100 measurements.

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Impacts

This project is in position to make a major contribution to breeding programs by speeding up the development of grain varieties by increased sorting. In addition to using commercial high speed sorting machines that operate on the basis of one or two wavelength of light, this group has developed automated sorter that utilize full NIR spectra and images to select grain traits. Some of these devices are commercially available and operate at approximately 30 kernels/minute. We also have prototypes of image and spectral based sorters that have throughputs over 600 kernels/minute.

Funding Sources

Federal Grain Inspection Service for a study to investigate prediction of end use qualities from whole grain wheat samples.

Federal Grain Inspection Service for a study to investigate the relation between single kernel particle size and Perten Single Kernel Characterization System (SKCS) measurements.

Contacts

Strong collaborations are maintained for these projects and others. Below is a list of some of the collaborations:

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

NC-213 Objective 3

Title

Hard winter wheat progenies research.

Project Objectives

Evaluate kernel characteristics, milling properties, and dough and bread-, tortilla- and Asian alkaline noodle-making properties of hard winter wheat progenies. Determine protein and lipid contents, and composition and interaction among these components of cereal grains as they relate to storage, handling, and end-use properties.

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Results for 2006

The Hard Winter Wheat Quality Laboratory (HWWQL) continues to evaluate end-use intrinsic quality parameters of hard winter wheat lines from 14 federal, state, and private nurseries. Data were sent to breeders electronically, followed by written report upon special request. For the Southern and Northern Regional Performance Nursery (SRPN and NRPN) samples, several intra-zone production area composites were also tested for quality to study the environmental adaptability of each line. In addition, we have led both Wheat Quality Council (WQC) Sample evaluation for domestic customers and the U.S Wheat Associates' Overseas Varietal Analysis Project for international customers.

Quality data of the SRPN and NRPN were posted on the HWWQL web site in a timely manner. Immediate web access to the data allows the HWWQL to more rapidly respond to customer needs. Using a specially developed relational database system, we provided simultaneous assessment of multiple quality traits for both wheat and flour. It was the 8th year for us to offer free distribution of the database to all wheat breeders at the annual Breeders Field Day. Breeders and other industry customers can easily access current and archived regional performance nursery data via the world-wide web from our web site (<http://gqsru.gmprc.ksu.edu/hwwql/hwwqlhome.htm>). The relational database now contains individual mixogram images for each experimental line evaluated.

For the sixth year, the HWWQL has been actively involved in quality evaluation of major Hard Winter wheat varieties for the Overseas Varietal Analysis (OVA) project, and has collected and analyzed the data generated from 15 countries and regions (Brazil, China, Colombia, Egypt, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, Nigeria, Peru, Philippines, Thailand, and Taiwan) based on tests of their wheat-based products, such as French bread, pan bread, steamed bread, noodle, flat bread, sandwich bread, and pound cakes. The final yearly crop report issued from the HWWQL provides critical advice to U.S. wheat breeders for development of new wheat varieties that specifically meet the quality requirements of overseas customers.

The HWWQL remains actively involved in the Wheat Quality Council (WQC), whose mission is to advocate the development of new wheat varieties that improve the value of wheat to all parties in the United States supply chain. The HWWQL been directly involved in quality evaluation of advanced breeding lines submitted by major wheat-growing-state wheat breeders to the WQC. As well as participating as a test bake collaborator, the HWWQL compiles all the quality data generated by more than 15 collaborating laboratories across the country, performs the statistical analysis, produces the final report, and submits it to the Council in time for the Council's annually meeting of representatives from the milling and baking industry, breeders, and cereal researchers.

Accomplishment: For the fourth consecutive year, we have determined polyphenol oxidase (PPO) contents in wheat meals and the color (Minolta) values of Asian alkaline noodles at 0 and 24 hr for the 2005 crop NRPN and SRPN samples and also the 2005 Wheat Quality Council (WQC) samples. We have continued to provide our customers with this useful information to facilitate segregation of cultivars and breeding materials for these non-traditional products. Additionally:

Accomplishment: Samples were made into noodles and their color and cooked texture profile was analyzed. Results were reported at the annual meeting of the Wheat Quality Council (February 22-24, 2006 at the Embassy Suites Hotel in Kansas City).

Accomplishment: The 5% lactic acid solvent retention capacity (SRC) test and SDS-sedimentation test were investigated to find their relationships to loaf volumes (LV) of hard winter wheat (HWW) and hard spring wheat (HSW) flour. We found that both 5% lactic acid SRC and SDS-sedimentation tests showed strong correlations with the LV of low protein group ($r = 0.83$ and 0.78 , respectively), whereas with high protein group, only 5% lactic acid SRC test showed a high correlation ($r = 0.81$) and SDS-sedimentation test showed a lower correlation ($r = 0.38$, $P < 0.01$). The results demonstrate that 5% lactic acid SRC test is a more robust test to predict the LV of both classes of wheat flours over a broad range of protein content.

Accomplishment: The use of frozen dough has seen tremendous growth in the last 30 years due to the benefit of producing a fresh baked product while saving time, equipment, and labor costs. Fourier Transform Horizontal Attenuated Total Reflectance (FT-HATR) spectra were collected on doughs varying in frozen storage time. Mid-infrared bands associated with changes in the secondary structure of dough proteins were identified and found to change as a result of frozen storage. Spectral analysis of all the samples showed that the most significant change occurred within the first 24 hrs with a decrease in β -sheet structure. This change in protein structure could have a significant impact on frozen dough rheology.

Accomplishment: Research was conducted in '05 in which we developed NIR partial least squares (PLS) calibration models from the spectra of whole grain, meal, and flour using multivariate statistical analysis. Calibrations for Asian noodle color prediction were revised to include the '06 crop year data from the HWWQL. The results of this work yielded calibrations with minor improvement in predictive ability (r^2 values of 0.84 for noodle color prediction at 24 hr). However, it is expected that these calibrations will improve with the continued accumulation of sample data since we only have a few crop years of data for this new test within the HWWQL.

Accomplishment: In 2004, the HWWQL, in collaboration with the Grain Inspection, Packers and Stockyard Administration (GIPSA), conducted an extensive study on a selected number of commercial wheats (100 Hard Red Winter and 98 Hard Red Spring wheats) to evaluate the potential for the rapid determination of wheat/flour quality. This study incorporated all of the various quality parameters used to evaluate wheat and flour, as well as near-infrared analysis (NIR) of both wheat and flour samples used in the study.

In 2005, the data were statistically evaluated and multivariate statistical calibration models were developed from the NIR spectra. Results of the study were submitted for publication (see Publications and Presentations). Evaluation of this sample set (flour and dough) by FTIR was initiated in the third quarter of 2006; results are still pending.

Accomplishment: In FY04, the HWWQL supported a grant proposal by Dr. Scott Haley, a wheat breeder at Colorado State University (CSU), to acquire a sophisticated NIR instrument for calibration development specific to his breeding program. The grant was successfully funded in FY05, and a graduate student was found to help work on the project. Specific collaborative work with Dr. Scott Haley at Colorado State University was finally began in earnest in late FY05 with the acquisition of an NIR instrument in Dr. Haley's lab. Dr. Seabourn has since worked in

close collaboration with Dr. Haley to assist in calibration development, as well as calibration transfer and validation of existing HWWQL NIR calibrations for his breeding program. Our collaborative efforts thus far have involved standardization of our NIR instrument with theirs, and transferring equations for mixograph water absorption ($R^2=0.72$), bake water absorption ($R^2=0.74$), test weight ($R^2=0.82$), loaf volume ($R^2=0.75$), protein content ($R^2=0.96$), and moisture ($R^2=0.97$) to him for testing and use on his NIR instrument. The goal of the grant and collaborative efforts will be to enhance his breeding program by developing NIR calibrations to successfully screen early generation breeding lines for desirable quality attributes.

Accomplishment: In 2005, the HWWQL purchased a C-cell bread image analysis system to provide a more objective measure of crumb texture in bread. The system is currently under-going evaluation and comparison to data generated by our skilled baker. Although many bread/crumb characteristics can be determined by C-cell instrument, thus far the correlation between the objective and subjective tests, especially crumb grain scores, has been low.

Plans for 2007

Continue to evaluate intrinsic quality parameters of hard winter wheat breeding lines; continue to improve the activities of the HWWQL as a Regional Wheat Quality Laboratory with efficient service and regional collaboration; continue to investigate the suitability of hard winter wheat in Asian noodle-making by testing the PPO levels in breeding lines and also determining noodle-dough color stability; introduce tortilla-making quality data into our routine quality evaluations; develop and test the usefulness of models to predict end-use quality using physical and chemical characteristics of wheat and milled flour, including SKCS data, spectral scans by an NIRSystem 6500, and computerized mixograph data; study the free lipid composition of commercial hard winter and spring wheat flours; and study the dynamic rheological changes and multiple interactions during dough mixing by FTIR and Raman spectroscopy in order to better understand the basis for flour/dough functionality.

Issues

The world wheat market continues to be extremely competitive. Thus, it is important to improve U.S. wheat quality to meet the demands of our customers in both domestic and international markets.

What Was Done

Intrinsic end-use (milling and bread-baking) quality of 1675 hard winter wheat breeding lines from the 2005 crop were evaluated at the ARS Regional HWWQL so that breeders could select their lines based on intrinsic quality in addition to agronomical quality. We have completed method development for small-scale evaluation of tortilla products, and will incorporate these evaluations into Regional Performance Nursery data. We continue to evaluate Asian alkaline noodles color in our regional tests.

Impacts

Securing and improving the quality of grains produced in the U.S. so that they meet the needs of both domestic and overseas customers is a very important but difficult task. Grain quality improvement begins with a sound breeding program and ends with growers. In 2006, the HWWQL evaluated intrinsic quality parameters of hard winter breeding lines (2005 crop), and our data is of prime importance for the release of breeding lines, some of which become released cultivars grown by farmers. During the three-year period from 2000-2002, the average U.S. wheat production was 66.5 million metric tons (about 2.24 billion bushels); nearly one-half of U.S. wheat production and 41% of U.S. wheat export comes from hard red winter wheat. Over 95% of all hard winter wheats have been evaluated for end-use quality before they were released as cultivars. Therefore, our efforts greatly impact the overall U.S. wheat industry.

Overviews

Personnel at the ARS Regional Hard Winter Wheat Quality Laboratory, Manhattan, KS, have evaluated intrinsic quality parameters of hundreds of hard winter wheat lines (2005 crop) from federal, state, and private nurseries.

This is the fourth crop year in which we have measured PPO contents and alkaline noodle color values at 0 and 24 hr after processing to improve new uses (non-bread products) of U.S. hard winter wheat quality in collaboration with breeders. Tortilla quality factors will be incorporated into regional quality reports.

Contingencies: Phase I of Center renovation began in February, 2005. The HWWQL was moved to KSU campus and functioned successfully, but with limitations. Other laboratories, including the spectroscopy lab, were closed down entirely and did not conduct research from Feb. 2005 to May 2006. Needless to say, renovation had a significant impact on various projects and research endeavors. As renovation continues through 2007, other Unit research activities will be significantly impacted.

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NC-213 Objective 3

Title

Gluten protein effects on tortilla quality.

Project Objectives

Determine the functional roles glutenin and gliadin proteins and their macromolecular interactions in the structure, texture and shelf stability of flour tortillas.

From

Grain Marketing and Production Research Center
USDA, Agricultural Research Service
Manhattan, Kansas

By

Tilley, M.
Akdogan, H.
Graybosch, R.A.

Results for 2006

The mixing parameters and polymeric proteins (PP) of two different wheat cultivars, Centurk (CK) and OK102, each with four lines differing in HMW-GS composition were analyzed using multivariate statistical analysis of mixograph parameters. Stepwise discriminant analysis was used to identify significant mixing parameters at $P < 0.0001$ level. The selected variables, mixing tolerance, peak mixing time, and peak height (torque), were subjected to Principle Component Analysis (PCA). The score plots of the first two principal components (PC 1 and PC 2) indicated a clustering in samples: CK with 7+8 and 7+9 at the Glu-B1 and 5+10 at the Glu-D1 loci; CK with 7+8 and 7+9 at the Glu-B1 and 2+12 at the Glu-D1 loci; OK102 with 6+8 and 7+9 at the Glu-B1 and 5+10 at the Glu-D1 loci; OK102 with 6+8 and 7+9 at the Glu-B1 and 3+12 at the Glu-D1 loci. Samples from different cultivars (CK and OK102) were successfully grouped using the same score plots. Polymeric proteins consistently correlated well with mixing tolerance and peak mix time. Insoluble polymeric proteins (IPP) showed a positive relationship with mixing tolerance and peak time, soluble polymeric proteins (SPP) showed a negative correlation with the same parameters. Overall, SPP was a better identifier in terms of grouping Glu-D1 subunits and contributed to higher correlation coefficients than IPP. This method could be beneficial in developing analysis tools in early selection of lines for quality traits in wheat breeding programs.

Plans for 2007

Determine the potential of near-infrared spectroscopy (NIRS) to detect molecular changes that occur in tortillas during the staling process and correlate to subjective analysis (rollability) and objective textural properties such as color, stretchability, rupture force, distance to rupture force.

Use FTIR, NIR, NMR, and rheological test to determine the functional interactions between individual glutenin proteins during dough formation and processing of flour tortillas.

Publications and Presentations

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.

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Tilley, M., Bean, S.R. and Tilley K.A. 2006. Capillary electrophoresis for monitoring dityrosine and 3-bromotyrosine synthesis. *J. Chromatography A*. 1103:368-371.

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

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. (In press)

Issues

Tortillas have become the most prevalent ethnic bread in the U.S., often replacing white pan bread in many instances. As a result, tortillas are the fastest growing segment of the U.S. baking industry with annual sales over US\$6 billion and growth exceeding 10% per year. Sustaining this tremendous demand requires sufficient definition and determination of fundamental quality characteristics of wheat flour tortillas. One of the major challenges in tortilla quality is the deterioration of texture with time (staling). In instances where tortillas are freshly prepared and consumed, shelf-life is not an issue, however, in the U.S. retention of fresh properties is important since tortillas are packaged sealed in plastic bags and consumed over the course of several weeks. Tortilla quality is measured using both objective and subjective methods and is dependent upon flour properties as well as ingredient formulation. Defining the functional roles that individual glutenins and gliadins proteins play in the formation of the glutenin network and macromolecular interactions will define the structural interactions and predictive analytical test for the selection of wheat cultivars ideally suited for the manufacture of premium quality tortillas.

NC-213 Objective 3

Title

How variations in endosperm relate to environmental changes.

Project Objectives

Investigate variations in starch size distribution of mature and developing endosperm and relate to environmental changes.

From

Grain Marketing and Production Research Center
USDA, Agricultural Research Service
Manhattan, Kansas

By

Wilson, J.D.

Results for 2006

Flours from 5 spelt cultivars grown over 3 years were evaluated as to their bread baking quality and isolated starch properties. The starch properties included amylose contents, gelatinization temperatures (differential scanning calorimetry), granule size distributions and pasting properties. Milled flour showed highly variable protein content and was higher than hard winter wheat, with short dough-mix times indicating weak gluten. High protein cultivars gave good crumb scores, some of which surpassed the HRW baking control. Loaf volume was correlated to protein and all spelt varieties were at least 10-15% lower than the HRW control. Isolated starch properties revealed an increase in amylose in the spelt starches of between 4 – 7 % over the hard red winter wheat (HRW) control. Negative correlations were observed for the large A-type granules to bread crumb score, amylose level, and final pasting viscosity for cultivars grown in year 1999 and to pasting temperature in 1998 samples. Positive correlations were found for the small B- and C-type granules relative to crumb score, loaf volume, amylose, and RVA final pasting viscosity for cultivars grown in year 1999, and to RVA pasting temperature for samples grown for 1998 samples. The environmental impact on spelt properties seemed to have a greater effect than genetic control.

Plans for 2007

Statistical analysis of 100 HRW and 100 HRS wheat is currently being completed to correlate starch size distribution to a variety of wheat quality parameters. We are also completing the analysis of 5 HRW wheat varieties grown over 7 years to determine crucial weather conditions that affect starch size distribution in developing caryopsis.

Publications and Presentations

Wilson, J.D., Bechtel, D.B., Todd, T.C. and Seib, P.A. 2006. Measuring wheat starch granule size distribution using image analysis and laser diffraction technology. *Cereal Chem.* 83:259-268

Maghirang, E.B., Lookhart, G.L., Bean, S.R., Pierce, R.O., Xie, F., Caley, M.S., Wilson, J.D., Seabourn, B.W., Ram, M.S., Park, S.H., Chung, O.K., and Dowell, F.E. 2006. Comparison of quality characteristics and breadmaking functionality of hard red winter and hard red spring wheat. *Cereal Chem.* 83:520-528.

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Issues

One area that has been neglected, with respect to wheat quality, is the impact weather conditions have on starch size distributions and chemical differences.

What Was Done

Spelt wheat is the only husked wheat that is currently grown in the US for human food consumption. This work assessed the composition and properties of flour and starch from five spelt varieties grown in the same location over 3 growing seasons.

Impacts

The results may help elucidate some unique characteristics of spelt flour and starch for future uses in the food industry, as well as provide additional information on environmental effects on starch granule size distribution and molecular structure.

Overview

The environment plays a critical role in spelt wheat development, as is the case in most cereals. Results of this work also support the importance of starch size distribution as a critical component in the study of wheat quality.