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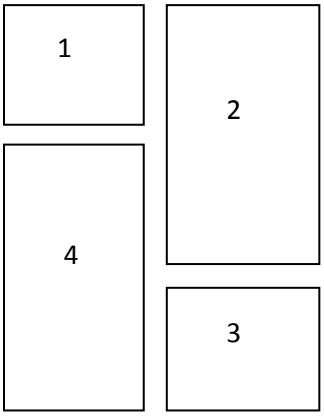
National Program 306
Quality and Utilization of Agricultural Products

Accomplishment Report 2008-2012

Captions of front page photos, clockwise from upper left:



1. Tara McHugh, research leader for the Processed Foods Research Unit, casts carrot wrap into rolls. *Photo by Peggy Greb/ARS.*

2. Technician Debra Stamm (right) feeds a sheet of wood into a glue spreader where it will receive an even coating of vegetable-based glue before being laminated to another sheet to form plywood. Chemist Mila Hojilla-Evangelista watches and waits to receive the piece as it exits. *Photo by Don Fraser/ARS.*

3. A seed company employee sprays a test plot with one of the cotton-based hydromulches developed by ARS during the research study on value-added processing of cotton gin byproducts. *Photo by Greg Holt/ARS.*

4. Roberto Avena-Bustillos, a collaborating researcher from the University of California-Davis, places an antimicrobial edible film into a small dish within a larger dish of spinach leaves inoculated with E. coli O157:H7. The larger dish is then sealed to evaluate the efficacy of antibacterial vapors released from the film. *Photo by Peggy Greb/ARS.*

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BACKGROUND AND GENERAL INFORMATION

To ensure the economic viability and competitiveness of U.S. agriculture, it is important that the quality and utilization of harvested agricultural commodities be maintained or enhanced. The U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) recognizes this and has established the Quality and Utilization of Agricultural Products National Program (NP 306) as the research link between farmers' fields and use by the consumer. The goal of NP 306 is to enhance the value and quality of the agricultural products consumers need and want by enhancing marketability, creating environmentally friendly and efficient processing, and expanding domestic and global market opportunities through the development of value-added foods, fibers and hides, and nonfood bioproducts.

NP 306 research findings contribute quality measures and product utilization outcomes applicable to many of ARS' National Programs. NP 306 is able to do this because the Program has one of the most diverse compositions of scientific disciplines within ARS, comprising biologists, biochemists, chemists, engineers, food science and technologists, molecular biologists, and plant physiologists. Significant contributions to NP 306 also come through teams of scientists from other National Programs with specialties in agronomy, genetics, horticulture, plant pathology, and human nutrition.

The research within NP 306 is shared among the 192 scientists and engineers who are assigned to its 71 projects. The laboratories and fields in which they work are located in 16 States.

The array of scientific expertise within NP 306 provides the necessary knowledge to conduct and generate meaningful research outcomes in three broad overarching areas:

- Technologies that define or enhance postharvest food quality/marketability/processing and generate new bioactive/functional foods;
- New or improved products from or processes for wool, hides, and cotton fibers; and
- New or improved non-food biobased products from agricultural materials and byproducts.

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In addition to having strong, productive collaboration with other National Programs and scientific disciplines, NP 306 is diverse in commodity-specific industry interactions that enhance postharvest value. These extensive collaborations with industry and fellow university scientists have generated numerous patents and brought many products to the marketplace.

PLANNING AND COORDINATION FOR THE NP 306 5-YEAR CYCLE

In June 2008, NP 306 National Program Leaders (NPLs) and scientists met with stakeholders from industry, universities, and other government agencies to assess the past performance of this National Program and to develop a list of needs to help guide the direction and focus of the Program during the next 5-year management cycle. Many of the research needs identified by stakeholders over the past several years continue to be relevant today and are addressed in the current Action Plan. However, new research needs were also identified in response to changes in our society, economy, and environment. Of primary concern was the need for NP 306 research to develop technologies to better measure or enhance the quality of food, fiber, and biobased products after harvest. Similarly, stakeholders expressed interest in increasing the marketability and value of commodities by ensuring that value-added food products (such as fresh-cut or minimally processed produce) retain sensory quality and nutritional value and are free from food safety hazards.

Incorporating the NPLs' knowledge of the science subject matter with input from other ARS scientists and customer/stakeholder interactions, the Action Plan writing team identified the priority needs that could be realistically addressed with ARS resources and base funding. These individual research needs were aggregated into problem statements under each of the three research components defined below. The final Action Plan guided development of new NP 306 research projects that began the current 5-year research cycle in 2008.

The 71 individual Project Plans include statements about the agricultural problem being addressed, the anticipated products to be generated, the planned research contributions for mitigating or solving the larger NP 306 Problem Statements, and timelines and milestones for measuring progress toward achieving project objectives. In compliance with the Agricultural Research, Extension, and Education Reform Act of 1998, each of the Project Plans was evaluated for scientific quality and feasibility by external peer review panels. Project Plans were subsequently revised in accordance with recommendations of the review panel before implementation. The next 5-year research cycle for NP 306 will begin with a new Action Plan to be written in October–December 2013, and new Project Plans will be developed in mid-2014.

ARS NPLs function as the NP 306 leadership team that coordinates research with the 34 research units (laboratories) located throughout the United States with projects in this Program. The NPL team also coordinates NP 306 activities with other National Programs and with other outside agencies and universities.

STRUCTURE OF NATIONAL PROGRAM 306

To accomplish the goals established in the NP 306 Action Plan, projects were placed into one of the three component areas by research objectives grouped around food, fiber, and biobased products:

Component 1: Foods

Food quality is the composite of those well-being attributes that contribute to the acceptability of a product by the customer. Thus, it becomes essential to identify and define those attributes contributing to appearance (pigments, surface components), flavor (including components of aroma and the basic tastes of sweet, sour, bitter, astringent, and savory), and human health (plant bionutrients) before one can measure quality or establish quality standards or grades. In this component, ARS researchers attempt to understand the relationships between chemical, physical, and sensory attributes that impact consumers' perception and consumption of foods. Also researchers engage in the development of new machines and detection methods to objectively identify, define, and measure quality attributes and defects in grains, vegetables, and fruits. These measures are important to rating quality and understanding the underlying processes involved in quality loss and retention and possible enhancement in grains and fresh, fresh-cut, and minimally processed foods. As consumer preferences change, an understanding of the role of changing food composition in determining quality never loses its importance.

Component 2: Fibers (including hides)

Globalization of production and markets for raw cotton and wool, yarn and its derived and finished products, raw animal hides, and finished leather products has resulted in new challenges for the U.S. fiber and hide industries. These challenges include high relative energy and labor costs, environmental imperatives, maintaining and improving current product quality, developing new processes and products, and improving management and utilization of waste and secondary products. ARS scientists have sought to enhance product quality preservation through development of improved harvesting, processing, and storage technologies; better quality measurement and grading systems; and increased understanding of basic fiber structure and properties. They have also developed more environmentally friendly finishing technologies and new applications and products for hides, agricultural fibers, and their byproducts.

Component 3: Biobased Products

Opportunities for the development and use of biobased, environmentally sustainable products and processes are increasing as consumers become more aware of their long-term benefits. These products and process help to decrease our country's dependence on imported petroleum and can more fully utilize the vast agricultural resources produced by U.S. farmers and ranchers. New policy incentives, such as the BioPreferred Program administered by the USDA, help to stimulate and give preference to the use of biobased products by government agencies. The goal of the research in this Component is to identify and characterize suitable agricultural feedstocks and develop cost-effective technologies that will yield functional industrial and consumer products that satisfy these demands. ARS scientists have been successful in developing many non-food, non-fuel, industrial and consumer products with cost and performance features comparable or superior to those of petroleum-based products.

RELATIONSHIP OF NP 306 TO OTHER NATIONAL PROGRAMS

Research in NP 306 helps scientists in other National Programs by quantifying product bionutrient and marketable quality attributes, as well as developing measurements and processes relevant to their research. Some of that assistance is illustrated in Figure 1 and detailed below.

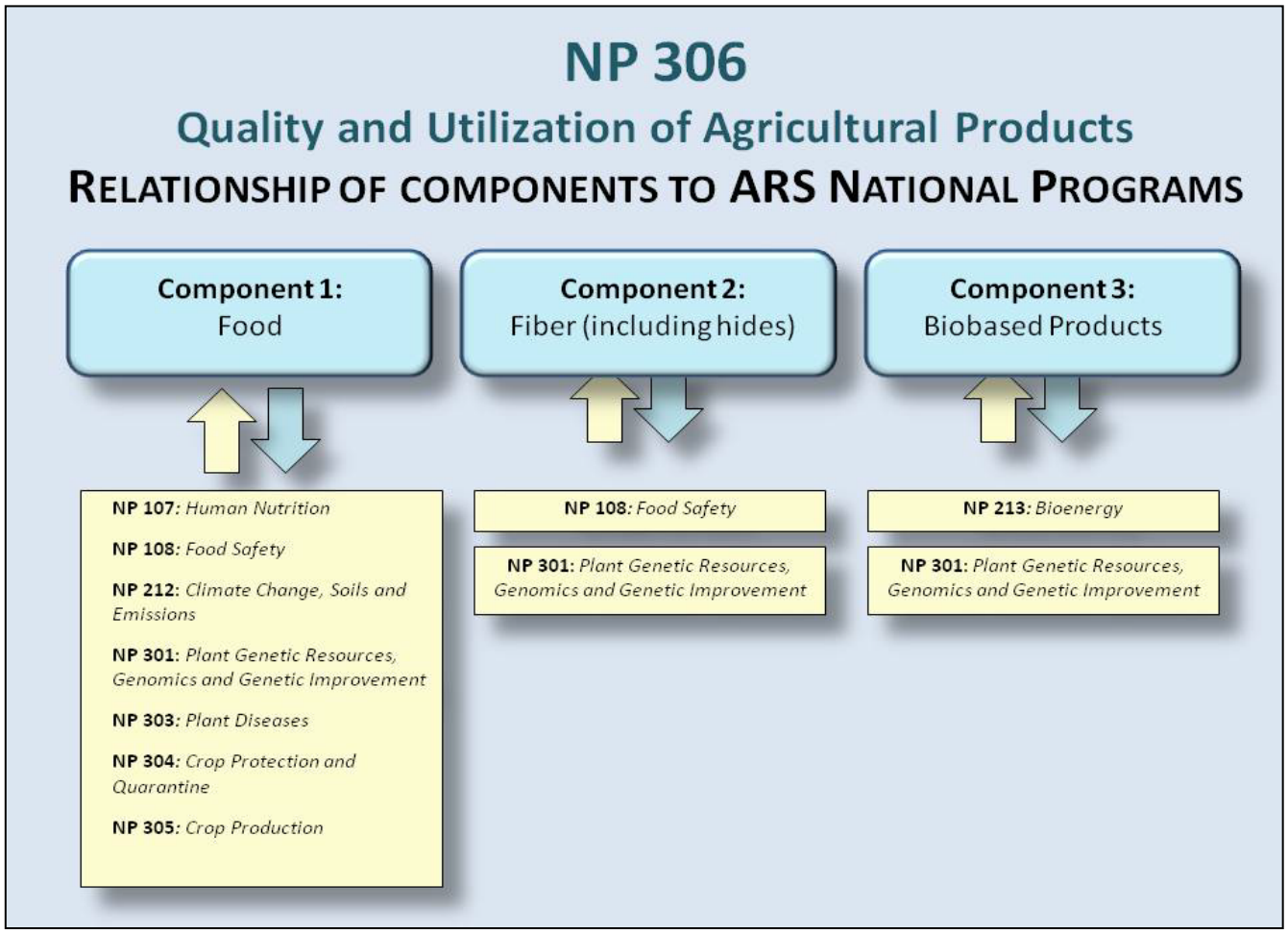

FIGURE 1: Association among other ARS National Programs both contributing to and receiving assistance from the three components of National Program 306–Quality and Utilization of Agricultural Products.

- **NP 107–Human Nutrition:** Prior to recommending or using new plant-based foods and varieties, processed foods, or new food-handling procedures, researchers in this National Program rely on NP 306 scientists to establish the changes in sensory (consumer acceptance) and nutritional composition (bioactive compounds) and to establish quality standards.
- **NP108–Food Safety; NP 303–Plant Diseases; and NP304–Crop Protection and Quarantine:** The scientists in these National Programs who develop treatments (chemicals, temperatures, and modified gas atmospheres) to control enteric bacteria; fruit, vegetable, and grain diseases; and quarantined pests collaborate with NP 306 scientists to establish treatment tolerances so as to avoid adversely affecting the nutritional/marketable quality of agricultural foods and bioproducts.
- **NP 212–Climate Change, Soils and Emissions; and NP305–Crop Production:** NP 212 and 305 scientists who measure changes in climate, soils, atmospheric gas emissions and who develop production systems (e.g., organic and conventional) rely on NP 306 scientists to establish resultant "cause-and-effect" changes in food and fiber end-product quality and the suitability of agricultural resources for bioproduct development.

- **NP 213–Bioenergy:** NP 306 scientists select and determine suitability of feedstocks and cellulosic plant sources utilized in technologies developed by researchers in NP 213 projects for hydrolyzing/producing fermentable sugars that can be commercially converted into non-fuel industrial products.
- **NP 301–Plant Genetic Resources, Genomics, and Genetic Improvements:** NP 306 scientists collaborate with NP 301 scientists in establishing the impact of genetic changes and modifications—intended or unintended—on end-product physiology as well as appearance, flavor, bionutrient quality, and functional use of bioproducts.

HOW THIS REPORT WAS CONSTRUCTED AND WHAT IT REFLECTS

The NP 306 Accomplishment Report is a distillation of some of the most significant accomplishments of the past 5 years by ARS scientists working on the Program's goals. It is a 5-year snapshot of the research conducted during this period and its early benefits. In a report on the value of agricultural research (www.ers.usda.gov/publications/eb10/eb10.pdf), the USDA Economic Research Service pointed out that the benefits of research usually trail its completion by 5 to 10 years because it often takes that long before the technology is completely developed, transferred, and adopted by end-users. It is important to recognize that benefits often increase over a number of years after the completion of the research and that they remain constant for a significant time before declining as newer technologies become available. Thus the accomplishments and breakthroughs in this report are unlikely to reflect all of the resulting impact of the research.

Most of the accomplishments described in this report were cited in NP 306 annual reports issued over the past 5 years, but this report stresses the impacts of those accomplishments and, where relevant, cites key publications or associated Web links. The accomplishments presented in this report are organized under the relevant Components and Problem Statements described in the NP 306 Action Plan.

Appendix 1 lists the research projects in NP 306, organized by the ARS project number. Publications associated with each of the projects are listed in Appendix 2, by project. Appendix 3 lists patents issued during this report period and information about how NP 306 research aligns with the ARS Strategic Plan.

This report was prepared for an external (to ARS) retrospective review of NP 306 to assess how well it attained its projected goals, as outlined in its current Action Plan. The purpose of the retrospective review is not to judge the performance of individual NP 306 research projects, but rather to gauge the overall impact of the Program. Consequently, the report does not attempt to catalogue all the individual accomplishments reported by the scientists assigned to NP 306's research projects.

In the same way that only selected accomplishments are reported, details of those accomplishments are selected and summarized to illustrate the overall variety of products and knowledge generated by this National Program. In some instances, the results from an individual study focusing on a specific problem are described, whereas in other instances, similar research or achievements are aggregated across the Program. Individual researchers or projects are not identified by name in the narrative text; rather, their achievements are described in the context of contributions towards accomplishing the Program's stated commitments to U.S. agriculture.

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COMPONENT 1: Foods

The research of the projects aligned with Component 1 integrate physical, chemical, biochemical, environmental, and genetic factors that influence nutritional and commercial quality of edible plant-based foods. In this Component, ARS scientists and engineers focus on solving four food problems areas: (1) defining and measuring quality, (2) preserving/enhancing quality and marketability, (3) creating new bioactive ingredients and functional foods, and (4) developing new and improved processing technologies.

Summaries of a select sub-set of numerous significant accomplishments made by ARS scientist and engineers—often in collaboration with university and industry scientists—are highlighted on the following pages where they support the anticipated food product. The products of this research are used by growers, extension specialists, and Federal, State, university, and industry researchers and regulators.

During this 5-year period, ARS scientists have made significant advancements in:

1. Defining and Measuring Quality: Enhancing flavor and sensory quality with tomato and peanuts; improving assessments/standards of quality with wheat, barley, and oats; determining genetic quality of barley and apple; improving accuracy of sampling quality with soybeans, oilseeds, wheat, corn, flax, and barley; creating the first moisture sensory technology for peanuts and almonds; and improving technologies to remove quality contaminants of wheat and corn.

2. Preserving/Enhancing Quality and Marketability: Reducing quality deterioration in citrus during storage; improving apple storage quality; protecting table grapes and small fruits from pests; improving quality packing with edible fruit-based films; and enhancing postharvest quality of mushrooms, melons, and wheat.

3. New Bioactive Ingredients and Functional Foods: Enriching functional food quality with whey proteins and grape-seed flour; characterizing and developing markers for new bioactive quality of cheese, blueberries, strawberries, and watermelon; improving varieties/sources of quality with potatoes, strawberries, and oranges; and developing health-promoting, quality food using corn, oats, and soybeans.

4. New and Improved Food Processing Technologies: Developing energy-wise processing with dairy and vegetables; improving/enhancing nutritional quality of rice, oranges, sunflower, and mushrooms; and controlling spoilage/human pathogens with eggs.

ARS projects in the following locations conducted research contributing directly to NP 306 in this component: Albany and Parlier, California; Fort Pierce, Florida; Athens and Dawson, Georgia; Peoria, Illinois; Manhattan, Kansas; New Orleans, Louisiana; Beltsville, Maryland;

East Lansing, Michigan; Oxford, Mississippi; Raleigh, North Carolina; Fargo, North Dakota; Wooster, Ohio; Wyndmoor, Pennsylvania; Pullman and Wenatchee, Washington; and Madison, Wisconsin.

The NP 306 Action Plan detailed 30 Anticipated Products in the four Problem Statements of Component 1 that were expected to result from this research. These Anticipated Products now serve to help measure the National Program's progress during the past 5 years in meeting the needs of food quality research and industry. Under each of the Problem Statements, the report lists the Anticipated Product and the accomplishments that highlight progress in meeting that goal.

PROBLEM STATEMENT 1.A: *Define and Measure Quality.*

The quality of a food derives from measurable chemical, nutritional, physical, and sensory properties and their complex interactions. Quality is the composite of those attributes and its latent ability to be efficiently milled, malted, baked, cooked, or otherwise processed into appealing, flavorful foods and beverages. Inaccurate or uninformative quality assessment methodologies are detrimental to producers, processors, and, ultimately, consumers of food products. Quality is assessed and measured at many points from the farm through processing to final packaging and marketing. Quality assessment often requires destructive sampling, expensive equipment, technically advanced protocols, and skilled labor—all of which increase final cost to the consumer. NP 306 technologies link crop and animal improvement programs with the food processing industry and consumers. ARS research develops, evaluates, and implements methods to accurately define and measure food quality for research, production, and manufacturing programs that improve food quality each step of the way from the farm to the consumer.

Anticipated Product 1: *Product quality descriptions and assessments based on measurable chemical, nutritional, physical, and sensory attributes.*

Chemical and sensory analyses of tomato. Tomato is the second largest vegetable crop in dollar value in the United States, with a fresh and processed market value of more than $2.0 billion in 2011. Although tomatoes are highly consumed, fresh fruits are often low in flavor. Using chemical and sensory analyses, ARS scientists in Albany, California, identified and quantified the important aroma factors responsible for fresh tomato flavor. They found that highly appetizing, flavorful tomatoes had high concentrations of decadienol and furanone compounds, with low concentrations of methional, phenylacetaldehyde, 2-phenylethanol, or 2-isobutylthiazole compounds. This fundamental knowledge will help plant breeders, with the aid of food scientists, to assist growers in developing cultivars with the highest consumer preference. As an off-shoot of this research, the ARS scientists are working with Del Monte to train industry flavor chemists to help standardize processed tomato flavor analyses.

Mayer, F., Takeoka, G.R., Buttery, R.G., Whitehand, L.C., Naim, M., and Rabinowitch, H.D. 2008. Studies on the aroma of five fresh tomato cultivars and the precursors and *cis*- and *trans*-4,5-epoxy-(*E*)-2-decenals and methional. Journal of Agricultural and Food Chemistry 56:3749-3757.

Breeding for good roast peanut flavor. Peanuts are highly consumed, but they are not considered as nutritious or flavorful as tree nuts. ARS scientists in Raleigh, North Carolina, analyzed unified peanut production trials on 235 peanut lines for moisture, fat, tocopherols (vitamin E), sugars, fatty acids (flavor) profiles, and sensory characteristics. These quality data, which also impact human health, are critical in developing new peanut varieties and have been used in the development of several released lines with improved roasted peanut flavor. This work is done every year for peanut breeders, on all 235 lines, across the nation. These analyses have been credited with assisting in the development of two peanut variety releases with higher human health and flavor characteristics. An annual research report (on peanut physical properties of the 235 peanut lines), published by ARS scientists in Dawson, Georgia, is on the Web at: http://152.1.118.27/downloads.htm.

Isleib, T.G., Tilman, B.L., Pattee, H.E., Sanders, T.H., Hendrix, K.W., and Dean, L.O. 2008. Genotype-by-environment interactions for flavor attributes of breeding lines in the Uniform Peanut Performance Test. Peanut Science 35:54-59.

Isleib, T.G., Tilman, B.L., Pattee, H.E., Sanders, T.H., Hendrix, K.W., and Dean, L.O. 2008. Genotype-by-environment interactions for seed composition traits of breeding lines in the Uniform Peanut Performance Test. Peanut Science 35:130-138.

Anticipated Product 2: ***New laboratory and pilot scale food processing methods to better replicate commercial processes and improve bench-top evaluation of cultivars, harvest methods, storage and processing procedures.***

Sugar-snap cookie method revision. The "sugar-snap cookie method" is an industry standard bake-test method widely used by the American Association of Cereal Chemists for determining soft wheat quality. A smaller-scale, rapid sugar-snap cookie baking method is needed to accommodate the ever-increasing range of available soft-wheat varieties. ARS scientists in Wooster, Ohio, and Pullman, Washington, led the methods development and coordinated the approval tests to revise a bake-test that is more uniform and more reliable than the previous method for soft wheat types in the United States, Europe, Latin America, and China. This revised bake-test method will improve and hasten progress in selecting better germplasm from other countries for incorporating into breeding programs that have potential to improve U.S. wheat value.

Kweon, M., Donelson, T., Slade, L., and Levine, H. 2010. Micro-sugar-snap and micro-wire-cut cookie baking with trans-fat and zero-trans-fat shortenings. Cereal Chemistry 87(5):415-419.

AACC International. 2010. *Approved Methods of Analysis*, 11th Ed. Method 10-52-02 Baking quality of cookie flour-Micro Method. AACC International: St. Paul, Minnesota.

Bettge, A.D. and Kweon, M. 2009. Collaborative study on updated method 10-52: Baking quality of cookie flour-Micro Method (Sugar-snap cookie). Cereal Foods World 54 (2):70-73.

Microplate method for analysis of beta-glucan in malted and unmalted cereal grains, including barley and oats. Due to the recent heart health claims extended to both barley and oats relating to their content of beta-glucans, there is a need for a simplified, efficient test

utilizing standard laboratory instrumentation to quantify beta-glucan in grains. A method developed by ARS scientists in Madison, Wisconsin, uses microplate fluorometers (commonly available in research laboratories) and simple, inexpensive reagents to measure beta-glucan, resulting in an analytical procedure much more widely available than the current flow-injection-analysis methodology. Although this technology has not been adopted as an official method by the Barley Malting Board, it is being used by breeders at Montana State University and North Dakota State University for determining barley malting traits.

Schmitt, M.R. and Buddle, A.D. 2009. Calcofluor fluorescence assay for wort β-glucan in microplate formate. Cereal Chemistry 86(1):33-36

Schmitt, M.R. and Wise, M.L. 2009. Barley and oat β-glucan content measured by calcofluor fluorescence in a microplate assay. Cereal Chemistry 86(2):187-190.

Anticipated Product 3: ***Baseline food composition information on effects of storage and postharvest processing.***

More accurate assessment of flour quality. Occasionally, analytical testing methods contain errors that become entrenched over the years. In a collaborative study, ARS scientists in Pullman, Washington, identified an error in the "Solvent Retention Capacity" method that is used extensively in both variety development and in industry to define the potential flour utility in baking. The official method was corrected and communicated to users, and the implications of the correction were evaluated. This corrected method will allow for a more accurate and reliable assessment of flour quality.

Haynes, L.C., Bettge, A.D., and Slade, L. 2009. Soft wheat and flour products methods review: solvent retention capacity equation correction. Cereal Foods World 54:174-175.

ACC International. *Approved Methods of Analysis,* 11th Ed. Methods 56-11.02 Solvent retention capacity profile, and 56-10.02 Alkaline water retention capacity. AACC International, St. Paul, Minnesota.

Development of improved wheat germplasm. Wheat producers, milling and baking industries, and overseas customers require high standards of wheat quality to meet their evolving needs. ARS scientists in Fargo, North Dakota, contributed wheat end-use quality data that helped lead to the development of improved wheat germplasm and a subsequent release of new cultivars of spring, winter, and durum wheat bred for commercial production. The scientists ran more than 40 different tests related to the physical and biochemical quality traits of the wheat kernel and related milling performance and flour (semolina, dough, baking, and spaghetti) processing on over 4,000 samples of hard spring, hard winter, and durum wheat lines supplied by public and private wheat breeders and cooperating scientists. They found that protein quality is the most important marker of milling and baking quality. The impact lies in the use of the ARS milling and baking quality method to certify five recently released experimental lines of spring wheat, including the South Dakota State University cultivar 'Brick', as superior to existing commercial cultivars in protein quality. ARS scientists have furthered this research, in collaboration with breeders and geneticists, by developing a rapid evaluation method for the precise determination of wheat protein quality, as well as other quality factors using population mapping techniques.

Soon to be completed, these rapid evaluation methods will greatly enhance segregation of quality wheat lines in current breeding programs.

Ohm, J.B., Simsek, S., and Mergoum, M. 2012. Modeling of dough mixing profile under thermal and nonthermal constraint for evaluation of breadmaking quality of hard spring wheat flour. Cereal Chemistry 89:135–141.

Liu, Y., Ohm, J.B., Hareland, G., Wiersma, J., and Kaiser, D. 2011. Sulfur, protein size distribution, and free amino acids in flour mill streams and their relationship to dough rheology and breadmaking traits. Cereal Chemistry 88:109–116. DOI:10.1094/CCHEM-06-10-0086.

Ohm, J.B., Hareland, G., Simsek, S., Seabourn, B., Maghirang, E., and Dowell, F. 2010. Molecular weight distribution of proteins in hard spring wheat: relationship to quality parameters and intra-sample uniformity. Cereal Chemistry 87:553–560. www.aaccnet.org/cerealchemistry/update/ccupdate37.htm.

Anticipated Product 4: ***Identification of plant and animal genes that affect the quality of food*** (in cooperation with National Program 301)**.**

Generation of malting quality data for the Barley Coordinated Agricultural Project (CAP). The Barley CAP is a broad, integrated project for the barley research community that involves 30 research programs from U.S. institutions and integrates genotypic and phenotypic information to develop more efficient tools for barley improvement. In the last 4 years, ARS scientists in Madison, Wisconsin, provided phenotypic (malting quality) data on over 5,100 lines submitted by participating U.S. public-sector barley breeding programs. These data are used in conjunction with other phenotypic data (agronomic, disease resistance, and food/feed quality) and detailed genotypic characterization to develop a comprehensive data set that links the genetic basis for phenotypic performance in a crop where a full genome sequence is not available. In 2011, the Barley CAP received the USDA Secretary's Honor Award for helping to promote sustainable agricultural production. This project will benefit researchers' understanding of genetic trait linkages with important performance features, and growers' development of malting barley varieties that comply with malting quality specifications while meeting disease resistance and agronomic standards. Eventually, this information will help the malting and brewing industries by providing suitable quality malting barley varieties. Barley CAP information is available at www.barleycap.org.

Gutierrez, L., Cuesta-Marcos, A., Castro, A.J., von Zitzewitz, J. Schmitt, M., and Hayes, P.M. 2011. Association mapping of malting quality quantitative trait loci in winter barley: positive signals from small germplasm arrays. The Plant Genome 4:256–272.

Control of superficial scald in apple fruit. Oxidation products of α-farnesene, a natural volatile compound that accumulates in the skin of apples during cold storage, are implicated in the induction of superficial scald, a costly storage disorder. Scald is manifested as brown or black patches on the skin that render the fruit unmarketable. Certain commercial varieties of apple are highly susceptible to scald, including Law Rome and Granny Smith. ARS scientists in Beltsville, Maryland, succeeded in cloning a key gene involved in production of α-farnesene, AFS1, from the skin of Law Rome apple fruit. This was the first gene of its kind cloned from a

FIGURE 2: Granny Smith apples stored for 5 months at 0 °C. Control fruit (right) show severe symptoms of superficial scald, while fruit on the left inhibited for AFS1 gene expression and α -farnesene production are free of scald.

fruit-bearing species. An altered version of AFS1, designed to shut down (silence) the 'scald-gene' was introduced into tissue of Granny Smith apples. This was the first step toward development of new scald-resistant lines of Granny Smith and other popular apple and pear cultivars world-wide. This research could lead to resistant lines that no longer require postharvest chemical drenching treatments currently used to control scald. Advances in this research generated PcAFS1, a homologue of AFS1, cloned from scald-susceptible d'Anjou pear, and, like AFS1 in apple, expression of PcAFS1 in pear fruit was shown to be linked with both α-farnesene production and scald development. A research agreement was recently forged with a biotechnology company to generate and grow transgenic Granny Smith apple trees silenced for AFS1 gene expression. When fruit from those trees are available, ARS scientists will test them for resistance to superficial scald.

Whitaker, B.D. 2012. Membrane lipid metabolism and oxidative stress involved in postharvest ripening, senescence, and storage disorders of fruits. Acta Horticulture (ISHS) 945:269-282

Whitaker, B.D. 2008. Genetic and biochemical mechanisms of superficial scald development in apple and pear fruits. COST Action 924 Proceedings of the International Congress: Novel approaches for the control of postharvest diseases and disorders, p. 257-268.

Anticipated Product 5: ***Sampling strategies to accurately measure quality attributes and detect defects.***

Analytical support for soybean and other oilseeds. Soybean breeders are dependent on rapid, standardized, and accurate chemical genetic markers to guide their breeding efforts. ARS scientists in Peoria, Illinois, performed oil, protein, and moisture content determinations on 30,601 soybean samples by near infrared and fatty acid profiles on 15,089 soybean samples. The compiled data were published in the U.S. Department of Agriculture's annual "Coordinated Soybean Analysis." All these data, which are critical to the development of improved soybean varieties, have been provided to breeders throughout the United States. The Peoria scientists also analyzed 100 Camelina accessions for free acid content and percent oil for breeders in Nebraska and 1,000 Brassica accessions for free acid content and percent oil in a collaborative study with the ARS Plant Introduction Station in Ames, Iowa. In addition, more than 140 Jojoba accessions were analyzed for free acid content and percent oil for the ARS National Plant Germplasm System. The continued analysis of accessions provides breeders with the information they need

to make plant selections and monitor breeding progress in improving oilseed quality. Much of the data have been made publicly available through trade papers and reports and Web sites, including:

Methods and Acknowledgements, some background information and definitions: www.unitedsoybean.org/topics/production/u-s-soybean-measurements/methods-and-acknowledgements-crop-year-2011/

Average Protein and Oil for 2011 crop: www.unitedsoybean.org/topics/production/u-s-soybean-measurements/average-protein-and-oil-crop-year-2011/

Estimated Gross Processor Margin for 2011 crop based on protein and oil results: www.unitedsoybean.org/topics/production/u-s-soybean-measurements/estimate-of-gross-processor-margin-egpm-crop-year-2011/

Lysine for samples for the 2011 crop: www.unitedsoybean.org/topics/production/u-s-soybean-measurements/lysine-to-crude-protein-relationship-crop-year-2011/

Information for crops prior to 2011: www.unitedsoybean.org/ussm-available-data/

Low-cost wheat color sorter. Wheat breeding programs are in critical need of fast, accurate, low-cost devices to separate red wheat from white wheat. ARS scientists in Manhattan, Kansas, developed a low-cost sorting device using a standard personal computer with a color camera and specialized programming software. The system, which was created to have high throughput while keeping the sorter cost low, was able to correctly separate 95 to 99 percent of the red wheat from white wheat at a throughput of 30 kernels per second, or 3.5 kilograms per hour. The accuracy is 20 percent higher than the rate achieved with traditional, costlier sorters. This sorter will help breeding programs isolate desirable kernels so that they can be propagated. It is currently used in approximately 20 seed breeding laboratories nationwide to help select higher quality wheat, beans, corn, and flax for breeding. In addition, the system is used to eliminate weed seeds and remove fungal damaged seeds, which help in developing seed varieties that are more disease resistant.

Tallada, J.G., Wicklow, D.T., Pearson, T.C., and Armstrong, P.R. 2010. Detection of fungus-infected corn kernels using near infrared reflectance spectroscopy and color imaging. Transactions of the ASABE 54(3):1151-1158.

Pearson, T.C., Knievel, D., and Hucl, P. 2010. Automated sorting of glabrous versus pubescent annual canarygrass seeds. Applied Engineering in Agriculture 27(4):663-667.

Pearson, T.C., Brabec, D.L., and Haley, S. 2008. Color image based sorter for separating red and white wheat. Sensing and Instrumentation for Food Quality and Safety 2008(2):280-288.

Selecting individual wheat kernels with specific quality characteristics using an automated near-infrared system. Developing new cultivars requires many years of repetitive crosses to develop pure lines with specific traits. An automated method that assists wheat breeders in selecting kernels with end-use characteristics specific for unique grower needs or select markets could help to speed that process. ARS scientists in Manhattan, Kansas, developed a system that can automatically select kernels with specific traits from different populations. The system utilizes near-infrared spectroscopy that measures attributes such as protein content, starch levels, or kernel hardness in individual kernels, then removes those kernels from the sample at a rate of about one kernel every 2 seconds. These kernels are then used by breeders to develop cultivars with specific traits that would improve field performance and end-use quality. This system can also be used to measure the variability of quality within samples, providing valuable information to grain handlers, storage managers, millers, and grain processors. The system has been applied to wheat and 'proso' millet, and it could apply to other grains. Currently, it is being used to assess single-grain traits as a service to grain breeders, and Monsanto and Dow AgriSciences are considering acquiring this instrumentation.

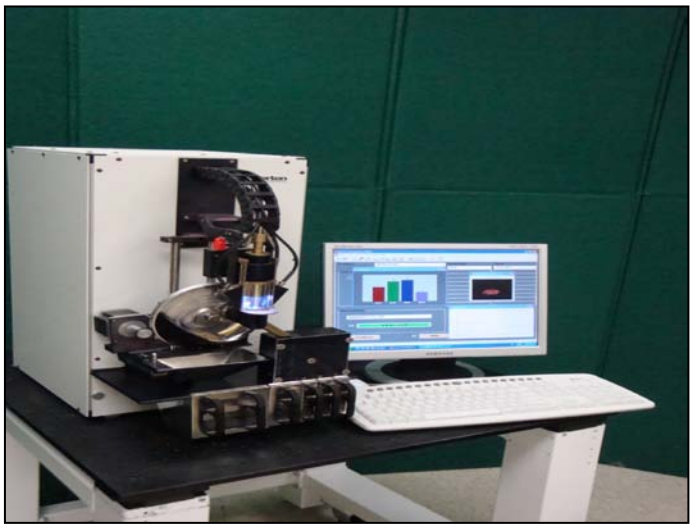

FIGURE 3: ARS designed and developed computerized automated wheat-kernel sorting system that uses near-infrared to select kernels with specific quality traits valuable to breeders and processors.

Dowell, F.E., Maghirang, E.B., Graybosch, R.A., Berzonsky, W.A., and Delwiche, S.R. 2009. Selecting and sorting waxy wheat kernels using near-infrared spectroscopy. Cereal Chemistry 86(3):251-255.

Dowell, F.E., Maghirang, E.B., and Baenziger, P.S. 2009. Automated single-kernel sorting to select for quality traits in wheat breeding lines. Cereal Chemistry 86(5):527-533.

Wegulo, S.N. and F.E. Dowell. 2008. Near-infrared versus visual sorting of *Fusarium*-damaged kernels in winter wheat. Canadian Journal Plant Science 88(6):1087-1089.

Commercialization of sorting technology and adoption by seed breeders/producers. Building on their research in developing a near-infrared system (see previous accomplishment) for detecting single-kernel quality traits, ARS scientists in Manhattan, Kansas, developed and commercialized a low-cost, color image-based sorting device for grains that is less expensive to operate. This high-volume system has unprecedented accuracy and throughput as a low-cost inspection/sorting system for large volumes of popcorn, yellow and brown flax, red and white wheat, and scab-damaged wheat and for removing weed seeds from seed stocks. The system sorts grains for market quality uniformity, whereas the infrared system is used to sort for genetic quality attributes. Industry collaborator, Jolly Time Popcorn, is adapting the machine for sorting popcorn, and the camera system has been transferred to an electronics manufacturer (Short Dog

Electronics). The color-imaging system is extensively used by the North Dakota State University seed foundation and is responsible for increasing production by 20 percent and reducing breeding time for yellow flax by 1 year by rapidly selecting for uniform yellow color and removing 90 percent of contaminated seeds. Other users report similar results. The sorting system is currently being adapted by major U.S. corn seed producers to increase germination and yield rates by removing broken and fungal damaged seeds, as well as for selecting seeds having very specific sizes that have a higher likelihood of successful planting.

Pearson, T.C., Moore, D., and Pearson, J. 2012. Machine vision system for high speed sorting of small spots on grains. Journal of Food Measurement and Characterization 6:27–34. DOI:10.1007/s11694-012-9130-3.

Pearson, T.C. 2010. High-speed sorting of grains by color and surface texture. Applied Engineering in Agriculture 26(3):499-505.

Pearson, T.C. 2009. Hardware based image processing for high-speed inspection of grains. Computers and Electronics in Agriculture 69:12-18.

Anticipated Product 6: ***Efficient, high-throughput and non-destructive technology to grade, sort and assign value to food based on desired quality traits after harvest.***

FIGURE 4: ARS designed and developed a portable, inexpensive moisture meter for wheat, corn, soybeans, and peanuts. Samples poured into the top funnel enter a calibratable, nondestructive microwave sensor that measures bulk density and moisture.

Inexpensive microwave sensor for instantaneous, nondestructive bulk density and moisture content determination in grain and seed. Low moisture levels in grains, nuts, and cotton are critical in determining optimal harvest time to prevent crops from rotting. Rapid and nondestructive measurement of moisture content of grain and seed is crucial not only in determining optimal harvest time, but in safe handling and storage and fair trade. ARS scientists in Athens, Georgia, assembled, tested, and calibrated a microwave sensor made with off-the-shelf components for predicting bulk density and moisture content of wheat, corn, soybeans, and peanuts. A patent for this technology has been submitted, and approval is pending. This new development in microwave sensing technology has generated interest from two major U.S. farm equipment companies; one has been granted a license. Routine use of this technology could allow American farmers to improve the quality of grain and seed and reduce spoilage and waste.

Trabelsi, S., Lewis, M.A., and Nelson, S.O. 2010. Microwave moisture meter for rapid and nondestructive grading of peanuts. ASABE Paper No. 1009183, American Society of Agricultural and Biological Engineers, St. Joseph, Missouri.

Trabelsi, S. and Nelson, S.O. 2010. Microwave moisture meter for granular and particulate materials. Proceedings of the 2010 IEEE International Instrumentation and Measurement Technology Conference, CD, Austin, Texas, May 3-6, pp. 1304-1308.

High-throughput, small-scale malt quality analysis methods. A method is needed to assess barley malting quality during early-stage breeding with small-scale seed allotments. ARS researchers in Madison, Wisconsin, developed a suite of methods for analyzing barley malting, mashing, and malting quality using only limited quantities of seed. Compared with current methodologies, these new methods are capable of three-fold greater sample throughput without increased costs, while reducing sample requirements 100-fold. These methods allow malting quality analysis earlier in breeding programs where only limited quantities of seed are available. This should aid barley breeders and malt barley users to accelerate data return and increase analysis capacity, facilitating the selection of barley varieties to better satisfy brewer and consumer preferences. This methodology is currently being used by Canadian and Australian government laboratories to determine malting quality in small-scale samples.

Schmitt, M.R. and Budde, A.D. 2011. Malting extremely small quantities of barley. Journal of the American Society of Brewing Chemists 69:191-199.

Schmitt, M.R., and A.D. Budde. 2010. Making the Cut: Options for making initial evaluations of malting quality in barley. Journal of the American Society of Brewing Chemists 68:183-194.

Anticipated Product 7: *Sensor technology to assess product quality and maturity in the field for optimum harvest timing.*

Moisture sensing in almond kernels. For almonds, initial moisture content and moisture migration are critical for optimal harvest and quality preservation during storage, thus requiring a real-time monitoring of moisture content at different stages of processing. At the request of the Almond Board of California, ARS scientists in Athens, Georgia, adapted a microwave dielectric method, which they originally developed for grains and seeds, to rapidly predict moisture content in almond kernels. Adoption of this technology by almond growers and processors will allow them to improve the quality of almonds offered for sale and greatly reduce spoilage and waste.

Trabelsi, S., Lewis, M. A., and Nelson, S. O. 2011. Microwave moisture meter for nondestructive and instantaneous peanut grading application. Proceedings of the 9th International Conference on Wave Interaction with Water and Moist Substances. ISEMA 2011, pp. 249-255, Kansas City, Missouri, May 31-June 3.

Trabelsi, S. and Lewis, M.A. 2011. Effect of foreign material in peanuts on in-shell nondestructive moisture sensing with a microwave moisture meter. ASABE Paper No. 111584, American Society of Agricultural and Biological Engineers, St. Joseph, Missouri.

Trabelsi, S., Lewis, M.A., and Nelson, S.O. 2011. Microwave meter for rapid, nondestructive determination of in-shell peanut kernel moisture content from dielectric measurements on cleaned and uncleaned pod samples. ASABE Paper No. 121338109, American Society of Agricultural and Biological Engineers, St. Joseph, Missouri.

Rapid digital-imaging wheat-sorting system. Single-grain wheat sorting is traditionally a human, hand-held visual detection of mold, weather, disease, and storage-damaged grains. Several attempts have been made over the decades to develop instrument-based alternatives, but inspection still remains a challenge. ARS scientists in Beltsville, Maryland, have developed a digital imaging system that captures images of individual seeds in freefall. The system, coupled with rapid-image processing, surface scans greater than 82 percent of each seed during high-speed sorting. This new system will aid the inspection/grading of U.S. wheat and its trading and milling industries by rapid, highly accurate image sorting. It is also being tested by a pharmaceutical company for assessing quality control of pill coatings. The scientists have filed patent and licensing applications for the technology. In follow-on work, they made a small retrofit to the hardware to accommodate cylinder-shaped objects, such as pharmaceutical pills, versus elliptically shaped seeds.

Delwiche, S.R., Yang, I.C., and Graybosch, R.A. 2013. Multiple view image analysis of freefalling wheat. Computers and Electronics in Agriculture (In review).

Yang, I.C., Delwiche, S.R., and Lo, Y.M. 2012. Development of a single channel, three view imaging system with classification model for defect and damage assessment of freefalling cereal grains. SPIE Proceedings Vol. 8369, No. 0E.

Anticipated Product 8: ***Technology to detect and remove contaminants or defective products from the food chain.***

Identification of volatile compounds produced by **Aspergillus flavus** ***on corn***. Growth of the fungus *A. flavus* on corn often leads to contamination with aflatoxin, a toxic and carcinogenic compound. To avoid contamination, early detection of this fungus is needed. Extensive testing by ARS scientists in New Orleans, Louisiana, determined the predominant volatile compounds produced by toxigenic and non-toxigenic isolates of *A. flavus*. Sensor detection work performed by ARS scientists, in cooperation with Sensor Development Corporation (SDC), developed a real-time electronic sensor to detect *A. flavus* growth and subsequent aflatoxin production in stored corn. The ARS researchers plan similar work in the future to detect *Fusarium* growth on stored grain. If successful, instruments using this technology and installed in grain storage facilities and hospitals could save many millions of dollars of stored grains and help to ensure the safety of the grain supply from fungal rot and toxin formation. Altogether seven patents based on the technology to detect *A. flavus* volatiles have been submitted to the U.S. Patent Office by SDC (www.sensordevelopmentcorp.com).

De Lucca, A.J., Boué, S.M., Carter-Wientjes, C., and D. Bhatnagar. 2012. Volatile profiles and aflatoxin production by toxigenic and non-toxigenic isolates of *Aspergillus flavus* grown on sterile and non-sterile cracked corn. Annals of Agricultural and Environmental Medicine 19:91-98.

De Lucca, A. J., Boué, S.M. Carter-Wientjes, C., Bland, J.M., Bhatnagar, D., and Cleveland, T.E. 2010. Volatile profiles of toxigenic and non-toxigenic *Aspergillus flavus* using SPME for solid-phase extraction. Annals of Agricultural and Environmental Medicine 17:301-308.

Problem Statement 1.B: ***Preserve or Enhance Quality and Marketability.***

Consumers intuitively seek food that is at optimal quality and value, and they bring to the marketplace quality preferences that influence their choices. As a result of internal biochemical processes and external factors (e.g., insect and microbial activity, storage conditions, and processing practices), desirable quality attributes often change with time after harvest. Uncontrolled sprouting, product moisture content, temperature, relative humidity, concentrations of atmospheric gases, and harvest and handling damage are known to affect the rate of deterioration. In contrast, aging and fermentation of some foods can enhance product quality while extending shelf life. New information and methods are needed to preserve and enhance the quality and utilization of agricultural products. ARS research attempts to identify processes and compounds that accelerate or inhibit degradation and develop novel methods of treating, storing, and processing agricultural commodities and foods that optimize product quality delivered to the consumer.

Anticipated Product 1: ***Descriptions of biochemical processes and metabolites that cause quality deterioration during storage.***

Pre-harvest sprays reduce citrus postharvest diseases. Canker and melanose diseases cause postharvest rejection of citrus fruit. Pre-harvest sprays of a carnauba wax emulsion combined with pesticide, applied by ARS scientists in Fort Pierce, Florida, along with industry cooperators, were successful in reducing canker bacteria and melanose fungus on citrus leaves and fruit in the field. This treatment resulted in less pathogen inoculum on the fruit as it entered the packing house and less postharvest decay and culled fruit. The wax spray allowed the pesticide to remain longer on the treed fruit during rain events. A patent application for this technology has been filed. In follow-up work, the scientists have been testing different waxes mixed with the bactericide in an attempt to configure a less expensive spray that will work as well as the original. Groves in central and south Florida are using this spray to produce blemish-free fruit.

FIGURE 5: Newly developed carnuba wax/pesticide pre-harvest spray reduces citrus disease. Older leaves that have been sprayed continue to be disease-free, while new leaves (new flush) not sprayed show disease symptoms.

Narciso, J., Widmer, W., Ference, C., Ritenour, M., and Diaz, R. 2012. Use of carnauba based carrier for copper sprays reduces infection by *Xanthomonas citr*i subsp. *citri* and *Diaporthe citri* in Florida commercial grapefruit groves. Agricultural Sciences 3(7):962-970.

Anticipated Product 2: ***Tools to effectively manage postharvest processing and storage systems, including instrumentation, control systems and decision support systems.***

A computerized, in-orchard, apple-sorting harvesting aid. Currently, defective and sound apple fruits are not sorted at harvest, but are combined, causing significant storage losses due to the defective fruits being susceptible to pest and disease infestation. The result is costly postharvest handling to remove unmarketable fruits. ARS scientists in East Lansing, Michigan, developed an in-orchard mobile system that automatically sorts and grades apples into cull (defective), processing, or fresh-market-quality fruits by measuring fruit color, size, shape, and weight using color-imaging, machine-vision technology. This system also incorporates harvest aid functions to reduce safety hazards for fruit harvesters. The technology will enable apple growers to separate or leave defective fruit in the orchard, resulting in less postharvest disease/pest problems and lowering postharvest storage and packing costs, ensuring a better fruit quality inventory at the warehouse. This novel harvesting aid is ready for testing in commercial orchards in Michigan in 2013. An invention disclosure was filed in 2012 awaiting a commercial partner.

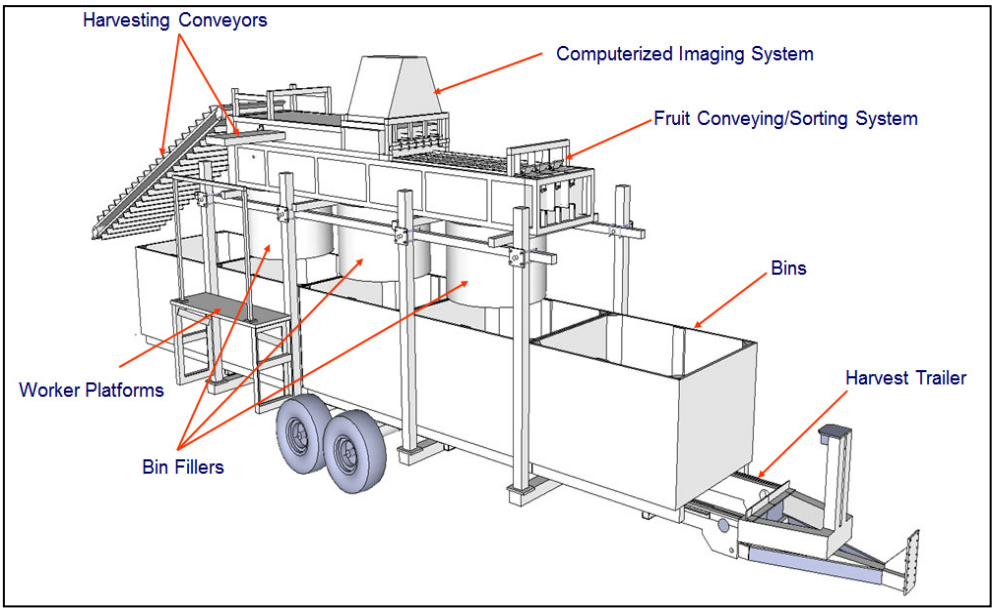

FIGURE 6: This ARS designed in-orchard apple sorting aid reduces storage losses by automatically culling defective fruit at harvest so that the culls can be left in the field.

Mizushima, A. and Lu, R.A. 2013. An image segmentation method for apple sorting and grading using support vector machine and Otsu's method. Computers and Electronics in Agriculture 94:29-37. http://dx.doi.org/10.1016/j.compag.2013.02.009.

Mizushima, A. and Lu, R.A. 2013. Low-cost machine vision system for in-field sorting and grading of apples: Fruit orientation and size estimation. Transactions of the ASABE 94(1):29-37.

Mizushima, A. and Lu, R.A. 2011. Cost benefits analysis of in-field presorting for the apple industry. Applied Engineering in Agriculture 27(1):33-40.

Anticipated Product 3: ***Innovative storage systems and treatments that maintain product quality and integrity and protect products from pathogens and insects.***

Ozone fumigation controls postharvest decay of table grapes. Table grapes rot and spoil after harvest unless actions are taken to preserve them, such as the fumigation of grape storage rooms with sulfur dioxide. However, growers of organic grapes cannot use sulfur dioxide and need an acceptable alternative. ARS scientists in Parlier, California, evaluated ozone fumigation in Parlier and in two commercial cold storages. Ozone gas, an approved substance for use by organic growers under the USDA National Organic Program rules, reduced rot and approximately doubled the storage life of the grapes in cold storage from 2-3 weeks to 4-5 weeks. This work provides a useful alternative method to reduce rot and extend the storage life of grapes for this industry. Follow-on work funded by the California Table Grape Commission-to extend ozone technology to organic grape growers, ARS scientists found that by not using sulfur dioxide, berry bleaching and flavor alteration caused by sulfur were eliminated. Organic grape growers have quickly adopted the use of ozone to extend storage life of their grapes.

Ames, Z.R., Feliziani, E., and Smilanick, J.L. 2013. Germination of fungal conidia after exposure to low concentration ozone atmospheres. Postharvest Biology and Technology 83:22-26.

Karaca, H., Walse, S.S., Joseph L. Smilanick, J.L. 2012. Effect of continuous 0.3 mL/L gaseous ozone exposure on fungicide residues on table grape berries. Postharvest Biology and Technology 64:154-159.

Ozkan, R., Smilanick, J.L., and Karabulut, O. A. 2011. Toxicity of ozone gas to conidia of *Penicillium digitatum*, *Penicillium italicum*, and *Botrytis cinerea* and control of gray mold on table grapes. Postharvest Biology and Technology 60:47-51.

Natural phosphites applied to crops to combat fungus-like pathogens. The organic food industry is in great need of environmentally friendly compounds that can control fruit pathogens. Postharvest treatment of citrus fruit with phosphite, a form of phosphorous, extends the shelf life of the fruit by controlling spoilage. Solutions of the chemically simple compound phosphite, which is relatively non-toxic and has very low environmental impact, have some potential to be used as fresh citrus fruit treatments to reduce postharvest rot losses. ARS scientists in Parlier, California, found that phosphite, when used in combination with another simple disinfectant compound, hydrogen peroxide, was effective enough to merit commercial use, but was inferior to conventional fungicides. To remedy this, it was determined that the combination could be used with conventional fungicides to reduce the rate of fungicides used. Chemical residues of the phosphite combinations used on the fruit are phosphorous, a common mineral nutrient, water, and oxygen. ARS scientists determined specific information about how phosphites can be valuable to those in the citrus fruit industry seeking alternatives to conventional fungicides. In part as a result of this work, two ARS-developed phosphite products were approved and introduced for commercial use in the United States.

Cerioni, L., Rapisarda, V.A., Doctor, J., Fikkert, S., Ruiz, T., Fassel, R., and Smilanick, J.L. 2013. Use of phosphite salts in laboratory and semi-commercial tests to control citrus postharvest decay. Plant Disease 97:201-212.

Cerioni, L. and Smilanick, J.L. 2012. Control of postharvest green and blue molds of lemons with potassium phosphite and hydrogen peroxide. Plant Disease Management Reports 6:V079.

Packaging inserts that fight decay of fresh produce. Decay of fresh produce, especially small fruits such as strawberries and blueberries that cannot be washed, contributes to a short postharvest shelf life. ARS scientists in Fort Pierce, Florida, in collaboration with an industry partner, Worrell Water Technologies, developed small, single-use packets that when inserted into packaged fruit release an antimicrobial vapor (Curoxin®) that surrounds the fresh fruit. This vapor extended the postharvest shelf life of blueberries and strawberries by maintaining fruit firmness, reducing water loss and decay, and maintaining color and overall quality. These packets were also used to treat citrus fruit infected with citrus canker. Canker is a problem for the fresh citrus market, as fruit coming from groves where canker is found cannot be marketed internationally. Packets placed inside containers of citrus significantly reduced bacterial canker counts. The antimicrobial vapor packets are being tested in pilot studies with commercial packing houses and could save the international fresh produce industry over $1.0 billion annually in costs incurred by postharvest losses. Application is now being expanded to California grapes.

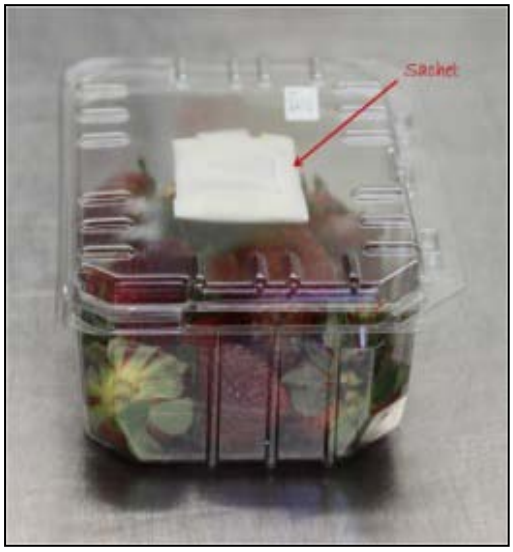

FIGURE 7: Attaching antimicrobial vapor packets to retail small fruit "clam-shell" containers reduces decay and water loss while extending overall quality.

Anticipated Product 4: ***Technology for improvement of packaging, storage containers, and food coatings through humidity and temperature control, and atmosphere regulation. This will extend the shelf-life of food and preserve flavor.***

Apple- and tomato-based natural antimicrobial-containing edible films. Americans are increasingly concerned over the safety of their foods. ARS scientists in Albany, California, with support from a National Research Initiative grant through the USDA National Institute of Food and Agriculture and in collaboration with University of Arizona scientists, are developing novel, natural antimicrobial-containing films from fruits and vegetables. The scientists found that incorporation of natural essential oils from oregano, thyme, cinnamon, allspice, clove, and lemon grass into fruit and vegetable films and coatings were active against *E. coli* 0157:H7, *Salmonella enterica,* and *Listeria monocytogenes*. The effectiveness of the films has been verified on ham, bologna, and chicken. In addition, research has confirmed the effectiveness of the vapors released from these antimicrobial films against *E. coli* 0157:H7 in packaged spinach and *Salmonella Newport* in packaged organic leafy greens. Concurrent sensory evaluations of films on foods are being performed to confirm sensory acceptability of these novel films. Continuous production methods have been developed to support future commercialization of the technology.

Ravishankar, S., Zhu, L., Jaroni, D., Olsen, C.W., McHugh, T.H., and Friedman, M. 2012. Inactivation of *Listeria monocytogenes* on ham and bologna using pectin-based apple, carrot, and hibiscus edible films containing Carvacrol and Cinnamaldehyde. Journal of Food Science 77(7):M377-M382.

Du, W., Olsen, C.W., Avena-Bustillos, R., McHugh, T.H., Levin, C.E., and Friedman, M. 2009. Effects of allspice, cinnamon, and clove bud essential oils in edible apple films on physical properties and antimicrobial activities. Journal of Food Science 74(7): M372-378.

Du, W., Olsen, C.W., Avena-Bustillos, R., McHugh, T.H., Levin, C.E., Mandrell, R.E., and Friedman, M. 2009. Antibacterial effects of allspice, garlic, and oregano essential oils in tomato films determined by overlay and vapor-phase methods. Journal of Food Science 74(7): M390-M397.

Anticipated Product 5: ***New methodologies to enhance the quality and utilization of agricultural products.***

Fertilizing leaves greatly improves fruit quality. Improving the nutritional content of fruits and vegetables using commercially available products and crops is an industry need. ARS scientists in Beltsville, Maryland, using six different commercial potassium fertilizers applied to the leaves of a commercial, field-grown cantaloupe crop, grew fruit with higher levels of sugar (sweetness), antioxidants (ascorbic acid and beta-carotene), potassium, and firmness. ARS scientists demonstrated that all potassium fertilizers, except potassium nitrate, enhanced melon marketable quality, especially sweetness, allowing growers to market their fruit at the higher USDA "Fancy Grade." The treatment also created firmer fruit, allowing for extended postharvest marketability. Foliar-applied potassium technology has been transferred to the California table grapes industry and is now a widespread commercial practice that produces uniformly colored, premium-priced grape bunches that are highly desired by the retail industry.

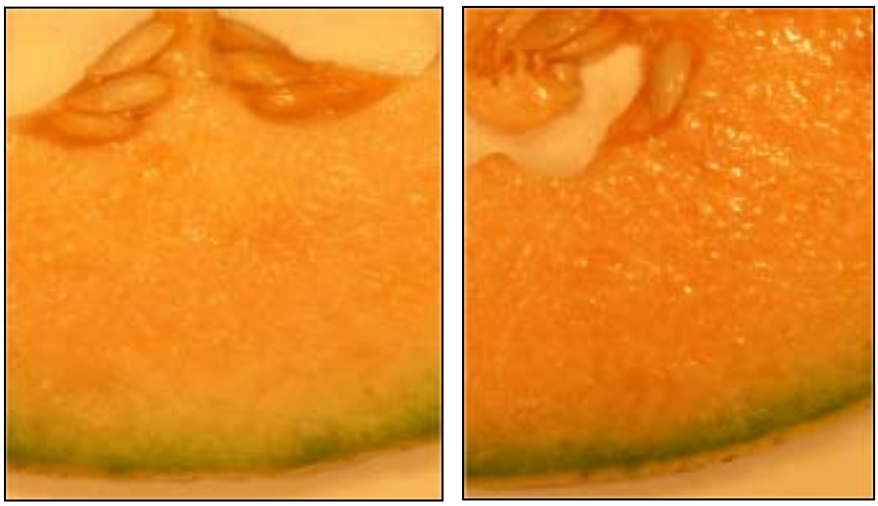

FIGURE 8: Cut cantaloupe showing effects of potassium fertilizer application on leaves. The results of fertilization (greater orange color) are visible on the cantaloupe on the right versus the unfertilized cantaloupe on the left. The fertilization also promoted higher sugars.

Lester, G.E., Jifon, J. L., and Makus, D.J. 2010. Impact of potassium nutrition on postharvest fruit quality: Melon (*Cucumis melo* L) case study. Plant and Soil 335:117-131.

Jifon, J.L. and Lester, G.E. 2009. Foliar potassium fertilization improves fruit quality of field-grown muskmelon on calcareous soils in south Texas. Journal of the Science of Food and Agriculture 89:2452-2460.

Starch-oil composite gel fat replacer for ground meat applications. Improving the tenderness, flavor and juiciness of reduced-fat meat products is an industry need. ARS scientists in Peoria, Illinois, developed a starch-oil composite fat replacer gel that has been commercialized and licensed by an industry partner, resulting in the large scale production of a fat replacer gel. Follow-on ARS research has added color and flavor attributes to the gel, by using clean label colorants and flavors to reduced-fat, ground-beef patties. Use of the gels allows the conversion of 93-95 percent lean beef patties—which when cooked tend to be chewy and dry—to have consistent tenderness, juiciness, and flavor. Similar results of this technology were also demonstrated in meatballs and pork sausages. The industry partner plans to expand the marketing of the low-fat beef patties to large volume institutional customers as well as broaden the product line to include emulsified meat products such as frankfurters and lunch meats. The availability of this technology, which delivers significant fat (and calorie) reduction while enhancing product quality, will ultimately enable progress in addressing consumer obesity and increasing acceptance of healthier alternatives to traditionally high fat foods. Industry (HF Food Technologies) has conducted sensory testing and completed a major presentation before a meat industry packer with a strong retail presence; and has discussed co-packing opportunities and has garnered the interest of several local school districts (Cleveland, Toledo, and Akron, Ohio).

Felker; F.C., Fanta, G.F., Kalebic, R.L., and Turner, W.E. “Starch-Lipid Composite”, U.S. Patent Application 20090117247, May 7, 2009.

Making frying batters low-fat. Wheat-based frying batters enhance sensory enjoyment of food, but they absorb large amounts of oil and contain gluten; both of which are health concerns for many consumers. ARS scientists in New Orleans, Louisiana, working with CrispTek, LLC, of Columbia, Maryland, developed a rice-based frying batter with low oil-uptake. Rice is naturally gluten-free and ARS scientists have determined that rice-based flour absorbs 50 percent less fat than wheat-based flour. The batter is being sold by CrispTek as ChoiceBatter. A benefit of using rice as a base for the batter is that persons with Celiac’s disease who cannot tolerate batters that contain wheat-based ingredients can use this product for their fried foods. CrispTek is considering extending the use of ChoiceBatter for baked foods. This has created 40 jobs in Maryland and the company expects to add up to another 40 employees.

Shih, F.F., Bett-Garber, K., Champagne, E., Daigle, K., and Lea, J. 2010. Effects of beer-battering on the frying properties of rice and wheat batters and their coated foods. Journal of the Science of Food and Agriculture 90:2203-2207.

PROBLEM STATEMENT 1.C: *New Bioactive Ingredients and Functional Foods.*

Food not only provides essential nutrients for sustaining life, but it can also impart healthy physiological responses that may reduce the risk of chronic diseases, such as obesity, diabetes, and colon cancer. Functional foods contain bioactive food ingredients and nutraceuticals that promote health beyond basic nutritional value (calories and basic metabolic requirements). Functional foods can be from plant, animal, or microbial sources, and bioactive ingredients

include naturally occurring or induced phytonutrients from plants, probiotic bacteria, and prebiotic oligosaccharides. The public health promise of the nascent functional foods industry necessitates a multi-pronged research approach to identifying biologically active compounds in agricultural materials and functional foods, characterizing their structures and physiological functions and examining the interplay between biologically active constituents and nutritional components in functional foods. Identification of these constituents, in turn, facilitates agronomic practices and breeding of crop cultivars, livestock, or microbial strains with enhanced bioactive qualities.

Anticipated Product 1: ***Functional foods with enhanced levels and activities of bioactive ingredients with established efficacy, bioavailability, and safety that represent cost-effective dietary interventions for reducing the risk of chronic disease.***

A sustainable, new process to enrich whey proteins. Commercial whey protein isolate, a concentrated form of cheese whey, provides superb functional and nutritional properties when added to foods because of the whey proteins—beta-lactoglobulin, alpha-lactalbumin, and glycomacropeptide. Separation of these proteins from whey protein isolate has the potential to enable creation of new food ingredients with even greater benefits. Existing processes to separate the proteins tend to contaminate the products with acids or salts. ARS scientists in Wyndmoor, Pennsylvania, developed a process to separate the proteins from whey protein isolate into three protein-rich fractions using supercritical carbon dioxide. The supercritical carbon dioxide becomes an environmentally friendly acid during processing and vaporizes upon completion of the experiments without contaminating the enriched protein fractions. The three protein-rich fractions contain approximately 90 percent beta-lactoglobulin, 60 percent alpha-lactalbumin, and 93 percent glycomacropeptide, respectively. This research has the potential to provide processors with new whey ingredients for enhancing the properties of foods using a sustainable processing method. A patent for this process has been applied for, and the scientists are in active discussions with companies interested in using the technology. However, no license has been awarded as yet.

Bonnaillie, L. M. and Tomasula, P.M. 2012. Fractionation of whey protein isolate with supercritical carbon dioxide to produce enriched alpha-Lactalbumin and beta-Lactoglobulin food ingredients. Journal of Agricultural and Food Chemistry 60:5257-5266.

Yver, A. L., Bonnaillie, L. M., Yee, W., McAloon, A., P.M. Tomasula. 2011. Fractionation of whey protein isolate with supercritical carbon dioxide – process modeling and cost estimation. International Journal of Molecular Sciences 13:240-259.

Bonnaillie, L. M., and Tomasula, P. M., P.X. Processes for Isolating Glycomacropeptides. U.S. Patent 13/211,689; filed 2011.

White grape seed flour may lower cholesterol and weight gain. Cholesterol in the blood can result in cardiovascular disease, the leading cause of death in the United States. Cholesterol blood levels can be managed through lifestyle changes, such as an improved diet. ARS scientists in Albany, California, in collaboration with an industry partner, Sonomaceuticals LLC, found that intake of flour made from seed of white wine chardonnay grapes prevented increases in plasma cholesterol and weight gain in hamsters on a high-fat diet similar to the typical American dietary intake. Chardonnay seed flour's anti-inflammatory compounds are among the highest

concentration of any food ingredient, and the seeds are a natural waste byproduct of the California winemaking industry. The scientists did not see the same results from red grape seeds or skins. Patent applications have been filed by the industry partner, and discussions are underway for additional hamster trials to assess the potential of the grape seed flour in lowering low-density lipoproteins (LDL cholesterol) and reducing triglyceride fat accumulation in liver cells (fatty liver disease). Human clinical trials are being planned. This research has the support of a dedicated food-grade drying and processing facility in Santa Rosa, California. The industry partner has created additional agricultural jobs and established a new industry.

Arvik, A., Lipsom, R., Bartley, G., Kim, H., and Yokoyama, W. 2012. Discovering bioactive compounds: chardonnay grape seed flour, not red grapes, reduces plasma cholesterol and body weight gain in hamsters on high fat diets. American Chemical Society presentation, Philadelphia, Pennsylvania, August 2012.

Lipson, R., Arvik, T., Bartley. G., Kim, H., and Yokoyama, W. 2012. Discovering bioactive compounds: chardonnay grape seed flour reduces plasma lipids and increases expression of heptic genes for cholesterol and fat synthesis in hamsters fed a high-fat diet. American Chemical Society presentation, Philadelphia, Pennsylvania, August 2012.

Anticipated Product 2: ***Identification of new bioactive ingredients (i.e., antioxidants, polyphenols, fibers, phytosterols, peptides, probiotic bacteria, prebiotic oligosaccharides) and methods to standardize their minimum concentration in food for health and labeling claims.***

Retuning the flavor to pasteurized Hispanic-style cheese. Many of the Hispanic-style cheeses made from pasteurized milk lack the unique flavors and textures found in traditional raw milk cheeses due to pasteurization destroying bacteria that contribute to these quality traits. ARS scientists in Wyndmoor, Pennsylvania, with collaborators from Mexico, identified the key bacteria found in the authentic Mexican Mennonite-style cheese, known as Queso Chihuahua. Different blends of these key cultures were added to pasteurized milk, which resulted in cheese with enhanced properties expected in traditional Queso Chihuahua. With starter cultures and manufacturing protocols specially tailored for Queso Chihuahua, cheesemakers now have tools to produce pasteurized versions that have the flavor and texture of the traditional cheese found only in Mexico. This research has been extended to the Mexican collaborator who is interested in testing the starter culture in a commercial setting. An American partner is being sought to get the starter culture to American cheese producers.

Olson, D.W., Van Hekken, D.L., Tunick, M.H., Tomasula, P.M., Molina-Corral, F.J., and Gardea, A.A. 2011. Mexican Queso Chihuahua: Functional properties of aging cheese. Journal of Dairy Science 94(9):4292-4299.

Van Hekken, D.L., Drake, M.A., Tunick, M.H., Guerrero, V.M., Molina-Corral, F.J., and Gardea, A.A. 2008. Effect of pasteurization and season on the sensorial and rheological traits of Mexican Chihuahua cheese. Dairy Science and Technology 88:525-536.

Renye, J.A., Jr., Somkuti, G.A., Paul, M., and Van Hekken, D.L. 2009. Characterization of *Antilisterial Bacteriocins* produced by *Enterococcus faecium* and *Enterococcus durans* Isolates from Hispanic-style cheeses. Journal of Industrial Microbiology and Biotechnology 36:261-268.

Commercialization of pterostilbene. Pterostilbene is a naturally occurring phenolic compound in blueberries and an analog of resveratrol, which is the well-known polyphenol in grapes and wine. ARS scientists in Oxford, Mississippi, showed that, in laboratory animals, pterostilbene is a more effective cholesterol-lowering agent than resveratrol in activating a protein that plays a major role in lipid metabolism and transport. ARS has been granted three patents for its research on pterostilbene. For these activities and the potential to explore similar effects in humans, pterostilbene was licensed by a company (ChromaDex) and was commercialized under the trade name pTeroPure™ in April 2010. pTeroPure™ pterostilbene is now on the market as a pure compound or mixed with other natural compounds as dietary supplements.

Chang, J., Rimando, A., Pallas, M., Camins, A., Porquet, D., Reeves, J., Shukitt-Hale, B., Smith, M.A., Joseph, J.A., and Casadesus, G. 2012. Low-dose pterostilbene, but not resveratrol, is a potent neuromodulator in aging and Alzheimer's disease. Neurobiology of Aging 33, 2062-71.

Joseph, J.A., Fisher, D.R., Cheng, V., Rimando, A.M., and Shukitt-Hale, B. 2008. Cellular and behavioral effects of stilbene resveratrol analogs: Implications for reducing the deleterious effects of aging. Journal of Agricultural and Food Chemistry 56:10544-10551.

Anticipated Product 3: ***Proteomic, metabolomic, and nutrigenomic tools for evaluation and characterization of bioactive ingredients.***

Release of two new strawberry varieties. Strawberry flavor improvement by breeders requires collaboration with flavor chemists. ARS flavor chemists in Fort Pierce, Florida, in collaboration with a University of Florida strawberry breeder, released two advanced strawberry selections, 'Florida Elyana' and 'Florida Radiance'. The ARS scientists deciphered the complex array of volatiles that define strawberry flavor to allow the development of the more flavorful fruit and determined the complimenting ripening period of the current commercial variety, 'Festival'. Strawberry advanced selections were evaluated for flavor, color, and horticultural characteristics, including sensory and nutrigenomic chemical analyses. 'Florida Radiance' is now the number one variety planted in Florida, with an estimated 45 percent of the 11,000 acres planted in 2012–2013; the equivalent of 90 million plants. 'Florida Radiance' is also popular overseas, particularly in Spain, where 110 million plants were set in 2012.

Chandler, C.K., Santos, B.M., Peres, N.A., Jouquand, C., Plotto, A., and Sims, C.A. 2009. 'Florida Radiance' strawberry. HortScience 44:1769-1770.

Chandler, C.K., Santos, B.M., Peres, N.A., Jouquand, C., and Plotto, A. 2009. 'Florida Elyana' strawberry. HortScience 44:1775-1776.

Anticipated Product 4: ***Improved biomarkers to predict success of full-scale human clinical trials and alleviate the need for animal testing*** (in cooperation with National Program 107, Human Nutrition, and other partners)**.**

Watermelon: a source of natural lycopene. Lycopene, a red, healthful, antioxidant carotenoid that gives some fruits color, forms in plant cells called chromoplasts. Fruits such as watermelon represent the most abundant, renewable natural form of lycopene. ARS scientists in Lane,

Oklahoma, developed a process to isolate intact chromoplasts from watermelon flesh and developed storage procedures that keep fresh lycopene-containing chromoplasts stable for at least 2 years and dried powder chromoplasts stable for up to 6 months. The ability to store watermelon lycopene for long periods of time helps it to become an important natural antioxidant source in nutraceuticals, as a biomarker, and as a red colorant in the food industry. Follow-up research was curtailed due to closure of the Lane, Oklahoma, laboratory.

Fish, W.W. 2012. Refinements of the attending equations for several spectral methods that provide improved quantification of Beta-carotene and/or lycopene in selected foods. Postharvest Biology and Technology 66:6-22.

Fish, W.W. 2008. Mother nature's packaging and organization of carotenoids in watermelon and cantaloupe. HortScience 43:614.

Anticipated Product 5: ***Innovative and improved delivery systems for functional food bioactive ingredients (i.e., novel encapsulation, nanoemulsion, controlled release, protein-based "natural", probiotic bacteria, synbiotics).***

New healthy functional foods from oats. Oat beta glucan has clinically proven health benefits in reducing cholesterol, controlling blood glucose, and in general gastrointestinal health, but getting enough beta glucan into a function food is problematic. Oat studies by ARS scientists in Peoria, Illinois, revealed that the "soft-solid" characteristics of various oat carbohydrates (beta glucan) provided creamer, less runny properties valuable for developing new functional foods such as yogurt, instant puddings, custard, batter, smoothies, and ice cream. Based on their findings, the scientists developed oat concentrates that have great potential for use in healthful foods of interest to consumers. ARS has been granted a patent for this technology, and an industrial partner has licensed this functional food for the production of Calorie-Trim and Nutrim, healthy oat grain-based products that are eligible for the FDA heart health claim. Also, Z-Trim, a fat substitute developed by ARS scientists from oat-grain dietary fibers, has been licensed for manufacture by Z-Trim Holdings, which has expanded its market to include the USDA school lunch program.

Lee, S., Biresaw, G., Kinney, M.P., and Inglett, G.E. 2009. Effect of cocoa butter replacement with a Beta-glucan-rich hydrocolloid (C-trim30) on the rheological and tribological properties of chocolates. Journal of the Science of Food and Agriculture 89(1):163-167.

Kim, S., Inglett, G.E., and Liu, S.X. 2008. Content and molecular weight distribution of oat Beta-glucan in Oatrim, Nutrim, and C-Trim Products. Cereal Chemistry 85(5):701-705.

Milk sugar metabolism encoded by human gut bacteria. Fundamental information is needed to understand how probiotics (live microorganisms) are beneficial to improved resistance to intestinal disorders, such as diarrhea. ARS scientists in Peoria, Illinois, in collaboration with the University of California at Davis, have sequenced the complete genome of *Bifidobacterium longum* subsp.*infantis* (a probiotic which offers relief from symptoms of irritable bowel syndrome) and demonstrated that this genome also encodes all genes required to metabolize human milk sugars. This work has potential impact for research to design milk-based pro- and pre-biotics that confers healthful benefits and patient well-being. Further research has revealed, through the genome sequencing of *Bifidobacterium longum* subsp. *infantis*, that there are

opportunities to make adaptive changes that assist infant's microbiomes to better utilize dairy-milk sugars.

Sela, D.A., Chapman, J., Adeuya, A., Kim, J.H., Chen, F., Whitehead, T.R., Lapidus, A., Rokhsar, D.S., Lebrilla, C.B., German, J.B., Price, N.P., Richardson, P.M., and Mills, D.A. 2008. The genome sequence of *Bifidobacterium longum* subsp. *infantis* reveals adaptations for milk utilization within the infant microbiome. Proceedings of the National Academy of Sciences U.S.A vol. 105, no. 48:18964-18969.

Anticipated Product 6: ***New and improved crop varieties, livestock and microbial strains as sources of bioactive ingredients*** (in cooperation with other ARS national programs and other partners)**.**

Presence of beneficial compound verified in California-grown mandarin oranges. Mandarin orange growers have been looking for ways to increase consumer utilization of their product by identifying value-added healthful, functional food compounds present in mandarin oranges. ARS scientists in Albany, California, determined that mandarin oranges contain significant levels of dietary synephrine, a bioactive compound that has shown promise as an aid to weight management and that also possesses decongestant properties. The researchers determined the effects of mandarin orange rootstock, soil depth, and differences in elevation influence on fruit synephrine concentrations. Fruit from trees grown in deeper soil and trifoliate rootstock and at higher elevation showed higher concentrations of synephrine, amino acids, succinate, and 4-aminobutyrate and lower concentrations of sugars and limonin glucoside. Data from this study were distributed through a peer-reviewed article and were picked up by the popular press. Growers are implementing these findings, which have been instrumental in generating increased consumer demand and ultimately contributed to the growers selling out their crop for the 2008–2009 season.

Zhang, X., Breska, A.P., Mishchuk, D.O. Fake, C.E., O'Mahony, M.A., and Slupsky, C.M. 2012. Fertilization and pesticide affect mandarin orange nutrient composition. Food Chemistry 134:1020-1024.

Zhang, X., Breska, A.P., Mishchuk, D.O., and Slupsky, C.M. 2011. Elevation, rootstock, and soil depth affect the nutritional quality of mandarin oranges. Journal of Agricultural and Food Chemistry 59:2672-2779.

Anticipated Product 7: ***Development of new health-promoting foods for elderly and populations most prone to chronic diseases.***

Improved emergency aid food. Ready-to-eat foods made for emergencies may suffer from reduced sensory and nutritional quality when they are delivered for use in hot, tropical climates unless storage conditions are adequate. In response to this problem, ARS scientists in Wyndmoor, Pennsylvania, developed a new instant corn and soy blend with superior properties and a 1-year shelf life. Twenty metric tons of this new emergency-aid food was shipped to Haiti in 2011 through a grant from the National Institute for the Severely Handicapped. The emergency food fed more than 3,000 malnourished children and provided jobs for 128 disabled employees in the United States. (*This accomplishment also contributes to Problem Area 1D:*

New and Improved Food Processing Technologies; Anticipated Product 6: Food tailored to meet nutritional requirements for the School Lunch Program, Food for Peace, and similar programs, on page 33.)

PROBLEM STATEMENT 1.D: ***New and Improved Food Processing Technologies.***

Food processing should make safe, nutritious, and convenient food readily available throughout the year and in every American community. Challenges to ensure our food supply in the 21st century have grown complex through a combination of rising energy costs, environmental imperatives, the capacity for unsafe food to be rapidly and widely distributed, and increasing world demand for high-quality foods. Major opportunities exist along with these challenges. Recovery of valuable bioactive food ingredients from processing operations can increase the economic value of foods while reducing environmental impact. New concepts for preservation, increased understanding of sensory mechanisms, and new structure-function relationship insights for food ingredients may make it possible to create new nutritious foods with excellent sensory properties. The United States needs expanded food processing research both to realize the opportunities and to successfully meet the challenges required to ensure an affordable, high-quality food supply.

Anticipated Product 1: ***More efficient food processing techniques that reduce energy use, water use, and waste generation per unit of food delivered to consumers.***

Milk processing plant simulator identifies opportunities to lower greenhouse gas emissions. Reductions in greenhouse gas emissions for milk processors are practical if processors can easily identify the energy hotspots in their plants and determine the cost-effectiveness of upgrades to reduce the emissions. ARS scientists in Wyndmoor, Pennsylvania, monitored life-cycle assessments of greenhouse gas emissions from fluid milk production and found that on-farm activities generated 70 percent of the emissions because of methane from cows and manure. The remaining 30 percent of the greenhouse gas emissions were found to come from off-farm activities, including milk processing, packaging, and refrigeration. ARS scientists partnered with dairy processors and created a computer-based model of the fluid milk process to identify and target potential areas where greenhouse gas emissions could be reduced. This model can offer multiple ways of making changes in individual processing plants and instantly calculate both greenhouse gas reductions and costs of implementing the changes. The model has been distributed to over 100 processors in the United States and should help the dairy industry realize its goal of reducing greenhouse gas emissions by 25 percent per gallon of milk by 2020. The model is available online at: www.ars.usda.gov/main/site_main.htm?modecode=19-35-47-00.

Tomasula, P.M. and Nutter, D.W. 2011. Mitigation of greenhouse gas emissions in the production of fluid milk. In: *Advances in Food and Nutrition Research,* ed. S.L. Taylor, publ. by Academic Press, Elsevier Inc., Waltham, MA. Vol. 62, Chapter 2, pp. 41-88.

More sustainable fruit and vegetable peeling technology. Reduced water use has become a high priority in agriculture and food processing. Currently, the majority of fruits and vegetables are steam or lye peeled. Total water usage from tomato peeling alone in California is estimated at 255 million gallons annually. ARS scientists in Albany, California, worked with a large fruit

processing company, the California League of Food Processors, the California Department of Food and Agriculture, the California Energy Commission, and the University of California at Davis to develop a novel infrared dry peeling technology for peaches, pears, and tomatoes. The novel peeling technology, which does not use water, is patent pending and in the process of being commercialized. It is estimated that this technology will eliminate the use of more than 50 million gallons of water during each fruit processing season. Additional benefits include significant energy savings and elimination of chemicals and lye.

Li, X., Pan, Z., Upadhyaya, S., Atungulu, G., and Delwiche, M. 2011. Three dimensional geometric modeling of processing-tomatoes. Transactions of the ASABE. 54(6):2287-2286.

Pan, Z., McHugh, T.H., Valenti-Jordan, J., and Masareje, C. 2011. Infrared based peeling of fruits and vegetables. U.S. Patent Application, Serial Number 61/418,859.

Pan, Z., Li, X., Bingol, G., McHugh, T.H., and Atungulu, G.G. 2009. Development of infrared radiation heating method for sustainable tomato peeling. Applied Engineering in Agriculture 25(6):935-941.

Anticipated Product 2: ***New processes (separation, concentration, extraction, fractionation) to convert low-value commodities or by-products into higher value food ingredients or non-food products.***

Development of standard rice sample preparation procedures. There is a great need for developing appropriate standard rice sample milling and preparation procedures aimed at improving the consistency and accuracy of rice quality. ARS scientists in Albany, California, worked with collaborators at the University of California at Davis; the USDA Grain Inspection, Packers, and Stockyard Administration (GIPSA); and the California Rice Research Board in the systematic investigation of the rice sample milling mechanism and the effect of milling parameters on the appraisal of rice milling quality. Based on the scientific knowledge and results obtained by the researchers, a new rice sample milling standard was implemented by GIPSA. The adoption of the new rice sample milling procedure adds an estimated value of more than $20 million each year to the U.S. rice industry. This research solved a serious problem that rice producers were facing with respect to rice quality evaluation at sales. The researchers have continued to study rice sample preparation and interrelated factors, including impact of dockage, field losses, and novel treatments such as infrared drying on milled rice quality. The new rice shrink chart standard will also be implemented soon.

Pan, Z., Khir, R., and Thompson, J.F. 2013. Effect of milling temperature and postmilling cooling procedures on rice milling quality appraisals. Cereal Chemistry 90(2):1-9.

Atungulu, G.G., Prakash, B., Wang, X., Wang, T., Fu, R., Khir, R., and Pan, Z. 2013. Determination of dockage for accurate rough rice quality assessment. Applied Engineering in Agriculture 29(2):253-261.

Prakash, B. and Pan, Z. 2012. Effect of geometry of rice kernels on drying modeling results. Drying Technology 30:801-807.

Pan, Z., Khir, R., Godfrey, L.D., Lewis, R., Thompson, J.F., and Salim, A. 2008. Feasibility of simultaneous rough rice drying and disinfestations by infrared radiation heating and rice milling quality. Journal of Food Engineering 84:469-479.

Anticipated Product 3: ***Food technologies yielding foods with enhanced nutritional benefits.***

Sunflower cultivars with high levels of gamma- and delta-tocopherols. Healthy oils that can stand up to high cooking temperatures are needed to replace oils containing trans fats. Studies on vegetable oils by ARS scientists in Peoria, Illinois, showed that gamma- and delta-tocopherols were much better antioxidants than alpha-tocopherol. Since sunflower oils contain mostly alpha-tocopherol, the Peoria scientists recommended that ARS plant geneticists develop sunflowers with higher amounts of gamma- and delta-tocopherols to enhance the oxidative stability of sunflower oil. In March 2008, three cultivars of this modified sunflower were publicly released by ARS plant geneticists. The oils from the new modified sunflower varieties have increased oxidative and frying stability compared to sunflower oils that contain only alpha tocopherol. These oils have the potential to help replace trans fat-containing hydrogenated oils for high-heat stability uses, such as cooking, to produce good quality, healthful foods.

Warner, K. and Moser, J. 2009. Frying stability of purified mid-oleic sunflower oil triacylglycerols with added pure tocopherols and tocopherol mixtures. Journal of the American Oil Chemists' Society 86:1199-1207.

Warner, K., Miller, J., and Demurin, Y. 2008. Oxidative stability of crude mid-oleic sunflower oils from seeds with high γ- and δ-tocopherol levels. Journal of the American Oil Chemists' Society 85:529-533.

Commercialization of ultraviolet process to enhance vitamin D content in mushrooms. Approximately 60 percent of Americans are deficient in vitamin D, and there is a need for new foods that are good sources of vitamin D. ARS scientists in Albany, California, in collaboration with industrial partner, Monterey Mushrooms (the largest fresh mushroom marketer in the United States), developed, optimized, and commercially implemented a new ultraviolet B light illumination process to produce vitamin D in mushrooms. The process was scaled up, and results showed that the sensory acceptability of the ultraviolet-treated mushrooms was equivalent to that of the untreated mushrooms. The research showed that one serving of the ultraviolet B-treated mushrooms contributes 100 percent of the Recommended Dietary Allowance of vitamin D. The vitamin D-enriched mushrooms (brown, white, and Portobello) are now marketed nationwide. Subsequent research was completed, funded by the Mushroom Council, to study the human bioavailability of vitamin D-enriched mushrooms. Additional research is being done by the scientists, with funds from the USDA National Institute of Food and Agriculture (through an Agriculture and Food Research Initiative grant) to apply this innovative ultraviolet B process to enhance the health-promoting bioactive components (e.g., carotenoids) in other specialty crops, such as carrots.

Du, W., Avena Bustillos, R.D., Breksa III, A.P., and McHugh, T.H. 2012. Effect of UV-B light and different cutting styles on antioxidant enhancement of commercial fresh-cut carrot products. Food Chemistry 134:1862-1869.

Stephensen, C.B., Zerofsky, M., Burnett, D., Lin, Y., Hammock, B.D., Hall, L.M., and T.H McHugh. 2012. Ergocalciferol from mushrooms or supplements consumed with a standard meal increases 25-hydroxyergocalciferol but decreases 25-hydroxy cholecalciferol in the serum of healthy adults. Journal of Nutrition 142(7):1246-1252.

Roberts, J.S., Teichert, A., and McHugh, T.H. 2008. Vitamin D2 formation from post-harvest UV-B treatment of mushrooms (*Agaricus bisporus*) and retention during storage. Journal of Agricultural and Food Chemistry 56:4541-4544.

Anticipated Product 4: ***Safer products and/or products with longer shelf-life from new processes that control growth of spoilage microorganisms and human pathogens*** (in cooperation with National Program 108, Food Safety, and other partners)**.**

Microfilter process developed to remove spores from liquid egg white. Pasteurization is a food processing operation that is used to reduce or eliminate the natural microflora in fluid milk or liquid egg whites. However, it is ineffective against threat agents such as spores of *Bacillus anthracis*, the etiologic agent of anthrax, if they are intentionally added to foods through a terroristic act. In a study conducted by ARS scientists in Wyndmoor, Pennsylvania, a cross-flow microfiltration membrane process was designed as an intervention strategy to filter spores of *B. anthracis* from egg whites. Since the whites of eggs are a viscous material, the scientists developed new techniques to alter the viscosity and the properties of the proteins so that only the liquid egg white would pass through the membrane. They also determined the optimum operating conditions that preserved the delicate functional properties of liquid egg whites, such as foaming, and ensured that the constituent egg white proteins permeated through the membrane. The scientists were able to intercept more than 99.9999 percent of *B. anthracis* spores during the use of a 30-gallon capacity pilot scale microfiltration unit to filter liquid egg whites inoculated with the surrogate strain of *B. anthracis* spores. These studies demonstrated that the addition of a microfiltration step followed by pasteurization will ensure the safety of liquid egg whites while preserving nutrients and quality. Industry currently heats egg whites to destroy microflora, but has expressed interest in the microfiltration process if fuel prices continue to rise.

Mukhopadhyay, S., Tomasula, P.M., Luchansky, J.B., Porto-Fett, A.C., and Call, J.E. 2011. Removal of *Bacillus anthracis* sterne spore from commercial unpasteurized liquid egg white using crossflow microfiltration. Journal of Food Processing and Preservation 35:550-562.

Mukhopadhyay, S., Tomasula, P.M., Luchansky, J.B., Porto-Fett, A., and Call, J.E. 2010. Removal of *Salmonella enteritidis* from commercial unpasteurized liquid egg white using pilot scale cross flow tangential microfiltration. International Journal of Food Microbiology 142:309-317.

Mukhopadhyay, S., Tomasula, P.M., Van Hekken, D., Luchansky, J.B., Call, J.E. and Porto-Fett, A.C.S. 2009. Effectiveness of cross-flow microfiltration for removal of microorganisms associated with unpasteurized liquid egg white from process plant. Journal of Food Science 74(6):M319-M327.

Anticipated Product 5: ***Increased methods to safely and economically produce and distribute locally produced foods.***

Effect of Huanglongbing disease on orange juice flavor. Huanglongbing (HLB), also known as citrus greening, is a devastating disease for the citrus industry. In addition to debilitating

trees, it had been anecdotally reported to affect fruit quality, but no chemical or sensory studies had been done to confirm that as fact. ARS scientists in Fort Pierce, Florida, showed that only fruit that were severely affected by the disease imparted a negative flavor to the juice. When fruit with normal appearance harvested from HLB-affected trees were juiced, the juice flavor was not different from juice made from fruit harvested from healthy trees. The research demonstrated to citrus processors that they only need to sort out symptomatic fruit (small, green, and lopsided fruit) from their processing line to maintain juice quality. Recent follow-up studies show that it takes about 25 percent of oranges with HLB disease in a load of juice oranges to negatively affect overall juice flavor. This research has generated two recently established cooperative agreements with industry, one with Southern Gardens Citrus, a subsidiary of U.S. Sugar, and another with Coca Cola North America, to develop an electronic tongue or quantitative PCR to detect HLB-induced off-flavor in orange juice. In addition, as part of the cooperative agreements, the scientists are attempting to manage HLB juice off-flavor by adjusting aroma packages to mask bitterness or enhance sweetness.

Baldwin, E., Plotto, A., Manthey, J., McCollum, G., Bai, J., Irey, M., Cameron, R., and Luzio, G. 2010. Effect of Liberibacter infection (Huanglongbing disease) of citrus on orange fruit physiology and fruit/fruit juice quality: Chemical and physical analyses. Journal of Agricultural and Food Chemistry 58:1247-1262.

Plotto, A., Baldwin, E., McCollum, G., Manthey, J., Narciso, J., and Irey, M. 2010. Effect of Liberibacter infection (Huanglongbing or "greening" disease) of citrus on orange juice flavor quality by sensory evaluation. Journal of Food Science 75:S220-S230.

Anticipated Product 6: ***Food tailored to meet nutritional requirements for the School Lunch Program, Food for Peace, and similar programs*** (in cooperation with National Program 107, Human Nutrition, and other partners).

Improved emergency aid food. Ready-to-eat foods made for emergencies may suffer from reduced sensory and nutritional quality when they are delivered for use in hot, tropical climates unless storage conditions are adequate. In response to that need, ARS scientists in Wyndmoor, Pennsylvania, developed a new instant corn and soy blend with superior properties and a 1-year shelf life. Twenty metric tons of this new emergency-aid food was shipped to Haiti in 2011 through a grant from the National Institute for the Severely Handicapped. The emergency food fed more than 3,000 malnourished children and provided jobs for 128 disabled employees in the United States. *(This accomplishment also contributes to Problem Area 1C: New Bioactive Ingredients and Functional Foods; Anticipated Product 7: Development of new health-promoting foods for elderly and populations most prone to chronic diseases, on page 28.)*

FIGURE 9: ARS researchers inspect extruded instant corn-soy blend before milling and packaging as an emergency, ready–to-eat food product. The corn-soy blend is being scooped into the processor for extrusion at right.

Improved food security in Tajikistan. Central Asian countries have struggled economically during the years following the breakup of the former Soviet Union. Many former Soviet biological weapon scientists in this region were unemployed. With funding from the U.S. Department of State, ARS scientists in Wyndmoor, Pennsylvania, developed new native plant-based food and non-food products (sunflower oil and corn protein extraction, as well as apple, grape, and apricot fruit pectin extraction) that will benefit the local economy in Tajikistan and assist in helping to make this country more self-reliant. In addition, this effort supported U.S. anti-terrorist objectives by redirecting 12 former biological weapon scientists into research with peaceful outcomes, as they are currently being trained in packaging technologies to develop materials to extend the shelf life of local fresh produce. ARS scientists received merit awards from the Tajikistan Academy of Sciences, and $l.0 million in funding from the Tajikistan government was awarded to Tajik scientists as a result of this work.

Anticipated Product 7: ***Protein-based food ingredients, ranging from native to modified proteins, for fortification of foods and beverages.***

The scientific program addressing this research area, located at Beltsville, Maryland, was terminated, and the scientists were reassigned to different national programs.

Anticipated Product 8: ***New protective films and coatings for foods made from proteins, carbohydrates, lipids, and other food components to enhance the appearance, improve quality, and contribute to the function of shelf-based packaging system.***

Commercial transfer of fruit and vegetable edible film technology. New processing technologies can provide new products that increase utilization and consumption of fruits and vegetables by American consumers. ARS scientists in Albany, California, developed and commercialized novel nutritious gluten-free fruit and vegetable wraps with industry partner NewGem Foods. The wraps provide consumers with a new way to eat more fruits and vegetables and are lower in calories and salt content than grain-based wraps (breads and tortillas). A patent was issued and licensed exclusively to NewGem Foods. The wraps are being sold through Costco, Trader Joe's, Wegman's supermarkets, and other outlets. In addition, the company continues to be highly successful in selling their sushi wraps, which were also developed in collaboration with ARS. The company is profitable, with 2011 sales of over $500,000 and 2012 sales projected to more than double to more than $1 million. The films are being sold in the United States, United Kingdom, and Japan, and the company now has 18 full-time employees, bringing jobs into the rural area of Stockton, California, which has a high unemployment rate.

McHugh, T.H., DeBord, M.D., and Olsen, C.W. 2011. Fruit and vegetable edible films and uses thereof. U.S. Patent 8048466.

Anticipated Product 9: ***New technologies for production of shelf-stable and extended shelf life food products containing bioactive ingredients.***

Exposure of simulated supermarket continuous light during simulated retail marketing of spinach increases vitamin concentrations. Human health benefits derived from consuming fruit and vegetables are due to the many human bioactive compounds (folate; vitamins C, E, and K; and pro-vitamin A) found in produce. However, concentrations of these bioactive compounds are heavily influenced by plant genetics and pre/postharvest environmental assaults. ARS scientists in Weslaco, Texas, used spinach leaves from two popular commercially grown cultivars (Lazio and Samish) and placed them in retail plastic containers stored under simulated supermarket continuous light or dark conditions. All vitamins increased in concentration with storage under continuous light and decreased under continuous dark. The research established for the first time with spinach that concentrations of human bioactive compounds in postharvest green tissues exposed to retail supermarket light levels will increase during display. This information should deter some of the concerns about diminishing nutritional quality of produce in retail settings and suggests consumers should pick the light-exposed package of greens at the front of the display case. Numerous popular press articles and cooking show hosts have detailed these findings to consumers and nutritionists, who are now aware of purchasing bags of greens exposed to light. The refrigeration manufacturing industry has shown interest in this research.

Lester, G.E., Makus, D.J., and Hodges, D.M. 2010. Relationship between fresh-packaged spinach leaves exposed to continuous light or dark, and their human-health bioactive contents: cultivars, leaf size and storage duration. Journal of Agricultural and Food Chemistry 58:2980-2987.

Anticipated Product 9: ***Best practices for government and industry responders for destruction of contaminated food and restoration of factory and farm premises*** (in cooperation with National Program 108, Food Safety, and other partners)**.**

Cleaning up infected animal tissues for use in biodiesel. Tissues of animals infected with a prion disease such as scrapie or Bovine spongiform encephalopathy (BSE, or "mad cow disease") remain infective even after being subjected to heat treatments normally used to kill all bacteria and viruses. These contaminated tissues are considered hazardous waste and are destined for incineration. ARS investigators in Wyndmoor, Pennsylvania, studied two methods for prion inactivation that, in contrast to the current heating protocols, retain value and utility of the animal tissue. In the first study, the researchers found that an alkaline methanol treatment simultaneously converted the fat in the tissue into biodiesel and reduced the prion contamination by six orders of magnitude. In the second, the investigators showed that prion-destroying enzymes could access prions, even those deep within particles of rendered tissue, and would produce a residue with valuable properties for further processing. The U.S. animal rendering industry has expressed interest in this research, and ARS is awaiting a biodiesel industry partner to scale up this technology.

Bruederle, C.E., Hnasko, R.M., Kraemer, T., Garcia, R.A., and Haas, M.J. 2008. Prion infected meat-and-bone meal is still infectious after biodiesel production. PLoS One 3: e2969.

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COMPONENT 2: Fibers (including hides)

In Component 2, the NP 306 research projects relate the physical, chemical, and biological characteristics of cotton, wool, and animal hides, with the processability, end-use quality, and end-use function of these materials. The research also seeks to develop environmentally friendly methods to increase fiber and hide quality and performance while reducing post-harvest degradation and wear. In this Component, ARS scientists and engineers focus on solving fiber and hide problems and on protecting and broadening fiber markets through defining, measuring, and preserving quality and creating new or improved technologies, processes, and products.

Summaries of significant accomplishments by ARS researchers in the following locations are highlighted in this section: Stoneville, Mississippi; Lubbock, Texas; New Orleans, Louisiana; Clemson, South Carolina; Wyndmoor, Pennsylvania; and Mesilla Park, New Mexico. The researchers often worked in collaboration with university and industry scientists.

The NP 306 Action Plan for Component 2 lists 12 Anticipated Products expected to result from this research. The report lists the accomplishments that demonstrate progress towards delivering the Anticipated Products associated with each of the two Problem Statements.

PROBLEM STATEMENT 2.A: *Define, Measure, and Preserve Quality.*

The emphasis of the research within Problem Statement 2A was on (1) developing new or improved metrics and analytical methods for measuring fiber and animal hide quality, and (2) developing technologies for preserving or enhancing the quality of raw or processed fibers and animal hides.

Anticipated Product 1: *Quantitative models of fiber and animal hide physical structure that can be used to refine interpretations of relationships between intrinsic quality properties and utility value.*

In-silico model for collagen microfibrils. Without accurate computational models to predict the performance of biobased materials in product applications, product design and material engineers cannot reliably specify the use of these renewable materials in their products. Collagen, which is produced from waste pieces of untanned hides, holds great promise as a biobased material, but no computational models for its use existed. To overcome this technical barrier to the commercial applications of collagen-based biomaterials, ARS researchers in Wyndmoor, Pennsylvania, developed a computerized model to predict the material performance of materials containing collagen microfibrils so that biomaterials engineers can evaluate methods and ideas for stabilizing collagen blends, inserting active agents into such blends, or modifying collagen. The model is incorporated into publicly available software (DeepView) and can be downloaded off the ARS Web site (www.ars.usda.gov/Main/docs.htm?docid=23380), so it can be easily used by material design engineers.

Brown, E. M. 2013. Development and utilization of a bovine type I collagen microfibril model. International Journal of Biological Macromolecules 53:20–25

Brown, E.M. and Shelly, D.C. 2011. Molecular modeling approach to vegetable tanning: preliminary results for gallotannin interactions with the collagen microfibril. Journal of American Leather Chemists Association 106(5):145-152.

Brown, E.M. and Qi, P.X. 2008. Exploring a role in tanning for the gap region of the collagen fibril: catechin-collagen interactions. Journal of American Leather Chemists Association 103(9):290-297.

Anticipated Product 2: ***Methods, definitions, and technologies to rapidly, accurately and economically measure desired quality parameters for quality assessment and process control.***

Preserving cotton bale quality through safe microwave moisture measurements. Cotton is one of the few commodities sold on a wet basis. Because quality can be significantly degraded if cotton is stored under high levels of moisture, the industry is in critical need of a sensor that can provide an accurate measurement of the moisture content of cotton bales. ARS scientists in Lubbock, Texas, found that existing commercial microwave moisture sensors provided a false dry reading when cotton bales are dangerously wet. When cotton handlers use such false readings to inject additional moisture into the bale, the result is an extremely high-moisture content that leads to significant degradation of the cotton in long-term storage. The researchers identified the underlying causes for these errors (back-reflection of microwaves by surface moisture and by metallic bale ties/bands) and developed methods to eliminate them. They also developed an electronic package to make the moisture measuring device portable. Cotton Inc. provided funding for this research, which resulted in four patents and another pending. The results, which will help maintain demand for U.S. cotton in the $5+ billion/year global export market, will be validated at three commercial ginners in 2013.

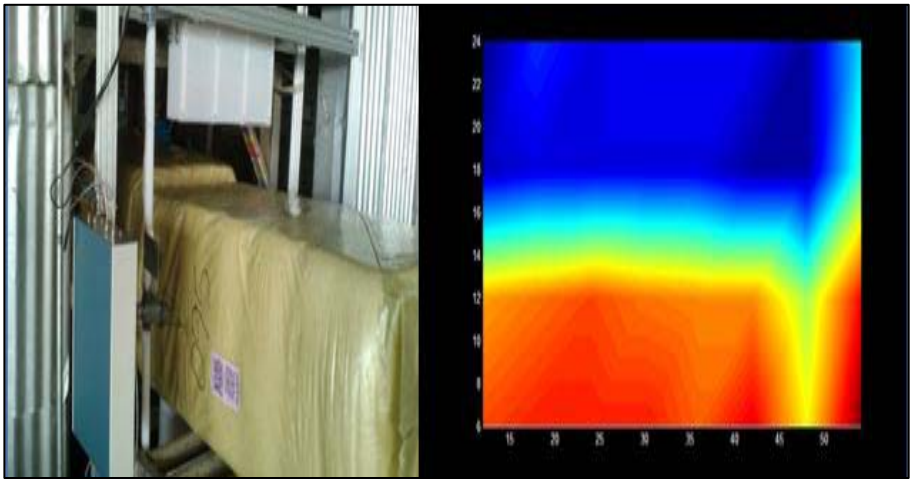

FIGURE 10: ARS cotton moisture imaging system measuring wettest spot in a cotton bale. Color image on the right denotes internal bale moisture ranging from dry (reddish-orange) to very wet (blue).

Pelletier, M.G. and Viera, J.A. 2010. Low-cost electronic microwave calibration for rapid on-line moisture sensing of seedcotton. Sensors 10(12),11088-11099.

Pelletier, M.G., Viera, J.A., Wanjura, J.D., and Holt, G.A. 2010. Accurate permittivity measurements for microwave imaging via ultra-wideband removal of spurious reflectors. Sensors 10(9), 8491-8503.

Pelletier, M.G. and Barnes, E.M. 2008. Microwave imaging of cotton bales. Sensors 8(11), 7241-7258.

Anticipated Product 3: ***New or improved equipment and processes that more effectively and efficiently harvest, and process agricultural fibers and by-products from raw material to finished product that will minimize fiber and by-product damage and improve end use value.***

Improving the quality of upland cotton. Upland cotton is the largest-volume cotton type produced in the United States, but fiber length in upland cotton is shorter than in pima cotton. Although yield-per-acre for pima cotton is significantly lower than for upland cotton, millers use pima cotton to produce high-quality yarns. Several years ago, ARS researchers in Las Cruces, New Mexico, developed high-speed roller ginning to maintain the high quality of pima cotton. Recently, ARS researchers in Las Cruces, New Mexico; Lubbock, Texas; Stoneville, Mississippi; and New Orleans, Louisiana, have shown that relative to conventional saw ginning, roller ginning minimizes fiber breakage in upland cotton as well and permits growers to take full advantage of new varieties of upland cotton that produce longer fibers. A miller and spinning frame manufacturer will begin commercial trials of this technology in 2013.

Byler, R. K. and C. D. Delhom. 2012. Comparison of saw ginning and high-speed roller ginning with different lint cleaners of Mid-South grown cotton. Applied Engineering in Agriculture 28(4):475-482. http://elibrary.asabe.org/azdez.asp?search=1&JID=3&AID=42076&CID=aeaj2012&v=28&i=4&T=2&urlRedirect

Improved lint cleaner. Saw-type lint cleaners currently used in cotton ginning operations tend to reduce cotton quality by shortening fiber length and creating neps (entangled fibers). Modeling the design of spike cylinders used in the textile industry, ARS researchers in Lubbock, Texas, developed a sawless lint cleaner to improve fiber quality. The device has successfully completed 2 years of a 3-year field test at a commercial cotton gin. This research, which was done under a cooperative agreement with an industry partner that ended recently, will be published in 2013.

Minimizing energy waste in cotton ginning. Electrical power accounts for about 20 percent of the variable costs in cotton ginning, with the bulk of electrical consumption being used to power the ginning equipment. ARS researchers in Stoneville, Mississippi, and Las Cruces, New Mexico, determined that, on average, ginners can minimize energy costs by shutting down idle equipment whenever the time between processing bales exceeds 12 minutes.

Hardin, R.G. IV and Funk, P.A. 2012. Electricity use patterns in cotton gins. Applied Engineering in Agriculture 28(6):841-849. http://elibrary.asabe.org/azdez.asp?JID=3&AID=42471&CID=aeaj2012&v=28&i=6&T=2&redirType

Funk, P.A. and Hardin, R.G. IV. 2012. Cotton gin electrical energy use trends and 2009 audit results. Applied Engineering in Agriculture 28(4):503-510. http://elibrary.asabe.org/azdez.asp?JID=3&AID=42078&CID=aeaj2012&v=28&i=4&T=2&redirType

Anticipated Product 4: ***Improved quality assessment criteria and methods for animal hides prior to tanning that will better reflect raw hide and end product value.***

New ultrasound method to inspect hides and leather. Animal hides are the highest-value by-product of the meat industry. The U.S. beef industry produces approximately 35 million cattle hides annually. Visual inspection is used to rank untanned hides for quality and sale price, but visual inspection is not reliable for detecting defects that are hidden by hair. Furthermore, this subjective assessment is non-uniform among operators and leads to disputes over fair price. To accurately, objectively, and nondestructively assess the quality of untanned hides, ARS researchers at Wyndmoor, Pennsylvania, developed an ultrasonic C-scan imaging technique to detect defects in hides and leather.

Liu, C.-K., Latona, N.P., and Yoon, S.-C. 2013. Evaluation of hides, wet blue and leather using airborne ultrasonics. Journal of the American Leather Chemists Association 108(4):128-138.

Liu, C.-K. and Latona, N.P. 2011. Airborne ultrasonic inspection of hides and leather. Journal of the American Leather Chemists Association 106(11):326-331. http://naldc.nal.usda.gov/download/55224/PDF

PROBLEM STATEMENT 2.B: ***New or Improved Technologies, Processes, or Products.***

Under this Problem Statement, ARS scientists created new or improved technologies, processes, or products to address issues and provide solutions to a wide variety of fiber and hide industry problems.

Anticipated Product 1: ***New and improved environmentally friendly chemistry for fiber and hide modification, processing, functional finishes, and processing applications.***

Economical fabrication of fire-retardant/fire-barrier cotton-rich fabrics/pads for mattresses and furniture. Cotton's high flammability, relative to synthetic fibers, is a major barrier to its use in applications such as bedding and furniture where flame retardancy is required. ARS scientists in New Orleans, Louisiana, developed a low-cost, cotton-rich, nonwoven pad using commercially available fire-retardant chemicals and fibers. The pad passed the California-legislated standard flammability tests for mattresses. ARS is looking for a mattress manufacturer to validate the technology at commercial scales.

Uppal, R., Bhat, B., Akato, K., Parikh, D., Nam, S., and Condon, B. 2012. Flame retardant antibacterial cotton high-loft nonwoven fabrics. Journal of Industrial Textiles 41:281-291.

Nam, S., Condon, B.D., Parikh, D.V., Zhao, Q., Cintron, M.S., and Madison, C. 2011. Effect of urea additives on the thermal decomposition of greige cotton nonwoven fabric treated with diammonium phosphate. Polymer Degradation and Stability 96:2010-2018.

Kamath, M.G., Bhat, G.S., Parikh, D.V., and Condon, B.D. 2009. Processing and characterization of flame retardant cotton blend nonwovens for soft furnishings to meet flammability standards. Journal of Industrial Textiles 38:251-261.

Economical and environmentally benign process for removing dried manure from hides. "Adobe" manure (dry and matted manure and hair) is difficult to remove from hides and is a major problem in meat and hide processing operations. Utilizing low-cost and biodegradable materials (crude glycerol and enzymes), ARS researchers in Wyndmoor, Pennsylvania, developed an effective low-cost cleaning process to remove adobe manure. ARS is looking for a meat packer to validate the technology at commercial scales.

Ramos, M., Muir, Z., and Ashby, R. 2012. Soaking formulations that can soften and remove hardened bovine manure: Part II, Effects on quality of leather. Journal of the American Leather Chemists Association 107(5):167-174.

Ramos, M.A., Muir, Z.E., Solaiman, D.K.Y., and Schreyer, S. 2012. Microbiological and near IR studies of leathjer from hides presoaked in formulations that can soften hardened bovine manure. Journal of the American Leather Chemists Association 107(9):302-310.

Ramos, M., Muir, Z., Ashby, R., and Liu, C.-K. 2011. Soaking (washing) formulations that can soften hardened bovine manure. Journal of the American Leather Chemists Association 106(7):212-218.

Value-added products from wool-based keratin. U.S. wool producers, and by extension, sheep farmers, need new high-value applications for wool to ensure profitability and market growth. ARS researchers in Wyndmoor, Pennsylvania, developed environmentally benign chemical processes to extract the protein keratin, the major chemical component in wool, and convert it into a variety of creams, emollients, and gels for applications in personal care products. For example, urethane-like derivatives were found to be elastomeric, to adhere well to hair, skin and nails (which are also keratin-based), and to be effective substitutes for silicones in cosmetics. Sulfonated keratin produced by the ARS scientists, unlike sulfonated keratin currently used in hair conditioners, actually strengthens hair. Because of the highly-functionalized chemical structure of native keratin, and because keratin forms porous hydrogels, these keratin derivatives can also act as carriers for biologically active compounds. A multinational company has entered into a cooperative agreement with ARS and is utilizing this technology to develop and commercialize environmentally friendly and "natural" personal care products. ARS has filed two patent applications for inventions associated with this research.

Cardamone, J.M., Tunick, M.H., and Onwulata, C. 2013. Keratin sponge as absorbent, excipient biomaterials Part I. Fabrication and Characterization. Textile Research Journal 83(7):661-670. http://trj.sagepub.com/content/83/7/661.abstract

Cardamone, J.M. 2013. Keratin sponge as absorbent, excipient biomaterials Part II. Active Agent Delivery. Textile Research Journal 83(9):917-927. http://trj.sagepub.com/content/83/9/917.abstract.

Martin, J.J., Cardamone, J.M., Irwin, P.L., and Brown, E.M. 2011. Keratin capped silver nanoparticles- synthesis and characterization of a nanomaterial with desirable handling properties. Colloids and Surfaces B: Biointerfaces 88:354-361. http://naldc.nal.usda.gov/download/54090/PDF

Cardamone, J.M. 2010. Investigating the microstructure of keratin extracted from wool: peptide sequence (MALDI-TOF/TOF) and protein conformation (FTIR). Journal of Molecular Structure 969:97-105. http://naldc.nal.usda.gov/download/43899/PDF

Cardamone, J.M., Nunez, A., Garcia, R.A., and Ramos, M. 2009. Characterizing wool keratin. Research Letters in Materials Science Volume 2009, Article ID 147175, 5 pages. www.hindawi.com/journals/rlms/2009/147175.abs.html.

Cardamone, J.M. 2008. Keratin transamidation. International Journal of Biological Macromolecules 42(5):413. http://naldc.nal.usda.gov/download/32757/PDF

Anticipated Product 2: ***Use of fiber in modified or new applications for both woven and non-woven structures as well as non-fibrous forms that will include both durable and non-durable products.***

Enabling market growth for non-woven cottons. Non-woven cotton fabrics hold great promise for increasing cotton demand in the United States and world-wide. ARS researchers in New Orleans, Louisiana, developed a needle punch process to attach nonwoven cotton batting to other fabrics for applications in home craft markets (e.g., quilting, pillows). Products utilizing this technology are now being sold in Jo-Ann Fabric and Craft Stores and Walmart. These same researchers also showed that lower-quality, lower-cost, byproduct cotton fibers from ginning can be blended with full fiber to create nonwoven fabrics of acceptable quality. In addition, they demonstrated that using hydroentanglement to produce cotton nonwoven fabrics results in products that exhibit unexpected strength when wet and retain more strength than expected after laundering. These findings indicate that cotton nonwovens are good candidates for applications in semi-durable products (e.g., geotextiles, automotive, and garments) and in disposables such as wipes, diapers, and personal care.

Sawhney, A.P.S., Allen, C., Reynolds, M., Slopek, R., and Condon, B. 2013. Whiteness and absorbency of hydroentangled cotton-based nonwoven fabrics of different constituent fibers and fiber blends. World Journal of Engineering 10(2):125-132.

Sawhney, A.P.S., Reynolds, M., Allen, C., Slopek, R., and Condon, B. 2013. Effects of greige cotton lint properties on hydroentangled nonwoven fabrics. Textile Research Journal 83(1):3-12.

Sawhney, A.P.S., Allen, C., Reynolds, M., Slopek, R., Condon, B., Hui, D., and Wojkowski, S. 2012. Effect of web formation on properties of hydroentangled nonwoven fabrics. World Journal of Engineering 9(5):407-416.

Sawhney, A.P.S., Allen, C., Reynolds, M., Condon, B., and Slopek, R. 2011. Effect of water pressure on absorbency of hydroentangled greige cotton non-woven fabrics. Textile Research Journal 82(1):21-26.

Sawhney, A.P.S., Reynolds, M., Allen, C., Condon, B., Slopek, R., Hinchliffe, D., and Hui, D. 2011. Greige cotton comber noils for sustainable nonwovens. World Journal of Engineering 8(3):291-294.

Sawhney, A.P.S., Reynolds, M., Condon, B., Slopek, R., and Allen, C. 2011. A comparative study of nonwoven fabrics made with two distinctly different forms of greige cotton lint. Textile Research Journal 81(14):1484-1492.

Condon, B., Gary, L., Sawhney, A.P.S., Reynolds, M., Slopek, R., and Delhom, C.D., and Hui, D. 2010. Properties of nonwoven fabrics made with UltraClean cotton. World Journal of Engineering 7(2):180-184. http://naldc.nal.usda.gov/catalog/49298.

Sawhney, A.P.S., Condon, B., Reynolds, M., Slopek, R., and Hui, D. 2010. Advent of greige cotton non-wovens made using a hydro-entanglement process. Textile Research Journal 80(15):1540-1549.

Sawhney, A.P.S., Reynolds, M., Condon, B., Slopek, R., and Hui, D. 2010. An efficient process for producing economical and eco-friendly cotton-based textile composites for mobile industry. World Journal of Engineering 7(1):150-153.

Developing new biobased products from waste hide material. Collagen fibers produced from untanned hide scraps exhibit superior toughness and ductility, but there are few value-added applications for these fibers. ARS scientists in Wyndmoor, Pennsylvania, developed technologies for using collagen fibers in industrial products such as air filters and biobased polymer reinforcements. A tanner is validating these technologies at commercial scales.

Liu, C.-K., Latona, N.P., Taylor, M., and Latona, R.J. 2013. Effects of bating, pickling and crosslinking treatments on the characteristics of fibrous networks from un-tanned hides. Journal of the American Leather Chemists Association 108(3):79-85. http://alcajournal.com/index.php/abstracts/march-2013/

Liu, C.-K., Latona, N.P., Taylor, M., and Latona, R.J. 2012. Effects of dehydration methods on characteristics of fibrous networks from un-tanned hides. Journal of the American Leather Chemists Association 107(3):70-77. http://alcajournal.com/index.php/abstracts/march-2012/

Expanding the use of cotton in sanitizing wipes. Although consumers prefer the weight, feel, and sustainability of cotton-based wipes, most sanitizing wipes marketed today contain little or no cotton because antimicrobial compounds adhere too strongly to the cotton. ARS researchers in New Orleans, Louisiana, developed a new wetting solution for producing wipes so that antimicrobials in the solution are released onto surfaces to be cleaned rather than adhering to the cotton. In collaboration with an industrial partner, they also developed technology for cotton-based, re-useable, anti-microbial wipes and towels. The technology involves a natural dye that releases antimicrobial gas (singlet oxygen) when exposed to visible light; ARS produced the dyed non-woven cotton fabrics for the effort. These products are currently being sold in Europe, and the Bill and Melinda Gates Foundation provided a grant to distribute wipes and towels based on this technology in third-world countries.

Slopek, R., Condon, B., Sawhney, P., Reynolds, M., and Allen, C. 2011. Adsorption of alkyl-dimethyl-benzyl-ammonium chloride on differently pretreated non-woven cotton substrates. Textile Research Journal 81(15):1617-1624.

Slopek, R., Condon, B., Sawhney, P., Reynolds, M., and Allen, C. 2010. Effect of cotton pectin content and bioscouring on alkyl-dimethyl-benzyl-ammonium chloride adsorption. Textile Research Journal 82(17):1743-1750.

Anticipated Product 3: ***A better understanding of fiber quality parameters and predicting their effects on woven and non-woven processes and product quality.***

Recovering more value from seed cotton. "Seed cotton" is the cotton fiber that is still attached to the seed, and much seed cotton is associated with seeds removed by machines that clean the cotton before actual ginning. This byproduct seed cotton is typically discarded with the ginning trash or blended with lower-quality 'mote' cotton, which sells at a significant discount. If this byproduct seed cotton could be added to the cleaned cotton before ginning, then ginners could potentially increase their production volumes of high-quality cotton by 2 percent. ARS researchers in Stoneville, Mississippi, in collaboration with a commercial ginner, determined that up to 2 percent of the seed cotton fiber recovered from pre-ginning cleaning equipment can be blended with normal cotton without any significant loss in overall product quality. The researchers also determined that cultivar type had the largest influence on fiber loss when cleaning seed cotton at high throughput rates (processing more material per unit width on the gin)—a practice that reduces the cost of ginning. Further, these scientists, in collaboration with ARS researchers in New Orleans, Louisiana, and a commercial mill, demonstrated that whereas seed cotton from saw ginning is not acceptable for spinning certain high-quality yarns, lint produced from roller-ginned seed cotton can be suitable for such demanding applications. Although these results were reported in conference presentations, the blending of byproduct seed cotton with normal cotton (prior to ginning) has not been accepted as standard practice because of the industry's current extremely high focus on product uniformity and quality.

Anticipated Product 4: ***Improved identification and quantification of sources of fiber quality variation, such as inherent genetic properties, production environment, harvesting methods, ginning technology and various post-harvest processing and finishing steps.***

Screening cotton cultivars that are easier to gin. Cotton breeders would like to develop new varieties that can be ginned faster and with less energy, but the traditional method used to measure fiber-seed attachment force is very time consuming (individual seeds are tested with a pendulum and inclinometer and involve two to four pendulum swings per seed). ARS researchers in Stoneville, Mississippi, developed an accurate automated method to estimate fiber-seed attachment force that involves simply measuring the power consumption in a laboratory-scale gin stand (where fiber is separated from the seed). Cotton breeders are using this new method to screen varieties and to identify specific genes associated with ginning efficiency.

Boykin, J.C., Bechere, E., and Meredith, W.R. 2012. Cotton genotype differences in fiber-seed attachment force. Journal of Cotton Science 16:170-178. www.cotton.org/journal/2012-16/3/loader.cfm?csModule=security/getfile&pageid=138575

Bechere, E., Boykin, J.C., and Meredith, W.R. 2011. Evaluation of cotton genotypes for ginning energy and ginning rate. Journal of Cotton Science 15:11–21. www.cotton.org/journal/2011-15/1/upload/JCS15-11.pdf

Anticipated Product 5: ***New or improved quality measurement methods, standards, and instrumentation.***

New standard analytical method for water content in cotton fiber. ARS scientists in New Orleans, Louisiana, developed a more accurate analytical method for measuring water content in cotton fiber. Traditional methods could not distinguish between water and organic volatiles. The new method, which simultaneously distinguishes the water content of the neat cotton fiber and the water content of the biological trash, has been adopted as the standard method for determining cotton fiber water content by both the cotton industry and ASTM International (ASTM D7785-12).

Montalvo, J.G. Jr., Von Hoven, T., Cheuk, S. and Schindler, A. 2010. Preliminary studies of non-aqueous volatiles in lint cotton moisture tests by thermal methods. Textile Research Journal 80(13):1360-1376. http://trj.sagepub.com/content/80/13/1360

Montalvo, J.G. Jr., Von Hoven, T.M., and Cheuk, S. 2011. Reference method for total water in lint cotton by automated oven drying combined with volumetric Karl Fischer titration. Journal of Cotton Science 15:189-205. 2011. www.cotton.org/journal/2011-15/2/loader.cfm?csModule=security/getfile&pageid=124850

Automated and portable systems for cotton color measurement. The color of ginned cotton is an important metric in commerce, but the traditional method for quantifying color requires a laboratory spectrophotometer and involves manual sample preparation techniques that increase the variability of measured values. ARS researchers in New Orleans, Louisiana, developed an automated sampling preparation system with significantly lower variability in color measurement on standard cotton samples used by the industry. ARS' improved cotton fiber sample preparation method is being used by the USDA Agricultural Marketing Service and Cotton Inc. These researchers also developed a portable spectroscopic-based device for assessing cotton color, thereby avoiding the need for a laboratory spectrophotometer. Cotton Inc. is deploying these portable devices world-wide.

Rodgers, J., Elkholy, K., Cui, X., Delhom, C., and Fortier, C. 2012. Fiber sampling system for spectrophotometer cotton fiber color measurements. Journal of Cotton Science 16(2):117-124.

Rodgers, J., Kang, S., Fortier, C., Cui, X., Delhom, C., and Knowlton, J. 2010. Minimization of operational impacts on spectrophotometer color measurements for cotton. Journal of Cotton Science 14:240-250.

Rodgers, J., Thibodeaux, D., Campbell, J., and Cui, X. 2009. Feasibility of "traceable" color standards for cotton color. AATCC Review 9(1):42-47.

Anticipated Product 6: ***Better methods and understanding for preventing fiber and hide quality deterioration during handling and storage from all causes.***

Environmentally friendly process for leather finishing to enhance leather durability. Leather production traditionally uses chromium treatments to increase leather's resistance to ultraviolet (UV) light and heat. Such resistance is especially necessary for leather upholstery in automobiles. However, U.S.-based tanners have found it increasingly expensive to apply

chromium treatments because of the costly waste-water treatment steps that are needed to keep chromium out of the environment, as mandated by environmental regulations. As a result, most UV- and heat-resistant leather is now produced in developing countries that have relatively lax environmental regulations. ARS researchers in Wyndmoor, Pennsylvania, developed an environmentally friendly finishing process to increase the UV and heat resistance of leather without the use of chromium. The process involves applying mixtures of biobased humectants and tocopherols (Vitamin E) to the grain layer of chrome-free leather. Leather treated with glycerol/tocopherol mixtures had significant improvement in strength retention and color fading resistance against UV radiation and heat. The results of this research provide the U.S. hides and leather industries with a means of producing UV- and heat-resistant leather in an environmentally friendly manner.

Liu, C.-K., Latona, N.P., and Ramos, M.L. 2011. Effects of alpha-tocopherol addition to polymeric coatings on the UV, heat resistance of a collagen fibrous material–chrome-free leather. Journal of Applied Polymer Science 122(5):3086-3091. http://onlinelibrary.wiley.com/doi/10.1002/app.34129/pdf

Liu, C.-K., Liu, L.S., Latona, N.P., Ramos, M.L., and Latona, R.J. 2010. The use of mixed tocopherols to improve UV and heat resistance of leather. Journal of the American Leather Chemists Association 105(1):9-15. http://naldc.nal.usda.gov/download/42759/PDF

Liu, C.-K., Ramos, M.L., Latona, N.P., and Latona, R. 2009. Leather coated with mixtures of humectant and antioxidants to improve ultraviolet and heat resistance. Journal of the American Leather Chemists Association 104(5):161-168. http://naldc.nal.usda.gov/download/34033/PDF

Anticipated Product 7: ***Better understanding of how changes in animal production and slaughterhouse practices affect the properties of raw hides and their finished products.***

Due to staff reductions, ARS was not able to pursue this objective.

Anticipated Product 8: ***Alternative methods of short-term hide preservation and points of processing will be developed and evaluated in response to environmental concerns and regulations.***

Environmentally friendly hide dehairing process. Caustic sulfide is traditionally used to dehair bovine hides; however, sulfide poses both a health hazard and an environmental hazard. Therefore, U.S. tanners, who are particularly subject to health and environmental regulations, have expressed interest in eliminating the use of sulfide in their processes. ARS scientists in Wyndmoor, Pennsylvania, developed a dehairing process based on alkaline sodium percarbonate (a white, crystalline, water-soluble chemical composed of sodium carbonate and hydrogen peroxide) that eliminates the use of sulfide and thus prevents sulfide effluents from the tannery. Since 2008, ARS has continued this research under a cooperative agreement with a major domestic tannery, which has precluded ARS from publishing the recent results of this research.

COMPONENT 3: Biobased Products

In Component 3, ARS scientists and engineers focus on research that enables environmentally friendly processes to convert agricultural feedstocks, including byproducts, into commercially viable biobased products without disrupting the animal or human food supply. To this end, the research is intended to (1) discover and develop biobased materials and conversion processes, and (2) improve biobased material performance and processing by enhancing understanding of relevant structure-function relationships.

Summaries of significant accomplishments by ARS scientist and engineers, often in collaboration with university and industry scientists, are highlighted on the following pages.

ARS research projects in the following locations contributed directly to NP 306 in this component: Albany, California; Beltsville, Maryland; Fort Pierce, Florida; Lubbock, Texas; Mesilla Park, New Mexico; New Orleans, Louisiana; Oxford and Stoneville, Mississippi; Peoria, Illinois; and Wyndmoor, Pennsylvania.

PROBLEM STATEMENT 3.A: *Agricultural Feedstocks and Byproducts.*

The processing of agricultural materials generates millions of tons of low-value byproducts that represent an enormous and underutilized renewable resource, and can create adverse environmental and economic impacts through disposal. Furthermore, agricultural materials and current processing byproducts can be a sustainable feedstock for chemicals, polymers, composites, and other industrial materials. New crops grown on underutilized lands or off-season rotation with commodity food crops can provide materials without affecting the food supply. ARS research in this section explored the potential use of new and existing crops, agricultural byproducts, and residues for feedstocks, and developed processes for their conversion into industrial materials.

Anticipated Product 1: *Improved feedstocks derived from new and existing crops, animal resources, and agricultural byproducts.*

Elite germplasm for fuel production. Pennycress (*Thlaspi arvense*) is an annual winter cover crop that produces superior oil suitable for renewable diesel or biodiesel production. Biodiesel fuel derived from pennycress oil has a lower cloud point and is more oxidatively stable than soy-based biodiesel. In addition, because pennycress can be double-cropped with soybeans, it does not compete with food production. ARS scientists in Peoria, Illinois, an elite pennycress germplasm from wild populations found in Illinois that exhibited germination rates of greater than 90 percent versus rates as low as 20 percent for previously used varieties. The new variety also yields up to 30 percent more seed with 6 percent greater oil content than current lines; thus, its oil yield per acre is about twice that of soybeans. ARS is working with several companies to commercialize the production of this new pennycress variety for conversion into biobased jet fuel, including one company that has leased 1,600 acres in Illinois to grow pennycress for biofuel

conversion. Follow-on research has discovered two, soon to be released, lines of pennycress that are 95 percent non-dormant at harvest. This is a significant improvement over the current "elite" line with dormancy of 6 months.

Cermak, S.C., Biresaw, G., Isbell, T.A., Evangelista, R.L. and Murray, R. 2013. New crop oils – properties as potential lubricants. Industrial Crops and Products 44(1):232-239.

Evangelista, R.L., Isbell, T.A., and Cermak, S.C. 2012. Extraction of pennycress (*Thlaspi arvense* L.) seed oil by full pressing. Industrial Crops and Products 37(1):76-81.

Moser, B.R., Knothe, G., Vaughn, S.F. and Isbell, T.A. 2009. Production and evaluation of biodiesel from field pennycress (*Thlaspi arvense* L.) oil. Energy Fuels 23(8):4149-4155.

Rubber from Russian dandelion has commercial potential. Roots of the Russian dandelion (*Taraxacum kok-saghyz*) produce high levels of natural rubber and have the potential of being a rubber-producing crop for the United States. ARS scientists in Albany, California, and Pullman, Washington, in collaboration with scientists from Kazakhstan, mounted an expedition to collect Russian dandelion in the high river valleys in southeastern Kazakhstan. Collections were made from 22 different populations, with the intent of finding genetic diversity for rubber production. All of the accessions were found to be viable and increased the collection of the ARS National Germplasm Collection from 2 varieties of Russian dandelion to more than 20. Phenotypes from the collected lines have been characterized with respect to plant biomass, root rubber content, inulin content, and root morphology. These data have helped breeders select the lines of interest for further development. The data from this work will soon be entered into the Germplasm Resources Information Network (GRIN). Half of the original collected material was transferred back to the Vavilov Institute of Research in St. Petersburg, Russia, which had no viable accessions. During the past 3 years, ARS has distributed 369 seed packets of Russian dandelion to 24 individuals and organizations in six countries. Russian dandelion from this distribution is now growing in test plots around the world to determine the best growing conditions.

Rawlins, L., Hellier, B.C., and McMahan, C. 2012. Phenotype analysis of Kazak dandelion root tissues from the National Plant Germplasm System collection. page 65. McMahan, C.M., and Berti, M.T. Eds. (2012), 24th Annual AAIC Meeting. Industrial Crops: Developing Sustainable Solutions: Program and Abstracts. November 12-15, 2012, Sonoma, CA.

Applying genetic engineering to guayule, an industrial crop. Most natural rubber is produced in Southeast Asia; but guayule, a woody plant, is now being cultivated in the United States for production of natural rubber for medical applications and possibly for automotive tires. ARS scientists in Albany, California, and Maricopa, Arizona, in collaboration with university scientists, studied highly expressed portions of the genome (expressed sequence tags) to identify which genes are most important to rubber biosynthesis. The Albany researchers also developed a new protocol for *in vitro* tissue culture of guayule. ARS submitted a patent application for the new protocol, which has a 30 percent faster regeneration rate compared to prior protocols. These accomplishments are facilitating the breeding of new guayule varieties with superior traits.

Dong, N., Ponciano, G., McMahan, C. M., Coffelt, T.A., Johnson, L., Creelman, R. Whalen, M.C., and Cornish, K. 2013. Overexpression of 3-hydroxy-3-methylglutaryl coenzyme A reductase in *Parthenium argentatum* (guayule). Industrial Crops and Products 46:15-24. www.sciencedirect.com/science/article/pii/S0926669013000125

Ponciano, G., McMahan C.M., Xie, W., Lazo, G.R., Coffelt, T.A., Collins-Silva, J., Nural-Taban, A., Gollery, M., Shintani, D.K., and Whalen, M.C. 2012. Transcriptome and gene expression analysis in cold-acclimated guayule (*Parthenium argentatum*) rubber-producing tissue. Phytochemistry 79:57-66. www.sciencedirect.com/science/article/pii/S0031942212001860

Kumar, S., Hahn, F.M., McMahan, C.M., Cornish, K., and Whalen, M.C. 2009. Comparative analysis of the complete sequence of the plastid genome of *Parthenium argentatum* and identification of DNA barcodes to differentiate *Parthenium* species and lines. BMC Plant Biology 9**:**131 DOI:10.1186/1471-2229-9-131. www.biomedcentral.com/1471-2229/9/131.

Enabling sweet sorghum as a feedstock for fuels and chemicals. There is significant interest worldwide in using sweet sorghum juice to produce products such as ethanol, butanol, and succinic acid. ARS scientists in New Orleans, Louisiana, developed a multi-step process for removing contaminants from sweet sorghum juice (clarification) so as to maximize shelf life of the juice and resulting syrup. An industrial partner is now using the process on a commercial scale. The scientists also found that using the traditional method of harvesting sweet sorghum (shredding the stalks) in warm and moist climates (e.g., the Mississippi Delta) leads to excessive microbial degradation whereas harvesting in 8- to 16-inch billets (short pieces of stalk) maximizes biofuel yield. Further research showed that different cultivars of sweet sorghum exhibit wide variations in juice quality—much more than is seen in sugar cane or sugar beets—and require adjustments in the clarification process to produce clarified juice or syrup of acceptable quality.

Andrzejewski, B., Eggleston, G., Lingle, S., and Powell, R. 2013. Development of a sweet sorghum juice clarification method in the manufacture of industrial feedstocks for value-added products. Industrial Crops and Products 44:77-87.

Lingle, S., Tew, T., Rukavina, H., and Boykin, D. 2013. Post-harvest changes in sweet sorghum II: pH, acidity, protein, starch, and mannitol. Bioenergy Research 6:178-187.

Lingle, S., Tew, T., Rukavina, H., and Boykin, D. 2012. Post-harvest changes in sweet sorghum I: Brix and sugars. Bioenergy Research 5:158-167.

Eggleston, G., Tew, T., Panella, L., and Klasson, T. 2010. Ethanol from sugar crops. In: Industrial Crops and Uses. Ed.: Singh, B.P., CABI, Wallingford, U.K**.**, Chapter 4, p. 60-83.

Camelina meal for healthful livestock feed. Camelina, an oilseed crop, is under development to produce and convert dcamelina oil into renewable jet fuel. However, value-added uses need to be developed for the seed meal byproduct (after deoiling). In response to this need, ARS scientists in Peoria, Illinois, developed the meal as a healthful ration in livestock feed. Specifically, they found that the meal contains cancer-inhibiting glucosinolates that are similar to the glucosinolates found in broccoli. Further, unlike glucosinolates in canola—another oilseed crop being developed for bioenergy production—camelina-derived glucosinolates are not goitrogens (causative agent for goiter disease). The research resulted in an FDA-approved feed additive for egg-laying chickens, and the FDA is considering approval of its use in feeds for dairy cattle and pets. The scientists are also evaluating the use of camelina meal and muscilage (the slimy coating on camelina seed hulls) as tackifiers in hydromulches and kitty litter.

Berhow, M.A., Polat, U., Glinski, J.A., Glensk, M., Vaughn, S.F., Isbell, T., Ayala-Diaz, I., Marek, L., and Gardner, C. 2013. Purification and quantification of glucosinolates from *Camelina sativa* seeds. Industrial Crops and Products 43:119-125.

Kakani, R., Fowler, J., Haq, A., Murphy, E.J., Rosenberger, T.A., Berhow, M., and Bailey, C.A. 2012. Camelina meal increases egg n-3 fatty acid content without altering egg quality or production in laying hens. Lipids 47:519-526.

Vaughn, S.F., Kenar, J., Felker, F., Berhow, M., Cermak, S., Evangelista, R., Fanta, G., Behle, R. and Edward, L. 2013. Evaluation of alternatives to guar gum as tackifiers for hydromulch and as clumping agents for biodegradable cat litter. Industrial Crops and Products 43:798-801.

Anticipated Product 2: ***Processes for more efficient use of natural resources that will not disrupt food supply.***

Biobased materials in tires. Most of the material in automobile tires is produced from petroleum, a non-renewable and increasingly scarce resource. Natural rubber is imported from Southeast Asia, but U.S. tire manufacturers would like to have a secure, renewable, domestic source of rubber for tires. Domestic production of natural rubber would expand U.S. agriculture into semi-arid regions unsuitable for food crops. ARS scientists in Albany, California, in collaboration with a U.S. tire manufacturer, conducted a life-cycle analysis comparing the use of petroleum-based and domestically produced biobased material in tire manufacturing. The analysis sought to estimate the potential impact of biobased materials technology on reducing oil dependency related to (1) raw material manufacture, (2) gasoline savings from improved fuel efficiency, (3) net energy savings associated in making raw materials, and (4) the potential impact on greenhouse gas emissions. The analysis provided preliminary data to support the awarding of $6.9 million in funding through NIFA and the Department of Energy for a guayule tire-building project in 2012. The project includes comprehensive sustainability analysis for guayule cultivation, processing, tire construction, and use. Knowledge from this project will lay the groundwork for future public and private domestic rubber research and development toward a more sustainable tire industry in the United States. Publication of this work has been delayed because it was done under a non-disclosure agreement with an industry partner.

Opening industrial markets for guayule rubber. Guayule is a rubber-producing shrub that can be grown in semi-arid regions. The shrub was used by the United States during World War II as a source of rubber when supply of Southeast Asia-grown natural rubber, called Hevea, was cut off. Recently, ARS research has enabled a 500-metric-ton-a-year, guayule-based U.S. rubber industry, mostly focused on the need for natural but hypo-allergenic rubber in medical applications. Although U.S. producers of automotive tires, belts, and other rubber-based industrial products would like to replace Hevea rubber with domestically grown, guayule-derived rubber in their products, a 100-percent replacement could change the performance quality of their products. ARS scientists in Albany, California, in collaboration with industry partners, showed that blends of guayule latex and imported Hevea rubber exhibit intermediate physical properties (tensile strength, gel, and thermo-oxidative stability), a finding that suggests that the peptide and amino acid degradation products in Hevea latex are capable of physically and

chemically blending with guayule latex. This new finding suggests that rubber users can use blends of guayule and Hevea rubber in their products, thereby opening initial industrial markets for guayule-based rubber in the United States.

Whalen, M., McMahan, C., and Shintani, D. 2013. Development of crops to produce industrially useful natural rubber. Chapter 23 in T.J. Bach and M. Rohmer (eds.), *Isoprenoid Synthesis in Plants and Microorganisms: New Concepts and Experimental Approaches*, Springer Science+Business Media, New York. 329-345. DOI:10.1007/978-1-4614-4063-5_23.

Ray, D.T., Foster, M.A., Coffelt, T.A., and McMahan, C.M. 2010. B. Singh (ed). Guayule: a rubber-producing plant. Chapter 18, 384-410. Industrial Crops and Uses. CABI, Cambridge, MA.

New value-added products from cotton gin trash. ARS researchers in Lubbock, Texas, developed biodegradable composites from cotton gin trash, mushroom mycelia, and a variety of cellulosic biomass (e.g., flax, kenaf, switchgrass, wheat straw) along with processes to produce these composites. Potential applications include form-fit packaging, automotive panels, acoustic tiles, and temporary buoys. An industry partner is conducting validation/qualification trials of these composite materials for specific end-use customers. Another industry partner has begun producing and marketing lawn and garden products (e.g., faux rocks, raised garden kits) consisting of thermoplastic composites—developed by these same researchers—of cotton gin trash and waste plastic wrap from cottonseed modules.

Bajwa, S.G., Bajwa, D.S., Holt, G.A., and Wedegaertner, T.C. 2012. Commercial scale evaluation of two agricultural waste products, cotton burr/stem and module wraps in thermoplastic composites and comparison with laboratory-scale results. Journal of Thermoplastic Composite Materials 5 Dec 2012. DOI:10.1177/0892705712454865.

Holt, G.A., McIntyre, G., Flagg, D., Bayer, E., Wanjura, J.D., and Pelletier, M.G. 2012. Fungal mycelium and cotton plant materials in the manufacture of biodegradable molded packaging material: evaluation study of select blends of cotton byproducts. Journal of Biobased Materials and Bioenergy 6:431-439.

Holt, G.A., Chow, P., Wanjura, J.D., Pelletier, M.G., Coffelt, T.A., and Nakayama, F.S. 2012. Termite resistance of biobased composition boards made from cotton byproducts and guayule bagasse. Industrial Crops and Products 36:508-512.

Bajwa, S.G., Bajwa, D.S., Holt, G., Coffelt, T., and Nakayama, F. 2011. Properties of thermoplastic composites with cotton and guayule biomass residues as fiber fillers. Industrial Crops and Products 33:747-755.

Bajwa, S.G., Bajwa, D.S., and Holt, G. 2010. Application of cotton burr/stem in thermoplastic composites, in: Oosterhuis, D.M. (Ed), Summaries of Arkansas Cotton Research 2009, Arkansas Agricultural Experiment Station, Research Series 582, pp. 183-185.

Bajwa, S.G., Bajwa, D.S., and Holt, G. 2009. Optimal substitution of cotton burr and linters in thermoplastic composites. Forest Products Journal 59(10):40–46.

Holt, G.A., Coffelt, T.A., Chow, P., and Nakayama, F. 2009. Biobased composition boards made from cotton gin and guayule waste: Select physical and mechanical properties. International Journal of Materials and Product Technology 36(1/2/3/4):104-114.

PROBLEM STATEMENT 3.B: ***Develop Biobased Products and Sustainable Technologies/Processes.***

Lack of fundamental knowledge of biochemical, cellular, and molecular properties and processes, and their role in determining functionality has limited utilization of agricultural materials. Sustainable materials and processes that meet functional properties are needed to displace petroleum-based products and create new markets for agricultural commodities and byproducts. Novel products, compounds, and materials are needed for many non-food uses as specialized products for niche markets. ARS research is being done to enable the development of sustainable biobased products.

Anticipated Product 1: ***New processes with reduced environmental impact for converting agricultural-based materials into biobased materials and products.***

Rapidly bio-degrading chewing gum material. In any given year, more than 650,000 metric tons of chewing gum is produced, corresponding to more than 374 trillion sticks of chewing gum. A significant problem for the industry is that much of this chewing gum ends up discarded on sidewalks and under tables. Gum material currently used on the market suffers from poor digestibility and poor biodegradability. Furthermore, all gum materials are made from either natural rubber or expensive carbohydrates. ARS scientists in Peoria, Illinois, used a new polymerization method to develop a new chewing gum material made from soybean oil. ARS has applied for a patent for this gum material, which has good flavor and is both biodegradable and digestible. The biodegradability of these soy-based chewing gums has been certified in an independent laboratory, and samples of the material have been tested by large chewing gum companies with favorable results regarding retained flavor and chewability. The scientists, in collaboration with industry partners, are evaluating the shelf-life of and developing the manufacturing process for the soy-based gums, both of which are important steps towards the commercialization of this technology. This new technology could improve the quality of chewing gum in the market and help to eliminate problematic, long-lasting chewing gum litter, while at the same time promoting the use of renewable and domestic agricultural products. Because this research has been done under a cooperative agreement, it has not been published.

Substitutes for gum Arabic. Gum Arabic, commonly used as a thickening agent and emulsifier in foods and beverages, is produced only in politically unstable sub-Saharan Africa. ARS researchers in Peoria, Illinois, developed and patented an enzymatic process for converting a microbially produced polysaccharide (alternan) into a product with properties similar to gum Arabic. The process is completely certifiable as "Generally Recognized as Safe," so the product can be used as a food ingredient. ARS is partnering with a large company to evaluate the product.

Leathers, T.D., Nunnally, M.S., and Cote, G.L. 2009. Modification of alternan by dextranase. Biotechnology Letters 31(2):289-293. DOI:10.1007/s10529-008-9866-3. http://link.springer.com/article/10.1007/s10529-008-9866-3.

Leathers, T.D., Nunnally, M.S., and Cote, G.L. 2010. Optimization of process conditions for enzymatic modification of alternan using dextranase from *Chaetomium erraticum*. Carbohydrate Polymers 81(3):732-736. DOI:10.1016/j.carbpol.2010.03.030. www.sciencedirect.com/science/article/pii/S0144861710002006.

Anticipated Product 2: ***Chemicals, polymers, composites, and other industrial materials from renewable agricultural feedstocks.***

High-value products from Cuphea. ARS scientists in Peoria, Illinois, developed a catalyst that efficiently converts the oil from seeds of the *Cuphea* plant, a common perennial, into a high-value specialty chemical. ARS filed for a U.S. patent on this technology and is working with an industrial partner to commercialize the *Cuphea*-derived chemical (2-undecanone) as a natural fragrance. In addition, the scientists, in collaboration with an industry partner, discovered that 2-undecanone is an effective slow-release mosquito repellant that may find applications as a commercially viable, natural, and less toxic alternative to DEET insecticide. The ARS scientists are considering additional research with industry and university collaborators to investigate the issues involved with the scale-up and commercialization of the technology.

Jackson, M.A. and Cermak, S.C. 2012. Cross ketonization of *Cuphea* sp. oil with acetic acid over a composite oxide of Fe, Ce, and Al. Applied Catalysis A: General 431-432:157-163.

A new family of bio-based lubricant additives using boron. Current anti-wear and anti-oxidant additives for lubricants use phosphorous, zinc, and sulfur, but those elements can react with water, forming acids that corrode engine parts and bearings. In addition, these additives are often incompatible with plant (biobased) lubricants. ARS scientists in Peoria, Illinois, in collaboration with an industrial partner, created new boron-based additives for lubricants made from gel-stabilized (hardened/epoxidized) vegetable oils. The scientists showed that the boron additives were highly effective when used with soybean oil lubricants. ARS has applied for a patent on these "organoboron" compounds, and industry partners are being sought.

Sharma, B.K., Doll, K.M., Heise, G.L., Myslinska, M., and Erhan, S.Z. 2012. Anti-wear additive derived from soybean oil and boron utilized in a gear oil formulation. Industrial and Engineering Chemistry Research 51:11941-11945.

Heise, G.L., Sharma, B.K., and Erhan, S.Z. 2012. "Boron containing vegetable oil based antiwear/antifriction additive and their preparation" Patent Application number: 13/241572, Filed September 23, 2011, Publication number US2012/0083433 A1.

Biodegradable fire-retardant gels to protect buildings. Fire retardant gels are applied to buildings and other structures imminently threatened by large, intense fires. Current fire retardant gel products are petroleum-based, are not biodegradable, and may produce toxic fumes when burning. Using starch, water, and bentonite clay, ARS scientists in Albany, California, developed a fire-retardant gel that is biodegradable and less expensive than gels currently on the market. Whereas the most intense heat of wildfires typically occurs during the first 10 minutes, the new biobased gel coating at ¼ inch thickness was found to give nearly 30 minutes of protection against intense heat (940°F). The scientists have applied for a patent and have been approached by the U.S. Forest Service to test this product in the field.

Glenn, G.M., Klamczynski, A.P., and Bingol, G. Starch-based fire retardant. U.S. Plant Patent Application 61/621,444. Docket No. 0057.11.

Glenn, G.M., Bingo, G., Chiou, B.S., Klamczynksi, A.P., and Pan, Z. 2012. Sodium bentonite-based coatings containing starch for protecting structures in wildfire emergency situations. Fire Safety Journal 51:85–92.

New rapid, low-cost process for making nanomaterials. The promise of nanotechnology to add value to agricultural applications has been slowed by the inability to scale-up production of nanomaterials and be cost-effective. ARS scientists in Albany, California, have developed a new blow-spinning process to produce nanomaterials that are much less expensive than those produced by electrospinning, the current process used in industry. The specific advantages of nanoscale blow-spinning include a higher fiber production rate, an ability to scale-up production using inexpensive commercially available components, an ability to blow nanomaterials onto surfaces without consideration of their electrical charge, relative portability, and savings in that no high-voltage equipment is required. A patent application has been filed for the technology.

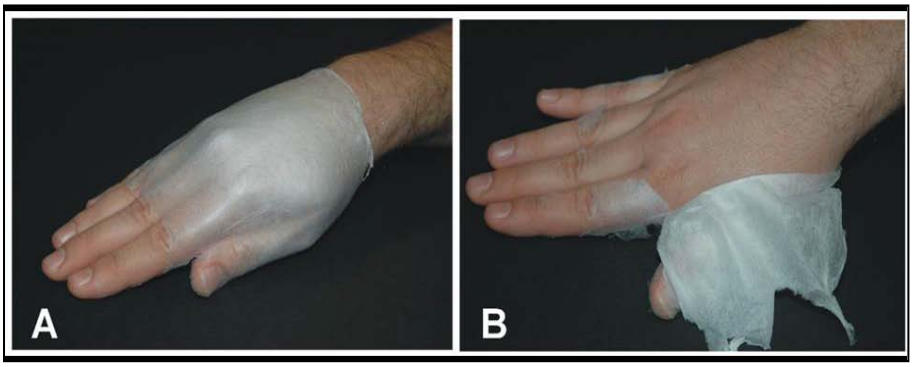

FIGURE 11: ARS developed blow-spinning of plant based cellulose into nano-materials can be used for numerous applications such as spray-applied wound dressings which easily conform to irregular surfaces (A) and, as they are non-adhesive, can easily be removed (B) without impacting the wound.

Oliveira, J., Grassi, V., Scagion, V., Mattoso, L., Glenn, G., and Medeiros, E. 2012. A sensor array for water analysis based on interdigitated electrodes modified with fiber films of poly(lactic acid)/multiwalled carbon nanotubes, Sensors Journal, IEEE PP(99):1,0.

Oliveira, J.E., Moraes, E.A., Costa, R.G.F., Afonso, A.S., Mattoso, L.H.C., Orts, W.J., and Medeiros, E.S. 2011. Nano and submicrometric fibers of poly(D,L-lactide) obtained by solution blow spinning: Process and solution variables. Journal of Applied Polymer Science 122(5):3396–3405.

Medeiros, E.S., Glenn, G.M., Klamczynski, A.P., Orts, W.J., and Mattoso, L.H.C. 2009. Solution blow spinning: a new method to produce micro- and nanofibers from polymer solutions. Journal of Applied Polymer Science 113(4):2322-2330.

Novel nanoparticles for window glass cleaners. Although nanoparticles have attractive industrial properties, they bind together and fall out of solution and lose their effectiveness when used in liquids over time. By attaching a biodegradeable synthetic polymer to nanoscale proteins, ARS scientists in Peoria, Illinois, created stable nanoparticles that make surfaces hydrophilic. When a solution of these particles is applied onto hydrophobic surfaces such as glass, it coats the surface and prevents water from beading without loss of transparency. Near-term applications include solar panels, dehumidifier fins, and automotive side windows that have no wipers. ARS has applied for a patent and is looking for an industrial partner to commercialize the product.

Kim, S., Evans, K., and Biswas, A. 2013. Production of BSA-poly(ethyl cyanoacrylate) nanoparticles as a coating material that improves wetting property. Colloids and Surfaces B: Biointerfaces 107:68-75. http://dx.doi.org/10.1016/j.colsurfb.2013.01.064

Biobased encapsulated fertilizers. Fertilizer costs have risen dramatically, a problem that affects food production costs and, ultimately, food prices. ARS scientists in Albany, California, developed a matrix to encapsulate live microbes that facilitate nitrogen fixation and release nutrients, growth promoters, and insecticides into the soil for extended periods of time. The resulting fertilizer is considered organic, and the encapsulation matrix, which is composed of gypsum and starch, reduces the required number of fertilizer applications, thereby saving labor, energy, and the environment. ARS has applied for a patent, and the scientists are refining the encapsulated product under a 3-year grant from the Pakistan-U.S. Science and Technology Cooperative Program. In addition, a collaborative research agreement has been reached with an industry partner to develop commercial formulations using this technology. Two U.S. companies have expressed interest in licensing the technology, as have companies in Africa, Southeast Asia, and Europe. An invited manuscript is being prepared.

Biobased flocculant derived from poultry blood. Unlike the blood generated in beef and pork processing, the byproduct blood from poultry processing often is not collected and becomes part of the processing plant's wastewater stream. Treating wastewater containing blood adds significantly to the cost of poultry processing and fails to capture the value of the blood. ARS scientists in Wyndmoor, Pennsylvania, determined that blood could be very effective at flocculating clay particles from water. In tests run by the scientists, this biobased flocculant compared favorably with the fossil fuel-based commercial flocculants in both price and performance. In addition to transforming a costly waste product into a revenue-generating product, these organic and biodegradeable flocculents can be used to recover clay particles and nutrients in runoff water from furrow-irrigated farm fields. Furthermore, the scientists identified the specific components responsible for the flocculation-promoting properties of blood, a finding that could enable the use of the remaining blood material in other value-added applications. A patent was recently granted for this technology.

Piazza, G. and Garcia, R. November 20, 2012, Methods for flocculating suspensions using biobased renewable flocculants. U.S. Patent No. 8,313,654.

Piazza, G.J., Nuñez, A., and Garcia, R.A. 2012. Identification of highly active flocculant proteins in bovine blood. Applied Biochemistry and Biotechnology 166:1203-1214.

Piazza, G.J., McAloon, A.J., and Garcia R.A. 2011. A renewable flocculant from a poultry slaughterhouse waste and preliminary estimate of production costs. Resources, Conservation and Recycling 55:842-848.

Formulation of soybean-, corn-, and sorghum-based plywood adhesives. The large and growing number of biodiesel and fuel ethanol producers would benefit from technology that could convert large quantities of soybean meal and corn germ byproducts into value-added products. Utilizing soybean meal, corn germ meal, or sorghum flour as protein extenders, ARS scientists in Peoria, Illinois, developed plywood adhesives that exhibit mixing properties and bonding strengths equivalent to those of current industry adhesives. The scientists are also developing adhesive formulations that contain protein extracts from new crops—lesquerella, cuphea, and pennycress—being considered for jet fuel and chemical production.

Hojilla-Evangelista, M.P. 2013. Evaluation of corn germ protein as an extender in plywood adhesive. Journal of Adhesion Science and Technology, Special Issue on Biobased Adhesives (In press; published online 8-10-2012. DOI:10.1080/01694243.2012.696958)

Hojilla-Evangelista, M.P. and Bean, S.R. 2011. Evaluation of sorghum flour as extender in plywood adhesives for sprayline coaters or foam extrusion. Industrial Crops and Products 34:1168-1172.

Hojilla-Evangelista, M.P. 2010. Adhesion properties of plywood glue containing soybean meal as an extender. Journal of the American Oil Chemists Society 87:1047-1052.

Commercialization of estolides as biobased lubricants. There is a growing world-wide demand for biodegradable biobased products to replace petroleum-based materials. ARS scientists in Peoria, Illinois, developed and patented biobased lubricants called estolides, which perform so well that they do not need additives normally required in biobased lubricants. The scientists, in collaboration with an industrial partner, developed new biobased lubricants that match or exceed the performance characteristics of the highest quality petroleum-based oils currently used in automotive and industrial applications. The industry partner is now commercializing these "green" lubricants.

Cermak, S.C., Isbell, T.A., Evangelista, R.L. and Johnson, B.L. 2011. Synthesis and physical properties of petroselinic based estolide esters. Industrial Crops and Products 33(1):132-139.

Isbell, T.A. 2011. Chemistry and physical properties of estolides. Grasas y Aceites 62(1):8-20.

Cermak, S.C., Biresaw, G., and Isbell, T.A. 2008. Comparison of a new estolide oxidative stability package. Journal of the American Oil Chemists Society 85(9):879-885.

Low-cost biodegradable biobased polymers. A small number of biodegradable biobased plastics have been commercialized, but their relatively high cost limits their market potential. ARS researchers in Peoria, Illinois, developed technologies to produce biodegradable copolyester glyceride polymers for less than $1 a pound, a price point that could be appealing to plastics manufacturers. ARS has applied for patent protection for these technologies, which utilize low-cost feedstocks, citric acid (the number one chemical product produced via fermentation), and glycerol (a byproduct of biodiesel production).

Tisserat, B., O'Kuru, H.R.E., Hwang, H.S., and Mohamed, A.A. 2012. Glycerol citrate polyesters produced through heating without catalysis. Journal of Applied Polymer Science 125:2429-3437.

Tisserat, B., Selling, G.W., Byars, J.A., and Stuff, A.M. 2011. Instrumental physical analysis of microwaved glycerol citrate foams. Journal of Polymers and the Environment 20:291–298. DOI:10.1007/s10924-011-0376-3.

Starch-based skin lotions that are not sticky. Most commercial body lotions for delivering antimicrobials onto human skin are based primarily on formulations of starch, lipid, pectin, and xanthan, but these formulations become sticky when dry. ARS scientists in Peoria, Illinois, have shown that "jet-cooked" formulations—prepared using high-amylose starch in the presence of a fatty acid—exhibit a smooth feel and do not become sticky after drying. An industry partner is now commercializing antiseptic skin lotions (DermCare) using this non-tacky formulation.

Fanta, G.F., Kenar, J.A., Byars, J.A., Felker, F.C., and Shogren, R.L. 2010. Properties of aqueous dispersions of amylose-sodium palmitate complexes prepared by steam jet cooking. Carbohydrate Polymers 81:645-651.

New platform for sugar-based chemicals. The creation of new biobased products will be greatly accelerated by the development of new platform chemistries for converting agricultural and food wastes into useful materials. ARS scientists in Peoria, Illinois, have developed and patented a chemistry that utilizes fruit and vegetable processing waste, converting it into glycoside-based oligosaccharides that are both water and fat soluble (a detergent). By changing the choice of sugars, these detergents can be either strong—for use in dishwashing—or exceptionally mild—for use as baby shampoos. The process also avoids the use of environmentally problematic organic solvents.

Price, N.P.J. 2012. Green detergents from agriculture-based lipids and sugars. U.S. Patent 8,314,219 B1.

Carpenter, C.A., Kenar, J.A., and Price, N.P.J. 2010. Preparation of saturated and unsaturated fatty acid hydrazides and long chain C-glycoside ketohydrazones. Green Chemistry 12:2012-2018.

Adeuya, A. and Price, N.P.J. 2009. Electron impact ion fragmentation pathways of peracetylated C-glycoside ketones derived from cyclic 1,3-diketones. Rapid Communications in Mass Spectrometry 23:1173-1182.

Price, N.P.J., Bowman, M.J., Le Gall, S., Berhow, M.A., Kendra, D.F., and Lerouge, P. 2010. Functionalized C-glycoside ketohydrazones: carbohydrate derivatives that retain the ring integrity of the terminal reducing sugar. Analytical Chemistry 82(7):2893-2899.

Biochars to reduce heavy-metal contamination in water from military training ranges. Rainwater draining from soils at military firing ranges is typically contaminated with heavy metals such as lead, copper, and antimony. An estimated 12,000 military and non-military shooting ranges are scattered across the United States, and heavy metal—especially lead—contamination is a regulatory concern. ARS researchers in New Orleans, Louisiana, in collaboration with the Army Research Laboratory and other Department of Defense partners, developed biochars specifically formulated to bind heavy metals in soils. The researchers determined that producing biochars via slow (lower-temperature) pyrolysis from materials containing higher levels of leachable phosphorous such as poultry litter, and activating them by a post-pyrolysis oxidation step maximized the biochars' ability to bind heavy metals. Adding these biochars to contaminated soils decreased soluble lead, copper, nickel, and cadmium concentrations in leachate water from 300µg per million to below detection limits.

Uchimiya, M., Bannon, D.I., Wartelle, L.H., Lima, I.M., and Klasson, K.T. 2012. Lead retention by broiler litter biochars in small arms range soil: Impact of pyrolysis temperature. Journal of Agricultural and Food Chemistry 60:5035-5044. http://pubs.acs.org/doi/abs/10.1021/jf300825n.

Uchimiya, M., Bannon, D.I., and Wartelle, L.H. 2012. Retention of heavy metals by carboxyl functional groups of biochars in small arms range soil. Journal of Agricultural and Food Chemistry 60(7):1798-1809. http://pubs.acs.org/doi/abs/10.1021/jf2047898.

Uchimiya, M., Wartelle, L.H., Klasson, K.T., Fortier, C.A., and Lima, I.M. 2011. Influence of pyrolysis temperature on biochar property and function as a heavy metal sorbent in soil. Journal of Agricultural and Food Chemistry 59(6): 2501-2510. http://pubs.acs.org/doi/abs/10.1021/jf104206c.

Biobased surfactants. Rhamnolipids are high-performing surfactants that could be used in personal care products and foods, but they are produced by a bacterium that is an opportunistic human pathogen. ARS scientists in Wyndmoor, Pennsylvania, transferred the metabolic machinery for producing mono- and di-rhamnolipids into a non-pathogenic microbe. A patent application for the transformant is being filed, and an industrial collaborator is evaluating use of the ARS-derived rhamnolipids in cosmetics.

Use of ginning trash in packaging materials. Expanded polystyrene (EPS) and expanded polypropylene (EPP) are used to make non-biodegradable protective packaging materials, a $2.2 billion industry. In the United States, cotton ginning produces about 2 million tons annually of waste that needs value-added uses. ARS researchers in Lubbock, Texas, developed six blends and mechanical processing techniques utilizing ginning trash that allowed an industrial partner to manufacture 100-percent biodegradable packaging composites that outperformed EPS and EPP. In 2010, the partner launched commercial production of the protective packaging material produced from ginning trash with a Fortune 500 company and attracted interest from two other Fortune 500 companies. Use of these biodegradable composite materials has been expanded to other applications, including candle holders, disposable footwear, limited-life buoys, insulation panels, and furniture cores.

FIGURE 12: ARS developed 'eco-friendly' packing–produced from mycelium and cotton byproducts–that can be manufactured to serve as form-fitting packing materials for any shippable product. Two examples are packages for shipping wine (right) and corner pieces for shipping items in boxes (left).

Holt, G.A., McIntyre, G., Flagg, D., Bayer, E., Wanjura, J.D., and Pelletier, M.G. 2012. Fungal mycelium and cotton plant materials in the manufacture of biodegradable molded packaging material: Evaluation study of select blends of cotton byproducts. Journal of Biobased Materials and Bioenergy 6:431-439.

Turning cotton ginning waste into revenue by making hydromulch. Each year, cotton ginners generate many thousands of tons of waste that could be used by higher-value markets. ARS scientists in Lubbock, Texas, developed technology to convert this ginning trash into hydromulch, a low-cost alternative to sod that can be sprayed onto the ground. The technology

for using ginning trash in hydromulch was patented and transferred to industry partners who have deployed it at commercial-scale facilities in Texas and are selling gin-trash-based hydromulch nationwide. The hydromulch application creates a new revenue stream to cotton ginners of $20 to $30 per ton of trash.

Scholl, B.N., Holt, G., and Thornton, C. 2012. Screening study of select cotton-based hydromulch blends produced using the cross-linked biofiber process. Journal of Cotton Science 16:249-254.

Holt, G.A., Lee, E., Ellis III, A., and Wedegaertner, T.C. Cross-linked biofiber products and a process for their manufacture. U.S. Patent No. 7,788,847. September 7, 2010.

Novel low-cost biobased nanocomposite. Nanofibers from waste coconut shells represent a large, under-utilized resource that could provide unique properties to value-added products. ARS researchers in Albany, California, in collaboration with EMBRAPA scientists from Brazil, developed a biodegradable starch/nanofiber composite material using the fiber from waste coconut shells. The addition of coconut-derived nanofibers into starch-based plastics improved strength and flexibility. Companies in Brazil have expressed interest in producing this low-cost and biodegradable biobased nanocomposite.

Rosa, M.F., Medeiros, E.S., Malmonge, J.A., Gregorski, K.S., Wood, D.F., Mattoso, L.H.C., Glenn, G.M., Orts, W.J., and Imam, S.H. 2010. Cellulose nanowhiskers from coconut husk fibers: effect of preparation conditions on their thermal and morphological behavior. Carbohydrate Polymers 81:83-92.

Rosa, M.F., Chiou, B., Medeiros, E.S., Wood, D.F., Mattoso, L.H., Orts, W.J., and Imam, S.H. 2009. Biodegradable composites based on starch/EVOH/glycerol blends and coconut fibers. Journal of Applied Polymer Science 111(2):612-618.

Rosa, M.F., Chiou, B., Medeiros, E.S., Wood, D.F., Williams, T.G., Mattoso, L.H., Orts, W.J., and Imam, S.H. 2009. Effect of fiber treatments on tensile and thermal properties of starch/ethylene vinyl alcohol copolymers/coir biocomposites. Bioresource Technology 100(21):5196-5202.

Anticipated Product 3: ***Bioactive compounds from renewable materials with agricultural applications (e.g., antifungals).***

New antimicrobial packaging materials made from crop processing residues. Buyers of packaging materials, a $2.2 billion market, are interested in biodegradable and renewable materials that also have antimicrobial properties. Citrus processors need higher-value uses for their citrus pulp, a byproduct currently being sold for livestock feed. In response to these needs, ARS scientists in Wyndmoor, Pennsylvania, developed and patented a process for producing antimicrobial packaging films from citrus pulp. Biodegradable citrus pectin/polylactic acid films developed by ARS scientists possess mechanical properties similar to those of non-biodegradable petroleum-derived thermoplastics, plus they can absorb antimicrobial agents and control their release, thereby inhibiting the growth of bacterial pathogens. The ARS process is relatively simple, efficient, environmentally friendly (using no organic solvents), and easily scaled up.

Liu, L.S., Hicks, B.K., and Jin, T.Z. Compositions containing poly(lactic acid), bacteriocin(s), plasticizers(s), and optionally pre forming agent(s), and methods for making. U.S. Patent 8,268,905, September 18, 2012.

Li, W., Coffin, D.R., Jin, T.Z., Latona, N., Liu, C-K., and Liu, L.S. 2012. Biodegradable composites from polyester and sugar beet pulp with antimicrobial coating for food packaging. Journal of Applied Polymer Sciences 126:E361-372.

Liu, L.S., Jin, T.Z., Coffin, D.R., Liu, C.-K., and Hicks, K.B. 2010. Poly (lactic acid) membranes containing bacteriocin and EDTA for inhibition of the surface growth of gram-negative bacteria. Journal of Applied Polymer Sciences 117:486-492.

Liu, L.S., Jin, T.Z., Coffin, D.R., and Hicks, K.B. 2009. Preparation of antimicrobial membranes: coextrusion of poly(lactic acid) and Nisaplin® in the presence of plasticizers. Journal of Agricultural and Food Chemistry 57:8392-8398.

Microbeads for protecting honeybees. The honeybee industry, which is critical to the success of agricultural production of crops that depend on pollination, has been plagued by Varroa mites in beehives. ARS scientists in Albany, California, developed starch microbeads as slow-release agents of miticides (heptanone and essential oils) to control the Varroa parasites. The scientists developed a process to produce starch-based microspheres that are 1—10µm in diameter and contain pores less than 1µm. The porous starch microspheres are infused with miticides and placed in beehives, where the miticides are slowly released. Tests by ARS bee researchers showed that the miticide-microspheres were effective in reducing Varroa infestations.

Glenn, G.M. and Klamczynski, A.P. 2012. Starch Foam Microparticles. U.S. Patent #8,163,309.

Glenn, G.M., Imam, S.H., and Orts, W.J. 2011. Starch-based foam composite materials: processing and bioproducts. Materials Research Society 36(9):1-7.

Jadhav, S.R., Chiou, B-S., Wood, D.F., DeGrande-Hoffman, G., Glenn, G.M. and John, G. 2011. Molecular gels-based controlled release devices for pheromones. Soft Matter 7(3):864-867.

Glenn, G.M., Klamczynski, A.P., Wood, D.F., Chiou, B-S., Orts, W.J., and Imam, S.H. 2010. Encapsulation of plant oils in porous starch microspheres. Journal of Agricultural and Food Chemistry 58(7):4180-4184.

Prebiotic for livestock. Hemicellulose, the second most prevalent biomaterial in the world, cannot be digested by humans and is thus an excellent feedstock for biobased products. However, few value-added applications currently exist. ARS researchers in Peoria, Illinois, developed a process to convert waste products from the Texas yellow pine wood-paneling industry into a low-cost nutrient additive for the livestock and pet food industries. This hemicellulose-based compound enhances the growth of bacteria that promote intestinal health and suppresses pathogenic enteric bacteria. This technology has been transferred to an industrial partner and is being used to produce Previda™, a commercial prebiotic.

Faber, T.A., Dilger, R.N., Hopkins, A.C., Price, N.P., and Fahey, G.C. 2012. Effects of oligosaccharides in a soybean meal-based diet on fermentative and immune responses in broiler chicks challenged with *Eimeria acervulina*, Poultry Science 91(12):3132-3140.

Faber, T.A., Dilger, R.N., Iakiviak, M., Hopkins, A.C., Price, N.P., and Fahey Jr., G.C. 2012. Ingestion of a novel galactoglucomannan oligosaccharide-arabinoxylan (GGMO-AX) complex affected growth performance and fermentative and immunological characteristics of broiler chicks challenged with *Salmonella typhimurium*. Poultry Science 91(9):2241-2254.

Faber, T.A., Dilger, R.N., Hopkins, A.C., Price, N.P., and Fahey, G.C. 2012. The effects of a galactoglucomannan oligosaccharide-arabinoxylan (GGMO-AX) complex in broiler chicks challenged with *Eimeria acervulina.* Poultry Science 91(5):1089-1096.

Price, N.P., Hartman, T.M., Faber, T.A., Vermillion, K.E, and Fahey, G.C. 2011. Galactoglucomannan oligosaccharides (GGMO) from a molasses byproduct of pine (*Pinus taeda*) fiberboard production. Journal of Agricultural and Food Chemistry 59:1854-1861. http://pubs.acs.org/doi/abs/10.1021/jf1037097.

Faber, T.A., Bauer, L.L., Price, N.P., Hopkins, A.C., and Fahey, G.C. 2011. In-vitro digestion and fermentation characteristics of temulose molasses, a coproduct of fiberboard production, and select temulose fractions using canine fecal inoculums. Journal of Agricultural and Food Chemistry 59:1847-1853. http://pubs.acs.org/doi/abs/10.1021/jf103737y

Faber, T.A., Hopkins, A.C., Middelbos, I.S., Price, N.P., and Fahey, G.C. 2011. Galactoglucomannan oligosaccharide supplementation affects nutrient digestibility, fermentation end-product production, and large bowel microbiota of the dog. Journal of Animal Science 89:103-112. www.journalofanimalscience.org/content/89/1/103.full.pdf.

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APPENDIX 1

National Program 306
Quality and Utilization of Agricultural Products

ACCOMPLISHMENT REPORT 2008 – 2012

Research Projects in NP 306*

1245-43000-012-00D
GENETIC AND BIOCHEMICAL MECHANISMS DETERMINING FRESH PRODUCE QUALITY AND STORAGE LIFE – Bruce Whitaker (P) and Tianbao Yang; Beltsville, Maryland.

1245-43440-004-00D
EVALUATION AND MAINTENANCE OF FLAVOR, NUTRITIONAL AND OTHER QUALITY ATTRIBUTES OF FRESH AND FRESH-CUT PRODUCE – Robert Saftner (P), Gene Lester, and Yaguang Luo; Beltsville, Maryland.

1245-44000-009-00D
OPTICAL AND MECHANICAL INSTRUMENTATION FOR QUALITY ASSESSMENT OF SMALL GRAINS – Stephen Delwiche (P); Beltsville, Maryland.

1935-41000-086-00D
MICROSTRUCTURED AND HEALTH-FUNCTIONALIZED FOOD PROTEINS – Charles Onwulata (P) and Phoebe QI; Wyndmoor, Pennsylvania.

1935-41000-087-00D
SUSTAINABLE STRATEGIES TO LOWER THE ENVIRONMENTAL AND ECONOMIC IMPACTS OF FOOD PROCESSING USING FLUID MILK AS A TEMPLATE – Peggy Tomasula (P), Michael Tunick, and Laetitia Bonnaillie; Wyndmoor, Pennsylvania.

1935-41000-088-00D
FUNCTIONAL FOOD DEVELOPMENT BY MICROBIAL BIOTECHNOLOGY – George Somkuti (P) and John Renye; Wyndmoor, Pennsylvania.

1935-41000-089-00D
NEW BIOACTIVE AND BIOBASED PRODUCTS FROM PLANT CELL WALL POLYSACCHARIDES IN SUGAR BEET PULP,CITRUS PEEL AND OTHER PROCESSING RESIDUES – Arland Hotchkiss (P) and Lin Liu; Wyndmoor, Pennsylvania.

1935-41000-090-00D
PRODUCTION AND VALUE ENHANCEMENT OF BIOSURFACTANTS AND BIOPOLYMERS DERIVED FROM AGRICULTURAL LIPIDS AND COPRODUCTS – Daniel Solaiman (P), Richard Ashby, and Jonathan Zerkowski; Wyndmoor, Pennsylvania.

1935-41000-091-00D
PROCESSING METHODS TO MODIFY THE LEVELS OF BIOLOGICALLY ACTIVE COMPOUNDS IN MILK AND CHEESE – Diane Van Hekken (P), Paul Moushumi, and Michael Tunick; Wyndmoor, Pennsylvania.

* Projects are listed and organized in Appendixes 1 and 2 according to the ARS project number used to track projects in the Agency's internal database. A (P) after a scientist's name indicates the project's principal investigator.

1935-41440-019-00D
ENVIRONMENTALLY FRIENDLY PROCESSES AND NEW APPLICATIONS FOR ANIMAL HIDES AND LEATHER – Cheng Kung Liu (P), Eleanor Brown, Maryann Taylor, and Mila Ramos; Wyndmoor, Pennsylvania.

1935-41440-020-00D
WOOL AND KERATIN FROM WOOL FOR BIO-BASED VALUE-ADDED PRODUCTS – Jenette Cardamone (P); Wyndmoor, Pennsylvania.

1935-41440-022-00D
BIOBASED INDUSTRIAL PRODUCTS FROM FOOD ANIMAL PROCESSING BY-PRODUCTS – Rafael Garcia (P) and George Piazza; Wyndmoor, Pennsylvania.

3607-43440-007-00D
GENETIC AND BIOCHEMICAL BASIS OF SOFT WINTER WHEAT QUALITY – Vacant; Wooster, Ohio.

3620-41000-150-00D
DISCOVERY AND UTILIZATION OF BIOACTIVE COMPONENTS FROM NEW CROPS AND AGRICULTURAL CO-PRODUCTS – Mark Berhow (P), Fred Eller, Steven Vaughn, Brent Tisserat, and Sean Liu; Peoria, Illinois.

3620-41000-151-00D
IMPROVING HUMAN HEALTH USING FUNCTIONAL FOOD INGREDIENTS FROM BY-PRODUCTS OF GRAIN MILLING INDUSTRIES USING INNOVATIVE TECHNOLOGIES – George Inglett (P), Jeffrey Byars, Mukti Singh, and Sean Liu; Peoria, Illinois.

3620-41000-152-00D
AMYLOSE HELICAL INCLUSION COMPLEXES FOR FOOD AND INDUSTRIAL APPLICATIONS – Frederick Felker (P), Jeffrey Byars, James Kenar, Mukti Singh, and Sean Liu; Peoria, Illinois.

3620-41000-153-00D
NOVEL TECHNOLOGY FOR RENEWABLE RESOURCE UTILIZATION – Joseph Laszlo (P), Kevin Evans, David Compton, Michael Jackson, and Ching Tsang Hous; Peoria, Illinois.

3620-41000-154-00D
NOVEL TECHNOLOGIES FOR PRODUCING RENEWABLE CHEMICALS AND POLYMERS FROM CARBOHYDRATES DERIVED FROM AGRICULTURAL FEEDSTOCKS – Christopher Skory (P), Gregory Cote, Neil Prince, Kurtzman Dombrink, Timothy Leathers, and Joseph Rich; Peoria, Illinois.

3620-41000-155-00D
BIO-BASED LUBRICANTS FROM FARM-BASED RAW MATERIALS – Girma Birshaw (P) and Grigor Bantchev; Peoria, Illinois.

3620-41000-156-00D
IMPROVED UTILIZATION OF PROTEINACEOUS CROP CO-PRODUCTS AND RESIDUES – Gordon Selling (P), Milagros Hojilla-Evangelista, and Gordon Sherald; Peoria, Illinois.

3620-41000-157-00D
NOVEL STARCH-BASED MATERIALS – Victoria Finkenstadt (P), Frank Momany, and Gordon Sherald; Peoria, Illinois.

3620-41000-158-00D
DEVELOPMENT AND UTILIZATION OF NEW OILSEED CROPS AND PRODUCTS – Steven Cermak (P), Rogers Harry-O'Kuru, Roque Evangelista, and Terry Isbell; Peoria, Illinois.

3620-41000-159-00D
FUNCTIONALIZATION OF VEGETABLE OILS FOR USE IN THE POLYMER, OLEOCHEMICAL, AND LUBRICANT INDUSTRIES – Kenneth Doll (P), Zengshe Liu, and Rex Murray; Peoria, Illinois.

3620-41000-160-00D
MODIFICATION OF NATURAL POLYMERS BY NOVEL PROCESSES – Atanu Biswas (P), Victor Finkenstadt, George Fanta, Gordon Selling, Sherald Gordon, and Jingyuan Xu; Peoria, Illinois.

3620-43000-007-00D
COORDINATED ANALYSIS OF SOYBEAN BREEDING GERMPLASM – Rex Murray (P); Peoria, Illinois.

3620-44000-050-00D
IMPROVING STABILITY AND HEALTHFULNESS OF U.S. COMMODITY VEGETABLE OILS AND PRODUCTS – Jill Moser (P), Sean Liu, Hong-Sik Hwang, and Erica Bakota; Peoria, Illinois.

3620-44000-051-00D
VISCOELASTIC PROPERTIES AND POLYMER COMPOSITE APPLICATIONS OF NANO-MATERIALS DERIVED FROM AGRICULTURAL BYPRODUCTS AND FEEDSTOCKS – Lei Jong (P); Sanghoon Kim, and Steven Peterson; Peoria, Illinois.

3635-43640-001-00D
TECHNOLOGIES FOR QUALITY MEASUREMENT AND GRADING OF FRUITS AND VEGETABLES – Renfu Lu (P); East Lansing, Michigan.

3655-43440-005-00D
IDENTIFYING THE NEXT GENERATION OF MALTING BARLEY THROUGH IMPROVED SELECTION CRITERIA AND QUALITY ANALYSIS OF BREEDING LINES – Mark Schmitt (P), Allen Budde, and Cynthia Henson; Madison, Wisconsin.

5302-43000-036-00D
MAINTAINING QUALITY AND EXTENDING SHELF AND SHIPPING LIFE OF FRESH FRUIT WITH NO OR MINIMAL SYNTHETIC PESTICIDE INPUTS – Joseph Smilanick (P), David Obenland, and Chang-Lin Xiao; Parlier, California.

5325-21410-020-00D
IMPROVEMENT AND UTILIZATION OF NATURAL RUBBER- AND CASTOR OIL-PRODUCING INDUSTRIAL CROPS – Colleen McMahan (P), Grace Chen, Thomas Mckeon, and William Belknap; Albany, California.

5325-41000-053-00D
OPTIMIZATION OF THE NUTRITIONAL, FUNCTIONAL, AND SENSORY PROPERTIES OF RAW AND PROCESSED LEGUMES, GRAINS, AND SPECIALTY CROPS – Gary Takeoka (P), Jose Berrios, and Tara McHugh; Albany, California.

5325-41000-056-00D
BIOPRODUCTS FROM AGRICULTURAL FEEDSTOCKS – Gregory Glenn (P), Syed Imam, Delilah Wood, William Orts, George Robertson, and Bor Sen Chiouo; Albany, California.

5325-41000-063-00D
NEW SUSTAINABLE PROCESSING TECHNOLOGIES TO PRODUCE HEALTHY, VALUE-ADDED FOODS FROM SPECIALTY CROPS AND THEIR CO-PRODUCTS – Tara McHugh (P), Zhongli Pan, and Rebecca Milczarek; Albany, California.

5325-41430-011-00D
IMPROVED UTILIZATION OF AGRICULTURAL PRODUCTS THROUGH IDENTIFICATION OF NITROGEN-CONTAINING BIOACTIVE COMPONENTS IMPORTANT TO QUALITY AND HUMAN HEALTH – Andrew Breska (P) and Tara McHugh; Albany, California.

5325-41440-006-00D
PROCESSING TECHNOLOGIES TO PREVENT WEIGHT GAIN AND OBESITY RELATED METABOLIC DISEASES – Wallace Yokoyama (P), Tara McHugh, and Talwinder Kahlon; Albany, California.

5325-44000-010-00D
QUALITY BASED INSPECTION AND SORTING OF SPECIALTY CROPS USING IMAGING AND PHYSICAL METHODS – Ronald Haff (P); Albany, California.

5348-43440-006-00D
ENHANCE WHEAT QUALITY, FUNCTIONALITY AND MARKETABILITY IN THE WESTERN U.S. – Craig Morris (P), Daniel Skinner, and Brian Beecher; Pullman, Washington.

5350-43000-006-00D
GENETIC, METABOLIC, AND PHYSIOLOGICAL FACTORS REGULATING DECIDUOUS TREE FRUIT QUALITY – James Mattheis (P), Eric Curry, Yanmin Zhu, and David Rudell; Wenatchee, Washington.

5430-43440-007-00D
PRESERVATION, ENHANCEMENT, AND MEASUREMENT OF GRAIN QUALITY AND MARKETABILITY – Thomas Pearson (P), Mark Casada, Floyd Dowell, and Paul Armstrong; Manhattan, Kansas.

5430-44000-023-00D
IMPROVE GRAIN SORGHUM END-USE QUALITY AND UTILIZATION BY IDENTIFYING THE PHYSICAL, CHEMICAL AND ENVIRONMENTAL FACTORS RELATED TO FOOD AND FEED – Scott Bean (P), Michael Tilley, Jeff Wilson, and Thomas Herald; Manhattan, Kansas.

5430-44000-024-00D
BIOCHEMICAL AND PHYSICAL CHARACTERIZATION OF HARD WINTER WHEAT QUALITY FOR END-USE QUALITY – Michael Tilley (P), Scott Bean, Bradford Seabourn, Jeff Wilson, Yuanhong Chen, and Thomas Herald; Manhattan, Kansas.

5442-21430-006-00D
IDENTIFICATION AND MANIPULATION OF POSTHARVEST PHYSIOLOGICAL AND MOLECULAR PROCESSES CONTROLLING POTATO NUTRITIONAL AND MARKET QUALITY – Jeffrey Suttle (P) and Edward Lulai; Fargo, North Dakota.

5442-21440-006-00D
QUALITY CHARACTERISTICS OF HIGH BETA-GLUCAN OAT CULTIVARS – Douglas Doehlert (P); Fargo, North Dakota.

5442-43440-011-00D
QUALITY OF HARD SPRING AND DURUM WHEAT – Jae-Bom Ohm (P); Fargo, North Dakota.

5442-43440-012-00D
IMPROVED POTATO MARKET QUALITY THROUGH GERMPLASM PROCESSING EVALUATIONS AND OPTIMIZED STORAGE TECHNOLOGIES – Martin Glynn (P) ; Fargo, North Dakota.

6204-43000-016-00D
ENHANCEMENT OF POSTHARVEST QUALITY OF FRUITS AND VEGETAGLES AND EVALUATION OF COMMODITY TREATMENTS OF QUARANTINED PESTS – Vacant (P), Robert Mangan, and Guy Hallman; Weslaco, Texas.

6208-21410-007-00D
ENHANCING PROFITABILITY AND SUSTAINABILITY UPLAND COTTON, COTTONSEED, AND COTTON BYPRODUCTS THROUGH IMPROVEMENTS IN HARVESTING, GINNING, AND MECHANICAL PROCESS – Gregory Holt (P), Matthew Pelletier, and John Wanjura; Lubbock, Texas.

6222-21430-003-00D
PHYSIOLOGICAL AND GENETIC BASIS OF POSTHARVEST QUALITY, DISEASE CONTROL, AND PHYTONUTRIENT CONTENT OF WATERMELONS – Benny Bruton (P), Angela Davis, and Wayne Fish; Lane, Oklahoma.

6235-41000-008-00D
ENHANCING QUALITY, UTILITY, SUSTAINABILITY, ENVIRONMENTAL IMPACT OF COTTON AND ITS BYPRODUCTS THROUGH IMPROVEMENT IN HARVEST/GIN PROCESSING – Derek Whitelock (P), Carlos Armijo, Kevin Baker, Paul Funk, and Sidney Hughes; Las Cruces, New Mexico.

6402-41440-007-00D
IMPROVE FIBER QUALITY AND INDUSTRY PROFITABILITY THROUGH ENHANCED EFFICIENCIES IN COTTON GINNING – Richard Byler (P), James Boykin, and Robert Hardin; Stoneville, Mississippi.

6408-41000-008-00D
CHEMISTRY OF NATURAL PRODUCTS FOR NUTRACEUTICAL USE, PEST MANAGEMENT AND CROP DEVELOPMENT – Agnes Rimando (P), Charles Cantrell, Stephen Duke, David Wedge, and Kumudini Meepagala; University, Mississippi.

6435-41000-102-00D
VALUE-ADDED PRODUCTS FROM COTTONSEED – Michael Dowd (P), Huai Cheng, Kjell Klasson, and Zhongoi; New Orleans, Louisiana.

6435-41000-103-00D
POSTHARVEST QUALITY AND PROCESSING OF SUGARCANE AND SWEET SORGHUM FOR SUGAR AND ETHANOL PRODUCTION – Gillian Eggleston (P), Kjell Klasson, and Maureen Wright; New Orleans, Louisiana.

6435-41000-104-00D
COTTON-BASED NONWOVENS – Paul Sawney (P), Brian Condon, and Doug Hinchliffe; New Oleans, Louisiana.

6435-41000-105-00D
RICE AS A SOURCE AND DELIVERY SYSTEM FOR NUTRIENTS AND LIPOPHILIC BIOACTIVE COMPOUNDS – Stephen Roue (P), Karen Bet Garber, and Casey Grimm; New Orleans, Louisiana.

6435-41000-106-00D
ENGINEERING ENZYMATIC REDIRECTION OF NATURAL CROP OIL PRODUCTION TO INDUSTRIAL OIL PRODUCTION – Jay Shockey (P), Heping Cao, Abul Uliah, and Kjell Klasson; New Orleans, Louisiana.

6435-41000-107-00D
NOVEL MICROBIAL SENSING AND ELIMINATION TECHNOLOGIES FOR PROTECTION OF AGRICULTURAL COMMODITIES – Anthony DeLucca (P), Deepak Bhatnagar, and Kanniah Rajasekaran; New Orleans, Louisiana.

6435-41430-006-00D
CHEMICAL MODIFICATION OF COTTON FOR VALUE ADDED APPLICATIONS – Judson Edwards (P), Sechin Chang, Brian Codon, and Michael Easson; New Orleans, Louisiana.

6435-43440-044-00D
PRIMARY AND SECONDARY PREVENTION OF PEANUT AND TREE NUT ALLERGY – Soheila Maleki (P), Yin Chung, Christopher Mattison, and Barry Hurlburt; New Orleans, Louisiana.

6435-44000-075-00D
NEW AND IMPROVED ASSESSMENTS OF COTTON QUALITY – *X*iaoliang Cui (P), Christopher Delhom, James oodgers, Channel Fortier, and Yongliang Liu; New Orleans, Louisiana.

6435-44000-076-00D
INFLUENCE OF STRUCTURE AND MOISTURE ON COTTON FIBER PROPERTIES – Alfred French (P), Joseph Montalvo, James Rodgers, and Cintron Santiago; New Orleans, Louisiana.

6435-44000-077-00D
REDUCING ASTRINGENCY, BITTERNESS, AND UNDESIRABLE FLAVORS OF POLYPHENOLIC-RICH FRUIT JUICES AND FUNCTIONAL BEVERAGES – John Beaulieu (P), Karen Bett Garber, and Casey Grimm; New Orleans, Louisiana.

6604-41430-005-00D
SYSTEMS TO ASSESS, MONITOR, AND PRESERVE PEANUT QUALITY AND SAFETY – Christopher Butts (P), Chari Kandala, and Marshall Lamb; Dawson, Georgia.

6612-41440-001-00D
DEVELOP METHODS TO ASSESS AND IMPROVE POULTRY AND EGG QUALITY – Ronald Holser (P), Kurt Lawrence, Samir Trabelsi, Seung Yoon, Hong Zhuang, Samantha Hawkins, Brian Bowker, and Gary Gamble; Athens, Georgia.

6612-44000-028-00D
SENSING METHODS AND INSTRUMENTATION FOR RAPID DETERMINATION OF MOISTURE CONTENT... AND OTHER QUALITY ATTRIBUTES OF GRAINS, SEEDS, AND NUTS – Samir Trabelsi (P) and Kurt Lawrence; Athens, Georgia.

6618-41000-015-00D
BIOACTIVE CONSTITUENTS AND SPECIALTY FOOD FIBERS AS VALUE-ADDED PRODUCTS FROM CITRUS PROCESSING WASTE – John Manthey (P), Wilbur Widmer, Randall Cameron, Gary Luzio, Jan Narciso, and Jinhe Bai; Fort Pierce, Florida.

6618-41000-016-00D
ENHANCED UTILIZATION OF CARBOHYDRATES AND POLYSACCHARIDES FROM CITRUS PROCESSING WASTE STREAMS – Wilbur Widmer (P), Randall Cameron, Gary Luzio, Jan Narciso, Jinhe Bai, and John Manthey; Fort Pierce, Florida.

6618-41430-005-00D
METABOLOMIC AND MICROBIAL PROFILING OF TROPICAL/SUBTROPICAL FRUITS AND SMALL FRUITS FOR QUALITY FACTORS AND MICROBIAL STABILITY – Anne Plotto (P), John Manthey, Elizabeth Baldwin, Jan Narciso, and Jinhe Bai; Fort Pierce, Florida.

6645-41000-007-00D
IMPROVED PROCESSES FOR CUCUMBERS, CABBAGE, SWEETPOTATOES, AND PEPPERS TO MAKE HIGH QUALITY, NUTRITIOUS PRODUCTS AND REDUCE POLLUTION – Van Den Truong (P), Frederick Breidt, Ilenys Perez Diaz, and Suzanne Johanningsmeier; Raleigh, North Carolina.

6645-43440-011-00D
IMPROVEMENT AND MAINTENANCE OF FLAVOR AND SHELF-LIFE, FUNCTIONAL CHARACTERISTICS AND BIOCHEM/BIOACTIVE PROCESS, AND USE OF GENETIC/GENOMIC RESOURCE – Timothy Sanders (P), Jack Davis, and Lisa Dean; Raleigh, North Carolina.

6655-41440-003-00D
ENHANCED COTTON QUALITY THROUGH MEASUREMENT AND PROCESSING RESEARCH – Gary Gamble (P), John Foulk, Yongliang Liu, and Devron Thibodeaux; Clemson, South Carolina.

APPENDIX 2

National Program 306
Quality and Utilization of Agricultural Products

ACCOMPLISHMENT REPORT 2008 – 2012

Publications by Research Project*

1245-43000-012-00D
GENETIC AND BIOCHEMICAL MECHANISMS DETERMINING FRESH PRODUCE QUALITY AND STORAGE LIFE – Bruce Whitaker (P) and Tianbao Yang; Beltsville, Maryland.

Whitaker, B.D. 2012. Membrane lipid metabolism and oxidative stress involved in postharvest ripening, senescence, and storage disorders of fruits. Acta Horticulture (ISHS) 945:269-282.

Yang, T., Peng, H., Whitaker, B.D., and Conway, W.S. 2012. Characterization of a calcium/calmodulin-regulated SR/CAMTA gene family during tomato fruit development and ripening. Biomed Central (BMC) Plant Biology 12:19.

Ma, C., Dastmalchi, K., Whitaker, B.D., and Kennelly, E. 2011. Two new antioxidant malonated caffeoylquinic acid isomers in fruits of wild eggplant relatives. Journal of Agricultural and Food Chemistry 59:9645-9651.

Ma, C., Whitaker, B.D., and Kennelly, E. 2010. New 5-O-caffeoylquinic acid derivatives in fruit of the wild eggplant relative Solanum viarum, Journal of Agricultural and Food Chemistry 58:11036-11042.

Whitaker, B.D., Villalobos, M., Mitcham, E.J., and Mattheis, J.P. 2009. Superficial scald susceptibility and a-farnesene metabolism in 'Bartlett' pears grown in California and Washington, Postharvest Biology and Technology 53:43-50.

Smith, D.L., Gross, K.C., and Whitaker, B.D. 2008. Analysis of softening in air- and ethylene-treated rin, nor and wild-type tomato fruit, Postharvest Biology and Technology 49(2):314-317.

Whitaker, B.D. 2008. Genetic and biochemical mechanisms of superficial scald development in apple and pear fruits. COST Action 924 Proceedings of the International Congress: Novel approaches for the control of postharvest diseases and disorders, p. 257-268.

Whitaker, B.D. and Gapper, N.E. 2008. Ripening-specific stigmasterol increase in tomato fruit is associated with increased sterol 22-desaturase (CYP710A7) gene expression. Journal of Agricultural and Food Chemistry 56(10):3828-3835.

1245-43440-004-00D
EVALUATION AND MAINTENANCE OF FLAVOR, NUTRITIONAL AND OTHER QUALITY ATTRIBUTES OF FRESH AND FRESH-CUT PRODUCE – Robert Saftner (P), Gene Lester, and Yaguang Luo; Beltsville, Maryland.

Jin, P., Wang, S.Y., Gao, H., Chen, H., Zheng, Y., and Wang, C.Y. 2012. Effect of cultural system and essential oil treatment on antioxidant capacity in raspberries. Postharvest Biology and Technology 132:399-405.

Wu, Y., Luo, Y. and Wang, Q. 2012. Antioxidant and antimicrobial properties of essential oil constituents encapsulated in zein nanoparticles prepared by liquid-liquid dispersion method. Journal of Food Science 48:283-290.

* Projects are listed and organized in Appendixes 1 and 2 according to the ARS project number used to track projects in the Agency's internal database. A (P) after a scientist's name indicates the project's principal investigator.

Bowker, B.C. and Eastridge, J.S. 2011. Use of gelatin gels as a reference material for performance evaluation of meat shear force measurements. Journal of Food Science 76(3):S210-S216.

Bowker, B.C. and Solomon, M.B. 2011. Utilization of sparker induced pressure waves to tenderize meat. Innovative Food Science and Emerging Technologies 12(2):135-141.

Eastridge, J.S. and Bowker, B.C. 2011. Effect of rapid thawing on the meat quality attributes of beef strip loin steaks. Journal of Food Science 76(2):S156-S162.

Fleshman, M.K., Lester, G.E., Riedl, K.M., Harrison, E.H., Kopec, R.C., S, N., and Schwartz, S.J. 2011. Carotene and novel apocarotenoid concentrations in orange-fleshed Cucumis melo melons: determinations of beta-carotene bioaccessability and bioavailability. Journal of Agricultural and Food Chemistry 59:4448-4454.

Jin, P., Wang, S.Y., Wang, C.Y., and Zheng, Y. 2011. Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries. Food Chemistry 124:262-270.

Lester, G.E. and Saftner, R.A. 2011. Organically versus conventionally grown produce: Common production inputs, nutritional quality, and nitrogen delivery between the two systems. Journal of Agricultural and Food Chemistry 59:10401-10406.

Xiao, Z., Luo, Y., Luo, Y., and Wang, Q. 2011. Combined effects of sodium chlorite dip treatment and chitosan coatings on the quality of fresh-cut d'Anjou pears. Postharvest Biology and Technology 62:319-326.

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Bowker, B.C., Liu, M., Eastridge, J.S., Callahan, J.A., Paroczay, E.W., and Solomon, M.B. 2010. Effect of postmortem aging and hydrodynamic pressure processing on pork loin quality. Journal of Muscle Foods 21(2):379-398.

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Wang, C.Y., Chen, H., Jin, P., and Gao, H. 2010. Maintaining quality of litchi fruit with acidified calcium sulfate. Journal of Agricultural and Food Chemistry 58:8658-8666.

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Jin, P., Zheng, Y., Tang, S., Rui, H., and Wang, C.Y. 2009. A combination of hot air and methyl jasmonate vapor treatment alleviates chilling injury of peach fruit. Postharvest Biology and Technology 52:24-29.

Jin, P., Zheng, Y., Tang, S., Rui, H., and Wang, C.Y. 2009. Enhancing disease resistance in peach fruit with methyl jasmonate. Journal of the Science of Food and Agriculture 89:802-808.

Liu, M., Vinyard, B.T., Callahan, J.A., and Solomon, M.B. 2009. Accuracy, precision and response time of consumer bimetal and digital thermometers for cooked ground beef patties and chicken breasts. Journal of Muscle Foods 20(2):136-159.

Liu, M., Vinyard, B.T., Callahan, J.A., and Solomon, M.B. 2009. Accuracy, precision and response time of consumer fork, remote digital probe and disposable indicator thermometers for cooked ground beef patties and chicken breasts. Journal of Muscle Foods 20(2):160-185.

Saftner, R.A. and Lester, G.E. 2009. Sensory and analytical characteristics of a novel hybrid muskmelon fruit intended for the fresh-cut industry. Postharvest Biology and Technology 51(3):327-333.

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Weaver, A., Bowker, B.C., and Gerrard, D. 2009. Sarcomere Length Influences u-calpain Mediated Proteolysis. Journal of Animal Science 87:2096-2103.

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1245-44000-009-00D

OPTICAL AND MECHANICAL INSTRUMENTATION FOR QUALITY ASSESSMENT OF SMALL GRAINS – Stephen Delwiche (P); Beltsville, Maryland.

Delwiche, S.R., Yang, I.C., and Graybosch, R.A. 2013. Multiple view image analysis of freefalling wheat. Computers and Electronics in Agriculture (In review).

Delwiche, S.R., Morris, C.F., Mabille, F., and Abecassis, J. 2012. Influence of instrument rigidity and specimen geometry on calculations of compressive strength properties of wheat endosperm. Cereal Chemistry 89(1):24-29.

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MICROSTRUCTURED AND HEALTH-FUNCTIONALIZED FOOD PROTEINS – Charles Onwulata (P) and Phoebe QI; Wyndmoor, Pennsylvania.

Oduro-Yeboah, C., Onwulata, C., Tortoe, C., and Thomas-Gahring, A. 2012. Functional properties of plantain, cowpea flours and oat fiber in extruded products. Journal of Food Processing and Preservation. DOI:10.1111/j.1745-4549.2012.00782.x.
Qi, P.X., Nunez, A. and Wickham, E.D. 2012. Reactions between beta-lactoglobulin and genipin: kinetics and characterization of the products. Journal of Agricultural and Food Chemistry 60:4327-4335
Qi, P.X. and Onwulata, C.I. 2011. Physical properties, molecular structures and protein quality of texturized whey protein isolate: effect of extrusion temperature. Journal of Agricultural and Food Chemistry 59:4668-4675.
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SUSTAINABLE STRATEGIES TO LOWER THE ENVIRONMENTAL AND ECONOMIC IMPACTS OF FOOD PROCESSING USING FLUID MILK AS A TEMPLATE – Peggy Tomasula (P), Michael Tunick, and Laetitia Bonnaillie; Wyndmoor, Pennsylvania.

Bonnaillie, L. and Tomasula, P.M. 2012. Fractionation of whey protein isolate with supercritical carbon dioxide to produce enriched alpha-lactalbumin and beta-lactoglobulin food ingredients. Journal of Agricultural and Food Chemistry 60(20):5257-5266.
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1935-41000-088-00D

FUNCTIONAL FOOD DEVELOPMENT BY MICROBIAL BIOTECHNOLOGY – George Somkuti (P) and John Renye; Wyndmoor, Pennsylvania.

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1935-41000-089-00D

NEW BIOACTIVE AND BIOBASED PRODUCTS FROM PLANT CELL WALL POLYSACCHARIDES IN SUGAR BEET PULP,CITRUS PEEL AND OTHER PROCESSING RESIDUES – Arland Hotchkiss (P) and Lin Liu; Wyndmoor, Pennsylvania.

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PRODUCTION AND VALUE ENHANCEMENT OF BIOSURFACTANTS AND BIOPOLYMERS DERIVED FROM AGRICULTURAL LIPIDS AND COPRODUCTS – Daniel Solaiman (P), Richard Ashby, and Jonathan Zerkowski; Wyndmoor, Pennsylvania.

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PROCESSING METHODS TO MODIFY THE LEVELS OF BIOLOGICALLY ACTIVE COMPOUNDS IN MILK AND CHEESE – Diane Van Hekken (P), Paul Moushumi, and Michael Tunick; Wyndmoor, Pennsylvania.

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ENVIRONMENTALLY FRIENDLY PROCESSES AND NEW APPLICATIONS FOR ANIMAL HIDES AND LEATHER – Cheng Kung Liu (P), Eleanor Brown, Maryann Taylor, and Mila Ramos; Wyndmoor, Pennsylvania.

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WOOL AND KERATIN FROM WOOL FOR BIO-BASED VALUE-ADDED PRODUCTS – Jenette Cardamone (P); Wyndmoor, Pennsylvania.

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BIOBASED INDUSTRIAL PRODUCTS FROM FOOD ANIMAL PROCESSING BY-PRODUCTS – Rafael Garcia (P) and George Piazza; Wyndmoor, Pennsylvania.

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DISCOVERY AND UTILIZATION OF BIOACTIVE COMPONENTS FROM NEW CROPS AND AGRICULTURAL CO-PRODUCTS – Mark Berhow (P), Fred Eller, Steven Vaughn, Brent Tisserat, and Sean Liu; Peoria, Illinois.

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IMPROVING HUMAN HEALTH USING FUNCTIONAL FOOD INGREDIENTS FROM BY-PRODUCTS OF GRAIN MILLING INDUSTRIES USING INNOVATIVE TECHNOLOGIES – George Inglett (P), Jeffrey Byars, Mukti Singh, and Sean Liu; Peoria, Illinois.

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AMYLOSE HELICAL INCLUSION COMPLEXES FOR FOOD AND INDUSTRIAL APPLICATIONS – Frederick Felker (P), Jeffrey Byars, James Kenar, Mukti Singh, and Sean Liu; Peoria, Illinois.

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NOVEL TECHNOLOGIES FOR PRODUCING RENEWABLE CHEMICALS AND POLYMERS FROM CARBOHYDRATES DERIVED FROM AGRICULTURAL FEEDSTOCKS – Christopher Skory (P), Gregory Cote, Neil Prince, Kurtzman Dombrink, Timothy Leathers, and Joseph Rich; Peoria, Illinois.

Price, N.P., Manitchotpisit, P., Vermillion, K., Bowman, M.J., and Leathers, T.D. 2013. Structural characterization of novel extracellular liamocins (mannitol oils) produced by Aureobasidium pullulans strain NRRL 50380. Carbohydrate Research 370(4):24-32.

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IMPROVED UTILIZATION OF PROTEINACEOUS CROP CO-PRODUCTS AND RESIDUES – Gordon Selling (P), Milagros Hojilla-Evangelist, and Gordon Sherald; Peoria, Illinois.

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DEVELOPMENT AND UTILIZATION OF NEW OILSEED CROPS AND PRODUCTS – Steven Cermak (P), Rogers Harry-O'Kuru, Roque Evangelista, and Terry Isbell; Peoria, Illinois.

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FUNCTIONALIZATION OF VEGETABLE OILS FOR USE IN THE POLYMER, OLEOCHEMICAL, AND LUBRICANT INDUSTRIES – Kenneth Doll (P), Zengshe Liu, and Rex Murray; Peoria, Illinois.

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MODIFICATION OF NATURAL POLYMERS BY NOVEL PROCESSES – Atanu Biswas (P), Victor Finkenstadt, George Fanta, Gordon Selling, Sherald Gordon, and Jingyuan Xu; Peoria, Illinois.

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VISCOELASTIC PROPERTIES AND POLYMER COMPOSITE APPLICATIONS OF NANO-MATERIALS DERIVED FROM AGRICULTURAL BYPRODUCTS AND FEEDSTOCKS – Lei Jong (P); Sanghoon Kim, and Steven Peterson; Peoria, Illinois.

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IDENTIFYING THE NEXT GENERATION OF MALTING BARLEY THROUGH IMPROVED SELECTION CRITERIA AND QUALITY ANALYSIS OF BREEDING LINES – Mark Schmitt (P), Allen Budde, and Cynthia Henson; Madison, Wisconsin.

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MAINTAINING QUALITY AND EXTENDING SHELF AND SHIPPING LIFE OF FRESH FRUIT WITH NO OR MINIMAL SYNTHETIC PESTICIDE INPUTS – Joseph Smilanick (P), David Obenland, and Chang-Lin Xiao; Parlier, California.

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IMPROVEMENT AND UTILIZATION OF NATURAL RUBBER- AND CASTOR OIL-PRODUCING INDUSTRIAL CROPS – Colleen McMahan (P), Grace Chen, Thomas Mckeon, and William Belknap; Albany, California.

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OPTIMIZATION OF THE NUTRITIONAL, FUNCTIONAL, AND SENSORY PROPERTIES OF RAW AND PROCESSED LEGUMES, GRAINS, AND SPECIALTY CROPS – Gary Takeoka (P), Jose Berrios, and Tara McHugh; Albany, California.

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BIOPRODUCTS FROM AGRICULTURAL FEEDSTOCKS – Gregory Glenn (P), Syed Imam, Delilah Wood, William Orts, George Robertson, and Bor Sen Chiouo; Albany, California.

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IMPROVED UTILIZATION OF AGRICULTURAL PRODUCTS THROUGH IDENTIFICATION OF NITROGEN-CONTAINING BIOACTIVE COMPONENTS IMPORTANT TO QUALITY AND HUMAN HEALTH – Andrew Breska (P) and Tara McHugh; Albany, California.

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PROCESSING TECHNOLOGIES TO PREVENT WEIGHT GAIN AND OBESITY RELATED METABOLIC DISEASES – Wallace Yokoyama (P), Tara McHugh, and Talwinder Kahlon; Albany, California.

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QUALITY BASED INSPECTION AND SORTING OF SPECIALTY CROPS USING IMAGING AND PHYSICAL METHODS – Ronald Haff (P); Albany, California.

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ENHANCE WHEAT QUALITY, FUNCTIONALITY AND MARKETABILITY IN THE WESTERN U.S. – Craig Morris (P), Daniel Skinner, and Brian Beecher; Pullman, Washington.

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GENETIC, METABOLIC, AND PHYSIOLOGICAL FACTORS REGULATING DECIDUOUS TREE FRUIT QUALITY – James Mattheis (P), Eric Curry, Yanmin Zhu, and David Rudell; Wenatchee, Washington.

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PRESERVATION, ENHANCEMENT, AND MEASUREMENT OF GRAIN QUALITY AND MARKETABILITY – Thomas Pearson (P), Mark Casada, Floyd Dowell, and Paul Armstrong; Manhattan, Kansas.

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IMPROVE GRAIN SORGHUM END-USE QUALITY AND UTILIZATION BY IDENTIFYING THE PHYSICAL, CHEMICAL AND ENVIRONMENTAL FACTORS RELATED TO FOOD AND FEED – Scott Bean (P), Michael Tilley, Jeff Wilson, and Thomas Herald; Manhattan, Kansas.

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BIOCHEMICAL AND PHYSICAL CHARACTERIZATION OF HARD WINTER WHEAT QUALITY FOR END-USE QUALITY – Michael Tilley (P), Scott Bean, Bradford Seabourn, Jeff Wilson, Yuanhong Chen, and Thomas Herald; Manhattan, Kansas.

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IDENTIFICATION AND MANIPULATION OF POSTHARVEST PHYSIOLOGICAL AND MOLECULAR PROCESSES CONTROLLING POTATO NUTRITIONAL AND MARKET QUALITY – Jeffrey Suttle (P) and Edward Lulai; Fargo, North Dakota.

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QUALITY CHARACTERISTICS OF HIGH BETA-GLUCAN OAT CULTIVARS – Douglas Doehlert (P); Fargo, North Dakota.

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IMPROVED POTATO MARKET QUALITY THROUGH GERMPLASM PROCESSING EVALUATIONS AND OPTIMIZED STORAGE TECHNOLOGIES – Martin Glynn (P); Fargo, North Dakota.

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ENHANCEMENT OF POSTHARVEST QUALITY OF FRUITS AND VEGETAGLES AND EVALUATION OF COMMODITY TREATMENTS OF QUARANTINED PESTS – Vacant (P), Robert Mangan, and Guy Hallman; Weslaco, Texas.

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ENHANCING PROFITABILITY AND SUSTAINABILITY UPLAND COTTON, COTTONSEED, AND COTTON BYPRODUCTS THROUGH IMPROVEMENTS IN HARVESTING, GINNING, AND MECHANICAL PROCESS – Gregory Holt (P), Matthew Pelletier, and John Wanjura; Lubbock, Texas.

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PHYSIOLOGICAL AND GENETIC BASIS OF POSTHARVEST QUALITY, DISEASE CONTROL, AND PHYTONUTRIENT CONTENT OF WATERMELONS – Benny Bruton (P), Angela Davis, and Wayne Fish; Lane, Oklahoma.

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ENHANCING QUALITY, UTILITY, SUSTAINABILITY, ENVIRONMENTAL IMPACT OF COTTON AND ITS BYPRODUCTS THROUGH IMPROVEMENT IN HARVEST/GIN PROCESSING – Derek Whitelock (P), Carlos Armijo, Kevin Baker, Paul Funk, and Sidney Hughes; Las Cruces, New Mexico.

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IMPROVE FIBER QUALITY AND INDUSTRY PROFITABILITY THROUGH ENHANCED EFFICIENCIES IN COTTON GINNING – Richard Byler (P), James Boykin, and Robert Hardin; Stoneville, Mississippi.

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CHEMISTRY OF NATURAL PRODUCTS FOR NUTRACEUTICAL USE, PEST MANAGEMENT AND CROP DEVELOPMENT – Agnes Rimando (P), Charles Cantrell, Stephen Duke, David Wedge, and Kumudini Meepagala; University, Mississippi.

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THERMOCHEMICAL PROCESSING OF AGRICULTURAL WASTES TO VALUE-ADDED PRODUCTS AND BIOENERGY – K. Thomas Klasson (P), Isabel Lima, and S. Minori Uchimiya; New Orleans, Louisiana.

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POSTHARVEST QUALITY AND PROCESSING OF SUGARCANE AND SWEET SORGHUM FOR SUGAR AND ETHANOL PRODUCTION – Gillian Eggleston (P), Kjell Klasson, and Maureen Wright; New Orleans, Louisiana.

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COTTON-BASED NONWOVENS – Paul Sawney (P), Brian Condon, and Doug Hinchliffe; New Oleans, Louisiana.

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RICE AS A SOURCE AND DELIVERY SYSTEM FOR NUTRIENTS AND LIPOPHILIC BIOACTIVE COMPOUNDS – Stephen Roue (P), Karen Bet Garber, and Casey Grimm; New Orleans, Louisiana.

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ENGINEERING ENZYMATIC REDIRECTION OF NATURAL CROP OIL PRODUCTION TO INDUSTRIAL OIL PRODUCTION – Jay Shockey (P), Heping Cao, Abul Uliah, and Kjell Klasson; New Orleans, Louisiana.

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CHEMICAL MODIFICATION OF COTTON FOR VALUE ADDED APPLICATIONS – Judson Edwards (P), Sechin Chang, Brian Codon, and Michael Easson; New Orleans, Louisiana.

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PRIMARY AND SECONDARY PREVENTION OF PEANUT AND TREE NUT ALLERGY – Soheila Maleki (P), Yin Chung, Christopher Mattison, and Barry Hurlburt; New Orleans, Louisiana.

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REDUCING ASTRINGENCY, BITTERNESS, AND UNDESIRABLE FLAVORS OF POLYPHENOLIC-RICH FRUIT JUICES AND FUNCTIONAL BEVERAGES – John Beaulieu (P), Karen Bett Garber, and Casey Grimm; New Orleans, Louisiana.

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SYSTEMS TO ASSESS, MONITOR, AND PRESERVE PEANUT QUALITY AND SAFETY – Christopher Butts (P), Chari Kandala, and Marshall Lamb; Dawson, Georgia.

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DEVELOP METHODS TO ASSESS AND IMPROVE POULTRY AND EGG QUALITY – Ronald Holser (P), Kurt Lawrence, Samir Trabelsi, Seung Yoon, Hong Zhuang, Samantha Hawkins, Brian Bowker, and Gary Gamble; Athens, Georgia.

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SENSING METHODS AND INSTRUMENTATION FOR RAPID DETERMINATION OF MOISTURE CONTENT... AND OTHER QUALITY ATTRIBUTES OF GRAINS, SEEDS, AND NUTS – Samir Trabelsi (P) and Kurt Lawrence; Athens, Georgia.

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BIOACTIVE CONSTITUENTS AND SPECIALTY FOOD FIBERS AS VALUE-ADDED PRODUCTS FROM CITRUS PROCESSING WASTE – John Manthey (P), Wilbur Widmer, Randall Cameron, Gary Luzio, Jan Narciso, and Jinhe Bai; Fort Pierce, Florida.

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METABOLOMIC AND MICROBIAL PROFILING OF TROPICAL/SUBTROPICAL FRUITS AND SMALL FRUITS FOR QUALITY FACTORS AND MICROBIAL STABILITY – Anne Plotto (P), John Manthey, Elizabeth Baldwin, Jan Narciso, and Jinhe Bai; Fort Pierce, Florida.

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IMPROVED PROCESSES FOR CUCUMBERS, CABBAGE, SWEETPOTATOES, AND PEPPERS TO MAKE HIGH QUALITY, NUTRITIOUS PRODUCTS AND REDUCE POLLUTION – Van Den Truong (P), Frederick Breidt, Ilenys Perez Diaz, and Suzanne Johanningsmeier; Raleigh, North Carolina.

Breidt, F., Medina-Pradas, E., Wafa, D., Perez Diaz, I.M., Franco, W., Huang, H., Johanningsmeier, S.D., and Kim, J. 2013. Characterization of cucumber fermentation spoilage bacteria by enrichment culture and 16S rDNA cloning. Journal of Food Science 78(3):M470-M476.

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IMPROVEMENT AND MAINTENANCE OF FLAVOR AND SHELF-LIFE, FUNCTIONAL CHARACTERISTICS AND BIOCHEM/BIOACTIVE PROCESS, AND USE OF GENETIC/GENOMIC RESOURCE – Timothy Sanders (P), Jack Davis, and Lisa Dean; Raleigh, North Carolina.

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ENHANCED COTTON QUALITY THROUGH MEASUREMENT AND PROCESSING RESEARCH – Gary Gamble (P), John Foulk, Yongliang Liu, and Devron Thibodeaux; Clemson, South Carolina

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APPENDIX 3

National Program 306
Quality and Utilization of Agricultural Products

ACCOMPLISHMENT REPORT 2008 – 2012

Selected Supporting Information and Documentation for Accomplishments and Impact on NP 306 Research

RELATIONSHIP OF THIS NATIONAL PROGRAM TO THE ARS STRATEGIC PLAN:

Outputs of NP 306 research support the "Actionable Strategies" associated with the performance measures shown below from the *ARS Strategic Plan for 2006-2011*, Objective 2.1: *Expand Domestic Market Opportunities*.

> **Performance Measure 2.1.2:** Develop cost effective, functional industrial and consumer products, including higher quality, healthy foods, that satisfy consumer demand in the United States and abroad.
>
> > **Target:** 2011 – Cumulatively, 20 new technologies developed by ARS and adopted for uses that provide food crops and products with higher quality and extended shelf life; convenient and acceptable healthy foods; non-food, non-fuel biobased products with cost and performance features comparable or superior to petroleum-based products; and valuable co-products from agricultural residues and processing wastes.

PATENTS:

There were 23 patents, 3 of which were licensed, and 3 in the list below are patent applications that were licensed (*), but not yet patented from 2008-2012; listed by title, inventor.

2012

- Bio-based fiber gums and processes for producing BFGS; Madhav Yadav, Kevin Hicks, and David Johnston.*
- Pterostilbine as a new agonist for the peroxisome proliferator-activated receptor alpha isoform; Agnes Rimando.
- Starch foam microparticles; G.M. Glenn and A.P. Klamczynski.

2011

- Fruit and vegetable edible films and uses thereof; Tara McHugh, M.D. DeBord, and C.W. Olsen.
- Pterostilbine as a new agonist for the peroxisome proliferator-activated receptor alpha isoform; Agnes Rimando

PATENTS [CONTINUED]:

2010

- Vegetable oil esterified lipoic acid; Joseph Laszlo and David Compton
- Cross linked biofiber products and processes for their manufacture; Gregory Holt, Edward Lee, and Watt Ellis.

2009

- A novel kinase-start gene conferring resistance to plant disease and transgenic plants comprimising it; Ann Blechl, George Dubcovsky, and Tzion Fahima.*
- Methods of promoting the growth of beneficial bacteria in the gut; Arland Hotchkiss, Alberto Nunez, and Robert Rastau.
- Method for flocculating suspensions using biobase renewable flocculants; George Piazza and Rafael Garcia.
- Bioactive gypsum strach composition; Syed Imam, Gregory Glenn, and Farooqe Azam.*
- Compositions of Keratin hydrolysate and microbes for pest control applications; Christopher Dunlap, Mark Jackson, and Maureen Wright.
- Process for the production of L-citrulline from watermelon flesh and rind; Wayne Fish.
- Mutant lycotoxin-1 peptide sequences for insecticidal and cell membrane altering properties; Stephen Hughes and Patrick Dowd.
- Green detergents from agriculture-based lipids and sugars; Neil Price.

2008

- Carbonate phase change materials; James Kenar.
- Transformed *Saccharomyces cerevisiae* engineered for xylose utilization; Stephen Hughes and Tauseef Butt.
- Low-carbohydrate digestible hydrocolloidal fiber compositions; George Inglett.
- Porous polymeric matrices made of natural polymers and optionally at least one cation and methods of making; Lin Liu, Marshall Fishman, and Kevin Hicks.
- Wood adhesives containing solid residues of biomass fermentations; Paul Weimer, Linda Lorenz, and Anthony Connor.
- Methods for improving the bioavailability of poly-saccharidesintignocellulosic materials; Nuhan Nghiem, Tae Hyun Kim, and Kevin Hicks.
- A method for co-extrusion of high melting temperature thermoplastics with heat-sensitive biologically active substances; Lin Liu, David Coffin, and Kevin Hicks.
- One dimensional linescan x-ray detector array; Ronald Haff.