APPENDIX D
SAES-422
Format for Multistate Research Activity
Accomplishments Report

Note: *This report is submitted each year of an activity's duration and is due 60 calendar days following the annual meeting. The SAES-422 is submitted electronically by AAs into NIMSS. Annual Reports for MRF projects are available to CRIS and CSREES through NIMSS.*

Project/Activity Number: NC-213

Project/Activity Title: "Marketing and Delivery of Quality Grains and BioProcess Coproducts"

Period Covered: October 1, 2008 – September 30, 2013

Date of This Report: April 4, 2014

Annual Meeting Date(s): February 12-13, 2013

Participants: Provide information with a focus on the decisions made. As an alternative, list the URL for the meeting minutes, if that report contains the list of those who were present. And, if available, add the address for the list server as well. (Max characters = 4,000. Suggested Format: "Last name, First name (email) - Institution;" The semicolon is used to separate participant information.)

Adam, Brian, brian.adam@okstate.edu, Oklahoma State University; Ambrose, Kinsly, kingsly@ksu.edu, Kansas State University; Andrada, Mario, mandrada@ksu.edu, Kansas State University; Bard, Sharon, Centrec Consulting Group LLC; Bhadra, Rumela, rumelabhadra31@yahoo.com, Kansas State University; Boac, Josephine, jmboac@ksu.edu, Kansas State University; Bowers, Erin, Iowa State University; Bryant, Morrie, morrie.bryan@pioneer.com, Pioneer; Cain, Jewelwayne, University of Missouri-Columbia; Campabadal, Carlos, campa@ksu.edu, Kansas State University; Cao, Nanning, nancycao@iastate.edu, Iowa State University; Casada, Mark, casada@ksu.edu, USDA ARS Manhattan KS; Chen, Shih-Fang, University of Illinois-Urbana; Hardy, Connie, chardy@iastate.edu, Iowa State University; Hiles, Abigail, Abigail.hiles@romerlabs.com, Romer Labs; Hill, Chuck, chuck.hill@agrigold.com, AgriGold Hybrids; Hurburgh, Charlie, tatry@iastate.edu, Iowa State University; Ileleji, Klein, Ileleji@purdue.edu, Purdue University; Jones, Carol, jcarol@okstate.edu., Oklahoma State University; Kandhola, Gurshagan, kandhol2@illinois.edu, University of Illinois-Urbana; Kojima, Yasutomo, University of Missouri-Columbia; Koshar, Bill, koshar.3@osu.edu, The Ohio State University; Lee, Kyung-Min, kml@otsc.tamu.edu, Texas A&M University; Li, Song, UIUC; Maier, Dirk, dmaier@ksu.edu, Kansas State University; McNeill, Sam, smcneill@uky.edu, University of Kentucky; Miller, Doug, dmiller@ilcrop.com, Illinois Crop Improvement Association; Montross, Mike, Montross@bae.uky.edu, University of Kentucky; Mosher, Gretchen, gamosher@iastate.edu, Iowa State University; Needham, Joe, joe_needham@andersonsinc.com, The Andersons, Inc.; Nelson, Camille, Iowa State University; Nenonen, Steve, steve.nenonen@romerlabs,com, ROMER Labs, Inc.; Ramchandran, Divya, ramchan2@illinois.edu, University of Illinois-Urbana; Ravlin, Bill, Ravlin.1@osu.edu, The Ohio State University; Ryan, Saxon, saxon@iastate.edu, Iowa State University; Scott, Megan, Iowa

State University; Sehgal, Blossom, blossom@ksu.edu, Kansas State University; Shepherd, Howard, howard@iastate.edu, Iowa State University; Singh, Chandra, Chandra@opisystems.com, OPIsystems, Inc.; Sobetski, Mike, msobetski@lifeline-foods.com, Lifeline Foods; Traar, Vera, vera.traar@romerlabs.com, Romer Labs; Tumbleson, Mike, mtunbles@illinois.edu, University of Illinois-Urbana

Brief summary of minutes of annual meeting: Provide information with a focus on the decisions made (Max characters = 12,000. Single line breaks are not preserved, use double line breaks instead or use a <p> tag to separate paragraphs.). As an alternative, list the URL for your meeting minutes.

--NC-213 Rewrite. The North Central Regional Association (NCRA) of Agricultural Experiment Station Directors Office approved the NC-213 Rewrite on July 17 and USDA/CSREES National Institute of Food and Agriculture approved the NC-213 Rewrite on August 12, 2013. This was reviewed during the annual meeting. Charlie Hurburgh and Bill Ravlin gave a presentation on the process and next steps for the group to be successful.

--Annual Report Discussion with an emphasis on: Impact Statement review and External Funding. Bill Ravlin/Klein Ileleji. The AA's Office will lead discussion on finalizing impact statements for the Annual Report. Other areas of the Annual Report are: meeting participants, meeting minutes, and publications, which the AA's Office will complete. The Executive Committee will complete, with assistance from members at large, the "Accomplishments" section. (Refer to handout for complete details on Impact Statements to be covered during this discussion.) This will also include an "Impact Statement" session where Bill Ravlin will take actual impacts from the report of progress and modify to make an acceptable "Impact Statement." This was discussed during the annual meeting. Bill Ravlin did give examples of successful impact statements and how to create successful impact statements.

--NC-213 Annual Progress Reports from Participating Stations. Bill Ravlin. There were approximately 21 reports received. The final publication is available by visiting the NC-213 web site.

--NC-213 Annual Meeting – 2015. The group voted to have the meeting with the Wheat Quality Council, in Kansas City, Missouri during the week of February 16. We would meet on Wednesday, February 18 for a joint Banquet and finish up on Thursday, February 19, 2014. Bill Koshar will get in touch with Ben Handcock to firm up the dates and to make sure that we can join them for their Banquet.

--Andersons Grants Update. Bill Ravlin. Distribute latest survey of grants received for competitions and grants awarded. Bill Ravlin shared with the group that eight were received, four were deemed to be ineligible and that two were funded. Bill also gave an overview of the entire review process. He stressed that it is a group decision.

--Officer elections. Klein Ileleji. This item can be initiated in the executive committee meeting and then discussed during the business meeting.

Carol Jones (past chair rolls off)
Klein Ileleji (current chair to past chair)
Senay Simsek (vice chair to chair)
Kingsly Ambrose (secretary to vice chair)

Note: Need to fill the position of secretary.

Chuck Hill (Chair of I.A.C.)

Note: All objective co-chair positions are filled.
A: K.M. Lee and S. Simsek
B**:** R.P. Kingsly Ambrose and C. Wolf-Hall
C: B. Adam and C. Hurburgh

The group nominated, and the nomination was accepted, by Gretchen Mosher, Iowa State University, to fill the position of NC-213 Secretary. The group voted and the vote was passed.

The group nominated, and the nomination was accepted, by Gretchen Mosher, Iowa State University, to fill Charlie Hurburgh's position as Objective C Co-Chair. The group voted and the vote was passed.

The group nominated, and the nomination was accepted, by Hulya Dogan, Kansas State University, to fill the position of Objective B Co-Chair, replacing Charlene Wolf-Hall, North Dakota State University. The group voted and the vote was passed.

The group thanked Klein Ileleji for all of his work and efforts over the past year helping guide NC-213 as NC-213 Chair.

The group thanked Chuck Hill for all of his work and efforts over the past year helping guide NC-213, specifically industry folks, as NC-213 Industry Advisory Committee – Chair.

Respectfully submitted, Bill Koshar NC-213 Administrative Support

Accomplishments: This section focuses on intended activities, outputs, and short-term outcomes. Committees should build information built around the activity's milestones, as identified in the original proposal. Please indicate significant evidence of linkages both internal to the project/committee and to external peer groups, stakeholders, clientele, and other multistate activities. The report should also reflect on the items that stakeholders want to know, or want to see. The committee should describe plans for the coming year in no more than one or two short paragraphs. If the committee is filing an annual report, the accomplishments will cover only the current year of the project; for termination reports, list accomplishments from the entire span of the project.

> **Short-term Outcomes:** Quantitative, measurable benefits of the research outputs as experienced by those who receive them. Examples include the adoption of a technology, the creation of jobs, reduced cost to the consumer, less pesticide exposure to farmers, or access to more nutritious food.

Outputs: Defined products (tangible or intangible) that are delivered by a research project. Examples of outputs are reports, data, information, observations, publications, and patents.
Activities: Organized and specific functions or duties carried out by individuals or teams using scientific methods to reveal new knowledge and develop new understanding.
Milestones: Key intermediate targets necessary for achieving and/or delivering the outputs of a project, within an agreed timeframe. Milestones are useful for managing complex projects. For example, a milestone for a biotechnology project might be "To reduce our genetic transformation procedures to practice by December 2004."

Accomplishments, Outputs and Outcomes from NC-213 Researchers Include:

Objective 1

The effective diffusion coefficient of carbon dioxide (CO_2) through bulk corn was determined at various temperatures (10, 20, and 30°C) and moisture contents (14.0, 18.8, and 22.2% w.b.). The diffusion coefficient measurements were conducted using a diffusion cell surrounded by a water jacket, which was used to control the bulk corn temperature in the diffusion cell. A source term (CO_2 respiration rate) was introduced in the diffusion equation to account for CO_2 production by corn during the diffusion process. Corn respiration rate increased when temperature and grain moisture content increased. As respiration rate increased, it had a larger effect on the diffusion pattern when measuring the effective CO_2 diffusion coefficient. The effective CO_2 diffusion coefficients through bulk corn ranged between 3.10×10^{-6} and 3.93×10^{-6} m^2/s, depending on temperature and moisture conditions. As temperature increased from 10 to 30°C, the effective CO_2 diffusion coefficient through bulk corn increased from 3.21×10^{-6} to 3.76×10^{-6} m^2/s. As corn moisture content increased from 14.0 to 18.8% (w.b.), the effective CO_2 diffusion coefficient through bulk corn decreased from 3.59×10^{-6} to 3.39×10^{-6} m^2/s, respectively. There was no difference observed in the effective CO_2 diffusion coefficient when corn moisture content increased from 18.8 to 22.2%.

Early detection of grain spoilage will reduce grain quantity and quality losses, decrease mycotoxin production in the food chain, and avoid financial loss by applying timely storage management, such as aeration. It has been reported that monitoring CO_2 concentration in the headspace of the storage bin with a CO_2 sensor can lead to earlier detections of grain spoilage compared to temperature monitoring. CO_2 monitoring in bulk grain in silo bags is even more important since it is in indicator of whether hermetic conditions are being maintained. In order to further develop effective and commercially feasible techniques for utilizing CO_2 sensors for grain quality monitoring in storage bins and silo bags, knowledge of movement of CO_2 in bulk grain is necessary. This study provides values of CO_2 diffusivity through bulk corn at different temperatures and grain moisture contents, including estimates of CO_2 production by corn respiration.

The ADM Institute for the Prevention of Postharvest Loss has the goal of reducing postharvest losses of grains and oilseeds in many parts of the world with focus on India and Brazil. Harvest losses from eight combines in soybeans and eleven combines in corn were measured in Goias

and Mato Grosso states of Brazil in February and June 2012, respectively. Work was done in cooperation with Universidade Federal de Vicosa, Universidade Federal de Goias, and Universidade Federal de Mato Grosso. Loss measurements followed the Embrapa method of using 2.0 m^2 for loose kernels and 30 m^2 for ears over the full width of the combine header. Yield estimates, and measurements for total and header losses were replicated three times for each combine.

Header/ separator kernel losses ranged from 34.4 to 120.0 kg ha^{-1}. The highest header/ separator kernel losses could have likely been reduced by driving slower. Rotor/ cylinder kernel losses ranged from 0 to 11.4 kg ha^{-1} and were low, less than 0.1% of estimated yield. Header loose kernel losses ranged from 5.3 to 59.7 kg ha^{-1}. The combine operating in lodged corn had the highest header loose kernel losses, likely from lodged ears that were partially shelled by the header. The second highest header loose kernel loss was from the combine with the highest ground speed. Of the four combines with header loose kernel losses below 8.1 kg ha^{-1} all operated at speeds of 5.7 km h^{-1} or less. Reduction in ground speed would benefit separation losses in corn. Not surprisingly, lodged corn increases header ear losses by more than any other source of loss.

Evaluation of NIRS instrumentation continued. Nine models of transmission analyzers and 9 models of reflectance analyzers are now in our program. Corn, soybeans, soybean meal, distillers grains, and bakery meal are now included in our databases. In 2013, Zeiss Corona X, JDSU MicroNIR, Perten Inframatic 9500, Bruins AgriCheck X, and Thermo Antaris were calibrated for proximate analysis of corn, soybeans, wheat, DDGS, soybean meal and bakery meal. The sample set optimization procedure was applied to the creation of smaller calibration sets for more rapid development of useable calibrations.

The Grain Quality Lab set up a mycotoxin analysis service, using aflatoxin from the 2012 as the source of development samples. As expected, our results from the 304 2012-crop samples collected by the Iowa Department of Agriculture (IDALS) were close to the average of the original IDALS results. Also as expected, there was a 50% coefficient of variation across the labs.

Fusarium head blight (FHB) is a major fungal disease affecting several gramineous hosts, including wheat (Triticum aestivum L.). Hard Red Spring (HRS) wheats of the Northern Great Plains of the United States and Western Provinces of Canada are susceptible to scab, especially in years that have wetter than average growing seasons.
FHB infection often results in the production of several trichothecene mycotoxins including deoxynivalenol (DON) and nivalenol (NIV), as well as, zearalenone (ZEA) and moniliformin (MON), all of which have a range of toxicity to animals. DON is the most common mycotoxin produced by Fusarium. Plants are able to “detoxify” mycotoxins such as DON by chemically modifying and/or including them in the plant matrix. These modified versions of the toxins are called “bound mycotoxins”, also known as masked deoxynivalenol. One of the most common forms of bound DON is DON- 3- glucoside. In this form, a glucose molecule has been attached to the DON molecule at carbon 3. Recent studies have shown that masked DON in wheat is a cause for concern, and escapes detection by routine analytical methods. The evidence that suggests masked DON may be released into the free form under some food processing

conditions, through enzymolysis in dough processing or in digestion, raises concerns that the potential toxicity of samples is being under estimated.

We performed physical tests of stress relaxation and creep recovery on wheat kernels and dough. We also studied the influence of specific key proteins (high and low molecular weight glutenin subunits) composition on the rheological properties as well as quality indicators of wheat and dough. Our work is based on the hypothesis is that protein material contributes largely to the viscoelastic properties of wheat kernels as well as dough.

The specific objectives of this NC-213 Team Project are to: (1) determine the effect of pre-cleaning shelled corn on mycotoxin reduction prior to processing into ethanol and distillers grains, (2) determine the effect of solvent extraction on mycotoxin reduction in co-product streams (WDG and CDS) and the final DDGS product and (3) determine the effect of ozone, aqueous sodium bisulfite, and microwave treatments, and their combinations on mycotoxin reduction in co-product streams (WDG and CDS) and final DDGS product.

One approach to reducing mycotoxin levels in co-products is removal of some of the infected kernels by means of pre-cleaning (Objective 1). This can be accomplished using differences in the properties of good kernels versus kernels infected with mycotoxin producing fungi. Properties currently being investigated are kernel dimensions and shape (sphericity), kernel density, and color sorting. Preliminary tests were conducted on kernels from the 2009 harvest season that were infected with *Gibberella zea* (which produces deoxynevalenol). Properties measurements were made on samples infected with *Aspergillus flavus* (which produces aflatoxin) collected during the 2012 harvest season. The major, intermediate, and minor diameters were measured with a caliper and kernel densities were measured with a micropycnometer similar in construction to a device used for a study of wheat kernels conducted at the Grain Marketing and Postharvest Research Center in Kansas (Martin et al., 1997).

The high demand for wheat flour tortillas (sales exceeded $ 6 billion in the US in 2012) and other flatbreads has resulted in the need for rapid, accurate and cost-effective means to predict tortilla making performance for large number of early generation wheat lines. Currently, the most reliable approach is to process tortilla which is laborious, time consuming, expensive and requires large sample size (2 kg wheat). At the same time, the popularity of tortillas as a dietary staple has created a growing need for healthier product offerings that meet consumer sensory expectations, while contributing to chronic disease prevention. Unfortunately most tortillas in the market have poor nutritional profile; high in rapidly digesting starch and fat, and low in dietary fiber and bioactive phytochemicals. Thus there is a strong need to develop wheat with the right protein functionality for tortillas and to improve tortilla quality to meet both sensory and nutritional expectations of consumers.

This study used a multivariate discriminant analysis to predict tortilla quality using kernel, flour and dough properties. A discriminant rule was used to classify wheat lines for suitability in making good quality tortillas. Wheat varieties from Texas (n = 186) were evaluated for kernel (hardness, diameter, and weight), flour (protein content, fractions and composition), dough (compression force, extensibility and stress relaxation from TA-XT2i) and tortilla properties (diameter, rheology and flexibility). First three principal components explained 62% of variance.

Canonical correlation analysis revealed significant correlation between kernel and tortilla properties (r= 0.83), kernel hardness contributed the highest to this correlation. Flour and tortilla properties were highly correlated (r = 0.88), Glutenin to Gliadin ratio (Glu:Gli) contributed highest to this correlation and can predict tortilla flexibility and deformation modulus. Dough and tortilla properties were significantly correlated (r = 0.91). Logistic regression and stepwise variable selection identified an optimum model comprised of kernel hardness, Glu:Gli, dough extensibility and compression force as the most important variables. Cross-validation indicated an 83% prediction rate for the model. This emphasizes the feasibility and practicality of the model as a wheat quality screening tool using variables that are easily and quickly measured.

Phenolic compounds from sorghum bran are known to have beneficial health properties and may be useful for improving health attributes of tortillas. Impact of sorghum brans with different phenolic profiles on dough rheology, starch digestibility, and phenolic profile of wheat flour tortillas fortified with 25% (baker's) bran from wheat and white, brown, and black sorghum were investigated. Dough compression and stress relaxation were measured using a TA.XT2i texture analyzer. Total (TS), rapidly digestible (RDS), slowly digestible (SDS), and resistant starch (RS) fractions were evaluated in tortillas using in vitro digestion. Phenolic profile was determined by UV-Vis Spectroscopy and HPLC. Dough force to compress increased from 105 N (control) to 170-263 N with the addition of bran. Dough with black sorghum bran required the largest force to compress (263 N) and lowest relaxation time (1.3 s) compared to other bran treatments (1.5-1.6 s), suggesting increased water absorption. As expected, addition of bran significantly decreased TS and RDS compared to control ($P<0.05$). Bran decreased the RDS from 61% (control) to 49-51% (db). There was no significant difference in RDS among the brans. Brown sorghum bran tortillas had significantly higher SDS (11.3%) than the other brans (6.38-8.15%); this may be due to high levels of proanthocyanidins in brown sorghum bran. RS was not significantly affected. Addition of brown and black bran significantly increased ($P<0.05$) the total phenolic content of tortillas to 43.3 and 52.4 (mg GAE/g), respectively, compared to 9.46 (wheat bran) and 12.09 (white sorghum bran). Brown and black sorghum bran utilization in wheat flour tortillas may beneficially affect the starch digestibility while increasing polyphenol content.

Rapid and sensitive surface-enhanced Raman spectroscopy (SERS) for aflatoxin detection was employed for development of the spectroscopic method to classify and quantify aflatoxin levels in maize. The proposed SERS method would serve as a valuable screening tool with a great accuracy and convenience for a high-throughput aflatoxin analysis in plant breeding programs, hybrid performance trials, or during harvest in the field requiring rapid routine analysis.

In preprocessed Raman spectra, qualitative spectral differences in the normalized and derivative preprocessed spectra were observed in the Raman shift ranges of 400−530 cm^{-1}, 800−980 cm^{-1}, 1100−1250 cm^{-1}, and 1500−1800 cm^{-1}. The major bands in these Raman shift regions may be associated with fugal cellular metabolites and modified cell membrane and inhibited protein and starch synthesis due to the effects of fungal and aflatoxin infection of kernels. Shifts of some aflatoxin bands, in particular, in the aflatoxin-related Raman spectral regions, were easily observed compared to corresponding bands of conventional Raman spectroscopy. The shifts of Raman bands can be attributed to the effect of charge transfer between adsorbed aflatoxin molecules and silver (Ag) metal in combination with the resonance excitation of surface

plasmon. In representative scanning electron microscope (SEM) images of the Ag nano-spheres and their mixture with the extract, dispersed Ag nano-crystals with various diameters can be observed and they form blocks into Ag nano-crystals with the diameters of 70−80 nm at an inter-particle spacing of 1-2 nm. The Ag nano-spheres with the packed Ag nano-crystals contain periodic hot spots or junctions which provide surface areas to adsorb aflatoxin or bioactive molecules.

The classification models for aflatoxin contaminated and non-contaminated maize sample groups were developed by applying the *k*-nearest neighbors (KNN) algorithm for the four preprocessed SERS spectra in the Raman shift region of 400–1800 cm^{-1}. The correct classification rate of all calibration models was 100% for training data regardless of the spectra preprocessing method while rather lower classification accuracies (71.4–91.4%) were achieved when the calibration models were applied to validation data. The KNN models offering higher classification accuracy in classifying aflatoxin contaminated samples were obtained using normalized and deconvolution preprocessed spectra data. In these two models, almost no samples with greater than 20 μg/kg were misclassified as aflatoxin negative. The chemometric methods including multiple linear regression (MLR), principal components regression (PCR), and partial least squares regression (PLSR) algorithms, were employed for development of aflatoxin quantification models. The performance of all models assessed by statistical measures showed a great dependence of the models on the chemometric and preprocessing method. The MLR models showed better regression quality, higher predictive accuracy, and lower error rate than other chemometric methods while the PCR models yielded far less satisfactory results compared to the MLR and PLSR models. All MLR models developed with the preprocessed spectra could account for more than 90% of variation in both training and validation data set. Coefficients of determination (r^2) and predictive error rate of the former three calibrations models applied to the validation data set were in the range of 0.913–0.934 and 86.2–92.4 μg/kg, respectively. This observation indicates a good quality of the regressions and high predictive capability of selected MLR models suitable for screening of aflatoxin contaminated samples. The PLSR calibration models yielded comparable results to the MLR calibration models for the training data set, resulting in high r^2 values (0.932–0.974), lower error rate (47.9–77.0 μg/kg), and a linear regression slope in the range of close to 1. However, the predictive accuracy of the PLSR calibration models predicting the validation samples was not as good. Paired sample t-test for the validation data set showed no statistically significant difference ($p < 0.01$) between the reference high performance liquid chromatography (HPLC) values and the predicted values of SERS in all aflatoxin quantification models, except for the MLR model for 2nd derivative spectra. According to the criterion of RPD (ratio of the standard deviation of the reference data to the standard error of cross-validation) values, the MLR models may be effective for screening of aflatoxin contaminated samples. Despite the chemometric models developed by the conventional Raman spectroscopy showed a slightly higher predictive accuracy than those of the SERS, the effectiveness and efficiency of the SERS would be better if more considerations are given to the sensitivity, analysis speed, the reproducibility of spectra, and potential improvement of SERS substrate.

Thirty six samples varying in in-vitro protein digestibility were used for in-depth biochemical characterization. A new multi-step extraction procedure was developed that was designed to extract as much protein as possible while leaving covalently bound protein structures intact. The

extraction procedure extracted ~90% of total protein. Significant negative correlations to the amount of the most difficult to extract were found suggesting that the proteins in these protein complexes are important factors in governing protein digestibility in sorghum. Work is in progress to characterize the proteins in these fractions and how they are linked together.

Work was also completed on a set of sorghum samples with known variability for kafirin alleles. Raw and cooked protein digestibility was measured on this set and protein composition characterized using size exclusion chromatography, reversed-phase high performance liquid chromatography and electrophoresis. The role of proteins on ethanol fermentation efficiency was also studied with this sample set. Kafirin allelic variants were found to influence ethanol fermentation efficiency and an RP-HPLC peak was found that was highly negatively correlated to protein digestibility suggesting it could be used as a marker to predict protein digestibility.

Objective 2

The objectives 1 and 2, optimization and verification of methods for detecting and quantifying fungal population in soil and development of analytical method to detect mycotoxins are in progress. Different methods using HPLC and LC-MS are being tested for the detection of mycotoxins while techniques to isolate and identify fungal strains are being examined.

Test plots for winter wheat varieties are located and sampling plan is being constructed to match the growing season in the area in collaboration with Washington State University Extension (Variety Testing Program). The test plots were selected based on the amount of rainfall and agricultural conditions. Grain samples will be analyzed for fungal population and mycotoxin concentration upon harvest. Soil samples from each testing plots will be collected and analyzed for the fungal population.

An educational module focusing on risk management in grains and oilseeds has been developed for regulatory personnel who are inspecting grain handling facilities as required by the Food Safety Modernization Act. The module is part of a larger distance education course offered to regulatory personnel and will be the basis for the development of a job aid to assist regulatory officials during inspections of grain handling facilities.

Educational modules on corn processing were created to complement wheat and oilseed processing modules created by Kansas State University. The modules will be included in the distance education course offered to regulatory personnel.

A review article on soybean composition as related to grain yield was accepted. As part of the American Association of Cereal Chemistry Food Safety Task Force outputs, a guidance document for the application of ISO22000, Food Safety Management Systems to bulk processing and handling operations was drafted.

Previous quality systems research was published. Several presentations were created and delivered in 2013 on topics that included: pre-harvest grain quality outlook, mycotoxin management, and grain storage economics.

From the increased profits and also the possibility of product streams with different quality concentrations, corn ethanol processing industries are increasingly inclined towards the production of Modified DDGS (M-DDGS). Though the industries are fast converting to this modified DDGS production, there is lack of information on handling characteristics of modified DDGS. This research work will determine the intrinsic particle characters of M-DDGS that influence their bulk handling behavior. This study involves lab scale testing of flow characteristics, development of mathematical models for optimizing cooling, and also concentrates on development of mechanical aids that improve the flow properties. The modified and regular DDGS samples were procured from dry-grind processing facility in the mid-west U.S. The DDGS samples with different oil contents were characterized for the physical and chemical characteristics. Particle size and particle size distribution were determined using ASABE Standard S 319.4. The flow properties of bulk granular solids are governed by the factors of product moisture content, particle size distribution, chemical composition, storage/handling conditions (temperature and relative humidity), and time consolidation and compaction pressure. Since a combination of these factors influence the flow behavior of DDGS, in this project work, different combinations of these effects were testing using the FT-4 powder rheometer (Freeman Technologies, UK).

Stored-grain packing is defined as the increase in grain bulk density caused by the cumulative weight of overbearing material on the compressible grain products. As material is added, the vertical pressure increases in an exponential manner with grain height. Bin geometry, material properties, and numerous other variables influence packing, therefore, these factors were considered when developing the new packing model and conducting subsequent model validation exercises. One goal of this scientific approach was to reduce the total amount of data required to achieve accurate packing estimates over the range of bin sizes and various storage conditions encountered in the grain industry.

In this study Hard Red Winter (HRW) wheat was intensively studied to evaluate the effects of blending, growing season, and dockage using 27 untreated HRW wheat samples from Idaho, Montana, South Dakota, Colorado, Oklahoma, North Dakota, Texas, Kansas, Nebraska, Washington, and Oregon. These were primarily from the 2007 through the 2010 crop years with a test weight (TW) that ranged between 52.9 and 64.3 lb/bu. The samples were tested at two moisture content (MC) levels, nominally 10% and 13%, that would represent the range in expected moisture contents for HRW wheat. Moisture content and test weight accounted for the majority of the variation in the compacted bulk density ($r^2 > 0.96$) over the 27 samples and two moisture content levels.

Although the packing behavior of the wheat samples was accurately described by test weight and moisture content there were significant differences in the compressibility of individual samples. For example, one sample with a test weight 54.4 lb/bu and a moisture content of 9.3% increased to 59.9 lb/bu when subjected to an overburden pressure of 10 psi. This is an increase of 10.1% in bulk density. Compared to a sample with a high test weight (63.3 lb/bu at a moisture content of 10.2%), the bulk density increased to 67.8 lb/bu at an overburden pressure of 10 psi, an increase of 7.1% in bulk density.

A training session was held for certified crop advisors and on-farm storage managers at the Crop

Pest Management School in Bozeman, Montana on January 2, 2013.

A popular press article entitled "Preserving Quality of Stored Grain" was delivered via the.Montana Farm Bureau Ag NewsWire on August 29.

A stored product pest management module was presented to AGSC 401 – IPM students on the Montana State University Campus on October 31, 2013.

An invited presentation, "Nanostructured materials and their potential as pest control tools" was given in the Member Symposium: Stored Product Entomology: Impacts on a Connected World at the 61st Annual Meeting of the Entomological Society of America, November 10-13, Austin, TX.

Grain from 40 durum wheat cultivars grown at four locations in North Dakota was used to identify grain attributes that relate to whole-wheat pasta quality. Grain attributes include test weight, kernel vitreousness, kernel weight, and kernel size. Kernel protein content and quality and ash content were also determined. Whole-wheat quality was assessed by determining physical quality (pasta color and mechanical strength) and cooking quality (cook time, cooked weight, cooking loss, and cooked firmness).

A poster was presented at the annual AACC International meeting, Albuquerque, NM, September 29-October 2, 2013.

We continued to develop a whole-chain traceability system with the unique feature that those who add information into the system can choose which parties in the supply chain are able to see that information, and what specific pieces of the information those parties can see. This provides confidentiality for those providing information, removing a major obstacle to voluntary participation in such systems. While the system is being developed initially for use in the beef supply chain, it can easily be adapted for use in other product supply chains. (Thus, although some of the publications and presentations identified below refer to beef – the focus of a major part of the initial funding – the technology is applicable to many food products, including those that are especially targeted in NC-213.)

One of our collaborators is a company (Top 10 Produce) that has developed technology to facilitate communication in a short supply chain between producer and consumer. Its currently-operating commercial system provides producer/production information directly to consumers with a computer or smartphone, and permits consumers to ask questions or provide feedback directly to producers. By collaborating, we can build a whole-chain traceability for long supply chains that allows participants to selectively share information all the way from producer to consumer.

Research by B.D. Adam and Suling Duan (graduate student), along with Frank Arthur and James Campbell (USDA/ARS) on the topic "Optimal insect control for grain storage in warm climates: Can chemicals ever be avoided?"

Abstract: Elevator managers in the Southern and Central Plains have been reluctant to switch

from routine fumigation to sampling-based IPM to control insects in stored wheat. Research has suggested that their reluctance is justified: under typical conditions the insects grow enough in the warm climate that fumigation is almost always necessary: sampling adds unnecessary expense. This study, though, better models actual weather variability faced by managers by simulating over a much longer data series. This makes sampling-based IPM relatively more economical since greater variability increases the likelihood fumigation will not be necessary in any particular year. This result holds, though, only if insect immigration rates into the bins are low, a condition that may or may not be under the control of managers.

Research by B.D. Adam and Li Niu (graduate student), along with Frank Arthur, James Campbell, and Paul Flinn (USDA/ARS) on the topic "A GIS Approach to Measuring Economic Costs of Integrated Pest Management Tools in Rice Processing Facilities."

Abstract: Methyl bromide is a commonly used fumigant for controlling insects in food processing facilities. However, it has been designated as an ozone depleter and is becoming less available and more costly. Integrated pest management (IPM) is an alternative, and may additionally reduce insecticide resistance, improve worker safety, and reduce environmental concerns and consumer concerns about pesticide residuals. However, little is known about the costs and efficacy of IPM in food processing facilities. Here, we consider several IPM approaches and measure both the treatment costs as well as the costs of failing to control insects for each approach.

Research by John Mann, B.D. Adam, and Frank Arthur (USDA/ARS) on the topic: "The Economics of Resistance to Phosphine by Stored Product Insects."

Abstract: The primary motivation for this study is that recently resistance by *Rhyzopertha dominica* – Lesser Grain Borer (LGB) – to phosphine in stored grain has been detected in parts of the US. Significant economic damage from LGB resistance to phosphine has already occurred in countries such as Australia and Brazil. Currently there are no economical alternatives to phosphine as a fumigant against stored grain pests.

The overall objective of this study was to determine how the costs of alternative strategies to control LGB in stored grain are affected by LGB resistance. Three possibilities for LGB population dynamics based on genetic research, and three grain management strategies (calendar-based fumigation, sampling-based IPM, and aeration-based IPM) were considered. When costs associated with LGB resistance were incorporated, simulation results suggested that in Oklahoma, where the weather is considered favorable to LGB growth, sampling-based IPM would only be cost-effective if the development of LGB can be slowed to considerably less than what occurs under calendar-based fumigation, perhaps through effective aeration.

In Kansas, where the weather is cooler, sampling-based IPM would be more likely to be cost-effective. Additionally, aeration-based IPM would be the most cost-effective strategy since LGB growth could be suppressed sufficiently that fumigation would seldom be necessary. Although these results only reflect the case of "low" immigration, they justify further research into the application of different IPM technologies and the impact of such technologies on LGB resistance and the corresponding costs from changes in resistance.

For grain managers, one symptom of increased insect resistance is the need for increased frequency of fumigation. Ironically, one of the implications of the model is that if fumigations are done well so that effectiveness is high, symptoms of increasing insect resistance may be initially over looked. In warmer climates where sampling-based IPM is relatively more expensive, grain managers may be unaware of current levels of resistance. If the development of LGB resistance is on the threshold, continuing to use current strategies may lead to significant economic loss. Once past this threshold, the options for grain managers to make alternative strategy decisions are further reduced. The main challenge is to extend the useful life of phosphine by developing and adopting strategies that can reduce insect exposure to the fumigant.

The objective of this study is to investigate the use of the Woods End Laboratories Solvita® Grain CO_2 Respiration Test Kit for determining the susceptibility of shelled corn to growth of fungi as a tool for reducing the risk of a loss in corn quality. Three series of tests were conducted. In the first series, samples of shelled corn collected for grading during the loading of rail cars by elevators were tested. These samples were collected from 29 shipments loaded between October of 2011 and May of 2012. For each shipment, one sample was taken from each hopper car. The total number of samples available from a single shipment varied between 4 and 60 cars. Between 2 and 4 samples (each ~300 g) were selected from each shipment and tested by the ABE Department. First, the moisture content of the shelled corn was determined using the whole kernel oven drying procedure (ASABE S352). De-ionized water was added to the samples to increase their moisture content to 21%. After 24 hours of equilibration, 100 g subsamples were placed in air-tight jars. After an additional 47 hours, which was 71 hours after re-wetting, the lids were removed for one hour to allow the air in the jars to equilibrate to the composition of the ambient air. Beginning at hour 72 and continuing through hour 78, the Solvita® test kit was used to determine the CO_2 content of the air in the jars. A small plastic "paddle" containing a strip of indicator gel that changes color in response to the concentration of CO_2 in the surrounding air was inserted into each jar. The indicator gel color was quantified by a number between 0 and 5.5 with higher color numbers indicating a higher percentage of CO_2 in the air inside the jar. Color numbers were determined by removing the paddle from the jar with minimal disturbance of the air in the jar and inserting it into a Digital Color Reader. The paddle was then returned to the jar.

Figure 1 shows the average color numbers at hours 72 to 78 for the samples from several shipments. The samples and shipments were selected to demonstrate the range in fungal susceptibility encountered from low, where the increase in color number versus time was relatively slow, to high, where the increase was relatively rapid. Figure 2 is a plot of the average color number of the samples from each shipment for each hour after re-wetting. Shipments are plotted in shipment number order. In general, corn lots with higher shipment numbers would have been in storage for longer periods of time. The peaks and dips formed by connecting the individual color number averages indicate variability in susceptibility to mold growth. Trend lines were fit to each hour's readings and the slopes of the trend lines are shown along with the line. The slopes for hours 74 through 78 are positive indicating that, for hours 74, 75, 76, 77, and 78, as the sample number increased (an indication that the corn had probably been stored longer) the color number at that hour tended to increase.

Storing grain in bulk storage units results in grain packing from overbearing pressure, which increases grain bulk density and storage-unit capacity. Packing factors for grains at varying depths in all bin sizes and types are required to determine the mass of grain in storage from bin volumetric measurements and test weights. Due to the increase in storage capacity of a bin from packing, accurate packing factors are crucial for everyone in the industry who is concerned with grain storage capacity and inventory control. This study has compared compaction factors of hard red winter (HRW) wheat and shelled corn in vertical storage bins using three existing methods: a packing model (WPACKING), the USDA Risk Management Agency (RMA) method, and the USDA Farm Service Agency (FSA) warehouse group method. Concrete and steel bins containing HRW wheat were measured in Kansas, Oklahoma, and Texas. Steel bins containing corn were measured in Kansas, Colorado, Iowa, Texas, and North Dakota.

For HRW wheat, packing has been measured in 35 bins of corrugated steel and reinforced concrete with diameters ranging from 4.6 to 31.9 m and grain heights ranging from 2.1 to 42 m. The predicted mass values of compacted stored wheat from the three methods were compared to the reported mass from scale tickets. The maximum and median differences between the WPACKING model-predicted mass and reported mass were -4.7% and -1.3%, respectively, for corrugated steel bins; and +9.7% and +2.2%, respectively, for reinforced concrete bins. In most cases, the model under-predicted the mass in the corrugated steel bins and over-predicted mass in concrete bins. For the existing RMA method, the range of difference was from -3.7% to +11% for steel bins and from -7.2% to +7.8% for concrete bins. The RMA method median difference was +1.9% for steel bins and +1.0% for concrete bins. Most of the data for steel bins (10 out of 19) and for concrete bins (26 out of 37) were over-predicted with the RMA method. For the FSA method the range of difference was from -1.4% to +7.6% with a median of +3.9% for steel bins and from -4.7% to +10.4% with a median of +3.5% for concrete bins. The average magnitude of the difference was 1.6% for WPACKING, 4.4% for the RMA method, and 3.4% for the FSA method for steal bins and 3.7% for WPACKING, 3.2% for the RMA method, and 4.3% for the FSA method for concrete bins containing HRW wheat.

Packing factors have been measured in approximately 50 steel bins for corn with diameters ranging from 3.6 to 32 m and eave heights ranging from 4.4 to 27.7 m. For corn bins, the difference between WPACKING model-predicted mass and reported mass ranged from -4.5% to +4.5% with a median of -0.32%. With about 70% of the corn bins, the model under predicted the mass of grain in comparison with reported mass. For the existing RMA method, the difference between predicted and reported mass of corn ranged from -2.7% to +5.0%, with a median of +0.90%. For the FSA method the difference between predicted and reported mass ranged from -3.3% to +7.1% and the median difference was +1.4%. The average magnitude of the difference was 1.8% for the FSA method, 1.6% for the RMA method, and 0.8% for WPACKING for the corn bins.

Overall, the current WPACKING program provided better predicted mass values than the existing RMA and FSA procedures with these bins. The current data will be used to calibrate the WPACKING model and further improve the predictions. The third beta version of the new software was completed this year. Laboratory tests of grain compressibility are being conducted at the University of Kentucky and are reported separately.

Computer simulations using the discrete element method (DEM) are capable of reducing the large effort and cost of evaluating grain handling issues experimentally. However, adequate particle models have not been developed and validated for most types of grain. Previously, we simulated bulk grain property tests for soybeans and corn kernels, as well as simulated soybean commingling in a pilot-scale boot using discrete element method (DEM) models.

In the current study wheat was modeled using particles comprised of one to four overlapping spheres. Using these models, bulk grain properties (angle of repose, bulk density, and hopper discharge flow) were simulated using DEM with published data on material and interaction properties as inputs. The material properties were particle shape, size distribution, Poisson's ratio, shear modulus, and density. The interaction properties were particle coefficients of restitution, static friction, and rolling friction. Predicted results were compared with published experimental data to determine the most appropriate particle models for simulating bulk behavior of wheat kernels using DEM.

The tests showed that a single-sphere wheat particle model with shear modulus, G, that was within the range of published values (G = 20 MPa), gave the most accurate values of angle of repose (AOR) and bulk density, while maintaining correct hopper flow and relatively high computational speed in the DEM models. This wheat particle model has coefficients of restitution of 0.80, static friction of 0.70 (for particle-particle contact) and 0.35 (for particle-surface contact), and rolling friction of 0.50. The particle size distribution was normally distributed.

Modeling problems where grain is not free flowing and is subjected to severe compression may require the use of particle models with fully realistic values of G. An alternative 1-sphere, high-G particle wheat model with G equal to the mean of published values (G = 210.8 MPa) was developed for these special cases, but the computational times were approximately 77% longer than for the first, low-G, model. Other modeling scenarios, where shape strongly affects the modeling results, may require particles that characterize the wheat kernel shape more exactly. A third model composed of three overlapping spheres was also developed for special cases requiring more a precise kernel shape. This particle model also produced computational times much longer than for the first model. All three particle models were effective in the tests considered (AOR, bulk density, and hopper flow) but the 1-sphere, low-G model was preferable except for the special cases mentioned because of its faster computational times.

Objective 3

Development on the International Center for Grain Operations and Processing, a non-profit entity, continues, with additional partners and supporters added in 2013. The Center aims to serve as the primary education and applied research partner to the global grain handling and commodity utilization industry. Globalization and rapid change in the grain handling industry has provided the need for the Center.

University and private sector agribusinesses continued to utilize our NIRS-based grain component testing service, with 10,529 samples of corn and soybeans submitted from the 2013 crop year. Especially the 2012 crop season had extremes of early moisture, heat, drought and

low humidity, which continued to create quality patterns outside of previous experience. Soybean protein and oil were both somewhat above average so that soybean meal protein remained high, and oil yields per bushel were high as well. Two examples are given in the test plot data from four Iowa counties over the past five years. Each year had a different pattern of quality.

In the U.S., number of grain dust explosions greatly reduced by the implementation of OSHA's Grain Handling Facilities Standard in the year 1987.Extensive awareness programs on potential hazards during grain handling and processing increased the knowledge of workers and supervisors. That standard focused on controlling grain fires, grain dust explosions, and hazards associated with entry into bins, silos, and tanks. Among these, grain dust explosions are considered the most severe hazard potentially causing loss of life and extensive property damage. Larger corporate companies usually have an in-house safety training program. But, small industries do not have a structured safety program to educate their workers on grain dust hazards. A lack of knowledge or awareness about safety threats, viewing regulations as against their independence, outdated handling/processing methods are some of the perceived obstacles to establishing a safety program in the work environment. Kansas State University has a history and tradition of documenting dust explosions in the U.S. and in the past has led the education of the grain processing industry on the perils of dust generation and explosion prevention. K-State has also published a DVD on grain dust explosion which continues to be in great demand in the industry.

Through this awareness creation program, we are focusing educating the workers on practical risk information on dust hazards and develop relevant educational materials to mitigate fatalities and loss in grain handling and processing facilities. Furthermore, we cover the sources of dust generation, handling/conveying equipment maintenance and their relation to dust generation, preventive maintenance in grain and feed handling and processing facilities, OSHA regulations, and NFPA standards. We will also educate supervisors/managers on training their workers and using best training practices to curtail the risk of dust explosion.

Kansas State University has continued to develop and support the *GEAPS-K-State Grain Operations Distance Education Program.* The program has also launched a credentialing component, allowing industry professionals to work through a series of six specific courses, providing them with an overview of the grain industry.

Impacts: This section focuses on actual or intended potential long-term outcomes and impacts. Committees should build information around the activity's milestones, as identified in the original proposal. The report should also reflect on the items that stakeholders want to know, or want to see. List any grants, contracts, and/or other resources obtained by one or more project members as a result of the project's activities. Include the recipients, funding source, amount awarded and term if applicable. If the committee is filing an annual report, the impacts will cover only the current year of the project; for termination reports, list impacts from the entire span of the project.

Additional Definitions of "Impact":

"The economic, social, health or environmental consequences derived as benefits for the intended users. These are usually quantitatively measured either directly or indirectly as indicators of benefits. (An example of an impact would be improved human nutrition for so many individuals through genetically engineering rice to contain the precursors to vitamin A.)"

Source: National Multistate Guidelines - Glossary

"'The quantifiable difference a land-grant program makes in the quality of life for its clients and general citizenry.' Supplementing that brief statement is also the definition of an impact statement: 'A brief document that describes the social, environmental, and/or economic difference that your research, teaching, or extension efforts have made on the public. Specifically, it states your accomplishments and the payoff to society.'"

Source: National Impact Statement Writing Team

Activities: Organized and specific functions or duties carried out by individuals or teams using scientific methods to reveal new knowledge and develop new understanding.

Milestones: Key intermediate targets necessary for achieving and/or delivering the outputs of a project, within an agreed timeframe. Milestones are useful for managing complex projects. For example, a milestone for a biotechnology project might be "To reduce our genetic transformation procedures to practice by December 2004."

Indicators: Qualitative surrogate observations or indirect measures of quantitative performance measures which permit monitoring the achievement of outcomes when direct measurement of performance is difficult, too costly, or not possible. An indicator of cultivar adoption might be seed certification records, rather than actual land area planted to that cultivar.

NC-213 scientists found that NIRS is a rapid nondestructive technique that is able to measure organic substances in minutes. Standard deviation of ethanol yield across typical corn samples was 0.1 gal/bu, which represents $5-7m variation in revenue to a 100m gal per year dry grind ethanol plant. Changes in agronomic practices, such as delayed planting, or increase N fertility can have $2-4m per yr impacts at the ethanol plant, based on compositional changes that drive ethanol yield changes.

Researchers developed lines of corn for organic systems with increased levels of methionine, lysine, and cysteine, deliberately manipulated to break the correlation with total protein. This program was created as NIRS measurement of amino acids in corn has been hampered by the high correlation between the total protein content and the typical amino acid level. When average corn is used to calibrate NIRS analyzers, the calibration estimates the amounts of amino acids for protein level.

NC-213 researchers found that sorghum is an excellent source of a wide variety of bioactive compounds that can be produced in large quantities because sorghum can be easily grown, stored and processed to concentrate its unique components effectively. In addition, they discovered that tortillas containing tannin sorghum brans have good dark color and good acceptability with significantly high levels of antioxidants and dietary fiber.

NC-213 researchers discovered that with the adoption of color image sorting technology, a low cost sorting device for wheat, could be built using a standard personal computer and color camera. Special programming techniques can be used for a high throughput while keeping the sorter cost low. Accuracy is 15 to 20% higher than traditional sorters.

NC-213 researchers created a system that measures insect infestation of wheat kernels using the electrical conductance. The apparatus is low cost (-/+$1500 for parts) and can inspect a one kg sample in less than one minute. A partnership was formed with private industry to produce and market commercial versions of the system. The technology is currently being adopted by a major food manufacturing company.

NC-213 scientists conducted research on automated detection of fusarium head blight or scab damaged wheat kernels. FHB causes yield reductions of up to 50% and crop losses in the US have exceeded $1 billion. In addition, FHB can produce the toxins that must be below FDA guidelines. This technology will help the grain industry detect FHB and improve the safety of the US food supply. The technology can also be used to rapidly screen new wheat lines for FHB resistance.

NC-213 researchers presented at GEAPS 2010, held in Wichita, Kansas in February 2010. This presentation helped bring together GEAPS participants and NC-213 researchers to see how both parties can work together in problem solving grain, cereals, and oilseeds issues. This was a tremendous opportunity for NC-212 as over 1,800 attended the annual international technical conference and exposition. Survey results for this presentation were outstanding.

As a result of work conducted by NC-213 scientists, information from research on DDGS will have an impact on U.S. dry grind ethanol producers. . Understanding the distribution of mycotoxins in wet grains and thin stillage and during corn fractionation will help develop strategies to reduce final mycotoxin concentrations in DDGS and other dry grind coproducts.

NC-213 researchers found that drying wet distillers grains and condensed distillers soluble to DDGS is an energy intensive process which consumes the second largest energy budget in corn to ethanol production. The results from this research will help in optimizing the drying process of DDGS in order to decrease energy consumption, while maintaining product quality.

Through extensive research, NC-213 scientists have found that single seed determination of viability and biotech status could preserve germplasm collections, improve seed quality monitoring, and open significant markets for non-GM grains that were previously inaccessible due to lack of practical testing methods.

Through NC-213 efforts, research has led to a better understanding of wheat flour quality to end-use products. These efforts will have a direct, positive impact as wheat growers will have new and improved agronomic wheat varieties to plant; millers will have wheat with better milling properties to mill; and, bakers will have flour with better baking quality to use. In addition, understanding the effects of the addition of bran fiber in a flour-based system could provide vital information for bakers utilizing these ingredients in their baked products to benefit consumers' health.

Through NC-213 work, an automated single kernel near-infrared (SKNIR) spectroscopic method was evaluated for identification of wheat kernels damaged by *Fusarium* fungi and for estimating the toxin deoxynivalenol (DON), that Fusarium produces. The kernels identified by the SKNIR system as FDKs had a better correlation than visual FDK % with other FHB assessment indices such as FHB severity, FHB incidence and kernels g-1. This technique can be successfully employed to non-destructively sort kernels with fusarium damage and to estimate DON levels of those kernels. In addition, because the method is non-destructive, seeds may be saved for generation advancement.

NC-213 scientists developed a method that simplifies and reduces cost of development calibrations to automatically measure grain and soybean composition. This method is being used at the University of Kentucky to measure soybean breeder samples oil and protein content and this method is being used at Iowa State University for single seed measurement.

NC-213 research resulted in the commercialization of sorting technology and adoption by seed breeders/producers. A low cost color image based sorting device for grains was refined, commercialized, and transferred to a manufacturing company through a Cooperative Research and Development Agreement with National Mfg. who has sold over ten of these machines to various seed breeders and seed foundations in the US and internationally. The new sorting system has unprecedented accuracy, throughput, and low cost for inspection/sorting systems.

NC-213 researches at North Dakota State University, through a Cooperative Research and Development Agreement, are working with Jolly Time Popcorn to adapt a sorting machine for popcorn. The system is also being used by US and international scientists. The camera design has been transferred to an electronics manufacturer (Short Dog Electronics). NDSU seed foundation states that the machines shortened production time for yellow flax by one year, increased production by 20%, and reduced contaminates by 90% over past practices.

Through research results, a commercially viable CO_2 monitoring sensor and system for grain storage structures was created and in late 2010, the system was introduced commercially on a limited scale through a licensing agreement between the developer (BinTech, Boulder, Colorado) and The GSI Group (Assumption, Illinois) as the exclusive distributor.

Research conducted in this program showed that a less expensive, user-friendly calibration and validation process will increase the feasibility of using NIRS analysis in many operating situations. If multiple models and makes of instruments can be approved for trade use, the total cost of testing will be competitively reduced and further enhance industry support services for analytical applications in bioindustries.

The results obtained from this preliminary assessment of Raman spectroscopy combined with chemometrics showed that this spectroscopic technique is an excellent alternative for a rapid and low-cost analytical method to detect aflatoxins in grains over conventional spectroscopic and standard wet chemical methods. Raman spectroscopic methods may allow fast qualitative and quantitative evaluation of mycotoxin substances to provide real-time monitoring for mycotoxins in grains and oilseeds at receiving points.

NC-213 scientists and engineers (USDA, Manhattan, KS) successfully built and demonstrated a new type of electronic sorting machine that can detect and separate many types of weed seeds, discolored seeds, and fungal infected seeds. This new capability has been demonstrated to and adopted by breeders and producers of grass seed, flax seed, alfalfa seed, pulses, corn seed, soybean seed, and wheat seed. Additionally, a popcorn producer is evaluating the technology for removing fungal damaged popcorn kernels.

Research conducted by NC-213 investigators resulted in an automated single kernel near-infrared (SKNIR) spectroscopic method being developed to identify wheat kernels damaged by Fusarium fungi and to estimate the toxin deoxynivalenol (DON) levels. Breeders throughout the US are using this technology to study scab infections, objectively score breeding lines, and to select resistant seed.

Research results by NC-213 have clearly demonstrated that CO_2 sensors can detect grain spoilage due to insects and molds prior (3-4 weeks) to detection by traditional methods such as visual, smell and temperature sensors.

Researchers at Iowa State collaborated with industry users of NIRS units/calibrations. Through this collaboration, the users were able to increase their operating efficiency, thus quickly recouping the cost of the process in discounts or improvements in ingredient quality for suppliers. In addition, NC-213 scientists at Iowa State have been able to make samples and calibration support available to the public, thus increasing the pace of NIRS instrument development. This availability will benefit both users and vendors alike.

NC-213 scientists discovered that Raman spectroscopy method combined with chemometrics, demonstrates that this technique is a rapid and non-destructive analytical method to detect fumonisins in maize over conventional spectroscopic and standard wet chemical methods. Raman spectroscopy as an easy, rapid, and inexpensive screening system for fumonisins and other mycotoxins can be a powerful tool for quality control of grains and oilseeds throughout the entire marketing chain to improve the safety of feed and food products supplied to consumers.

NC-213 researchers at Washington State University discovered that both dried egg powder and frozen eggs were identified as potential replacement of fresh eggs in Sponge Cake (SC) baking tests. SC baking tests using dried egg powder in substitute of fresh eggs can effectively differentiate wheat flours of different baking quality, despite a decrease in SC volume. Frozen eggs produce similar volume of SC to fresh eggs, so this is proven to be a suitable substitute of fresh eggs in SC. Research also proved that Bostwick flow distance of flour-water batter can be an effective and efficient predictor of SC baking potential of soft white wheat flour.

Research conducted by NC-213 scientists (USDA, ARS, CGAHR) focused on the production of wheat-free foods containing added nutraceutical compounds. A sorghum bread formula optimized to contain high levels of tannin, containing sorghum, resulted in bread with increased fiber and anti-oxidant levels. Development of this type of bread provides individuals suffering from Celiac Disease (a glutin allergy) with a bread that has improved nutritional properties while

providing sorghum producers an avenue to utilize high tannin sorghum lines for human food markets.

Careful evaluation of the grain and flour traits are important to select the appropriate attributes for Chinese noodle production. Research showed Sorghum is similar to other grains in terms of characteristics that dictate end product quality and application. Knowing grain quality, flour quality and end-use application are necessary in hybrid selection. Through control of starch damage and flour particle size, it is possible to manufacture sorghum flour based gluten free Chinese noodles with high quality physical attributes making sorghum more marketable.

Through the training efforts of NC-213 researchers at Iowa State University, U.S. Food and Drug Administration inspectors now have a better understanding of the real and potential food safety risks associated with feed production. Course reviews indicated that about 50% of the material could be made available via distance education, and would provide a wider distribution than onsite education. Researchers proved that this course offering is beneficial to the FDA in creating a better understanding of agriculture.

As a result of collaboration among NC-213 scientists and engineers (Purdue University, Kansas State University, North Dakota State University, Oklahoma State University, Iowa State University, USDA-GIPSA, and USDA-ARS) courses are continuing to be developed for the successful GEAPS-KSU Grain Operations Distance Education and Professional Credentialing Program. The partnership has had 1,500 participants from 23 countries enrolled in seventeen courses offered 53 times with a completion rate of 86%. In 2012, thirteen courses were offered between January and November including two new courses.

NC-213 researchers have proven that early detection of grain spoilage will reduce grain quantity and quality losses, decrease mycotoxin production in the food chain, and avoid financial loss by applying timely storage management, such as aeration. It has been reported that monitoring CO_2 concentration in the headspace of the storage bin with a CO_2 sensor can lead to earlier detections of grain spoilage compared to temperature monitoring. CO_2 monitoring in bulk grain in silo bags is even more important since it is in indicator of whether hermetic conditions are being maintained. This study provides values of CO_2 diffusivity through bulk corn at different temperatures and grain moisture contents, including estimates of CO_2 production by corn respiration, which lead to less losses in grain quality.

NC-213 scientists that have offered Industry users of Near Infrared spectroscopy (NIRS) assistance increased their operating efficiency, and quickly recouped the cost of the NIRS units/calibrations in discounts or improvements in ingredient quality for suppliers.

Research conducted by NC-213 scientists has shown that by reducing the levels of mycotoxins in distiller's grains, it will provide ethanol plants another means of managing the impact of outbreaks of mycotoxins to DDGS, and thus increase the marketability of DDGS co-products. This is achieved by the effectiveness of screen cleaning, density sorting, and color sorting that will allow processors to estimate the cost associated with achieving various levels of reduction. When information on the effectiveness of these methods has been obtained and the appropriate treatment protocols have been developed it will permit processors to select the best method of

reducing mycotoxin levels of corn processed in their facilities.

NC-213 research has proven that by identifying the impact of sorghum polyphenol composition and processing on flatbread nutritional and sensory quality results in innovative sorghum utilization to improve health attributes (e.g., reduced impact on blood sugar and calorie intake) of baked goods.

Protein digestibility in sorghum remains an important factor regarding the end-use quality of sorghum for food, feed, and fuel. Screening of a diverse set of sorghum lines for digestibility resulted in the discovery of germplasm with high levels of inherent digestibility and provided a sample set allowing NC-213 researchers a sample set to identify factors that govern protein digestibility. Information gained from this research can be used by the sorghum breeders to develop varieties exhibiting enhanced digestibility traits.

Research conducted by NC-213 scientists has shown that corn contaminated with toxigenic strains of A. flavus can result in great losses to the agricultural industry and pose threats to public health. Researchers' efforts provided a rapid, non-destructive method for screening corn at elevators and at grain collection points, identifying and diverting contaminated grain into alternative uses, thereby protecting the food supply and increasing producer profitability.

NC-213 experts from Purdue University, Kansas State University, North Dakota State University, Oklahoma State University, Iowa State University, USDA GIPSA, and USDA ARS formed the GEAPS-KSU Grain Operations Distance Education and Professional Credentialing Program. This program continues to be a success. Since inception approximately seven years ago, the program has had almost 2,000 participants from 27 countries enrolled in twenty courses offered seventy-one times with a completion rate of 85%. Courses are also being translated in Spanish, with two offerings scheduled in 2014 as well.

Publications: For SAES-422 reports list the publications for **current** year only (with the authors, title, journal series, etc.). If the list exceeds the maximum character limit below, an attachment file may be used. (Max characters = 50,000. Single line breaks are not preserved, use double line breaks instead or use a <p> tag to separate paragraphs.)

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Authorization: Submission by an AES or CES director or administrative advisor through NIMSS constitutes signature authority for this information.
*Limited to three pages or less exclusive of publications, details may be appended.

APPENDIX D -1

Description of SAES-422 NIMSS for Termination Reports

The Annual Accomplishments report is submitted each year of an activity's duration and is due 60 calendar days following the annual meeting.

The **Termination** report may be submitted following the annual meeting during the project's final year, but is due no later than March 31 following the termination date of the project. The **Termination** report replaces the Annual Accomplishments report for the final year.

Fields with asterisks (*) are required. If you are adding attachments (for participant lists, meeting minutes, or publications) you will need to add them before you submit as a working copy or final.

For **Termination** reports, provide a comprehensive summary of all accomplishments and impacts of this project, particularly related to each original objective as described in the project outline. Other pertinent information may be reported, such as extension activities, extramural funding or intellectual property generated, etc. If any grants or contracts were acquired as a direct result of this project's activity during this project period, list granting agency, title of project, duration (eg. 1999 _ 2003), and award amount. Also, indicate if there are plans to develop a new or revised MRF project in this area research.

Termination reports should include an impact statement(s) that reflects the overall impact of the project.

For **Termination** reports, list **all** significant publications resulting from the project. If this list exceeds the maximum character limit below, an attachment file may be used. Max characters = 50000. Single line breaks are not preserved, please use a double line break to separate paragraphs.