ACCOMPLISHMENTS REPORT (1999-2007)

ARS NATIONAL PROGRAM 306 QUALITY AND UTILIZATION OF AGRICULTURAL PRODUCTS

USDA

The Future Grows Here

TABLE OF CONTENTS

Background

GENERAL INFORMATION

The Agricultural Research Service (ARS; http://www.ars.usda.gov/main/main.htm) is the intramural research agency for the United States Department of Agriculture (USDA; http://www.usda.gov/wps/portal/usdahome), and is one of four agencies that comprise the Research, Education, and Economics mission area of the Department. In 1998, ARS organized its research under a National Program structure to better manage and coordinate research efforts under specific genres. These National Programs serve to bring coordination, communication, and empowerment to the approximately 1200 research projects carried out by the Agency. Management of National Programs focuses on ensuring the relevance, quality, and impact of ARS research.

The **Quality and Utilization of Agricultural Products National Program (NP) 306** (http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=306) was conceived with the mission to enhance the economic viability and competitiveness of U.S. agriculture by maintaining the quality of harvested agricultural commodities or otherwise enhancing their marketability, meeting consumer needs, developing environmentally friendly and efficient processing concepts, and expanding domestic and global market opportunities through the development of value-added food and nonfood products and processes. This National Program's mission follows the ARS Strategic Plan (http://www.ars.usda.gov/SP2UserFiles/Place/00000000/ARSStrategicPlan2006-2011.pdf) which, in turn, is directed towards achieving the goals mandated by the USDA Research Education and Extension Mission Strategic Plan and the USDA Strategic Plan (http://www.usda.gov/ocfo/usdasp/usdasp.htm).

In working to solve agricultural problems, the boundaries of ARS national programs often overlap, and as a result, many of the projects contributing to NP 306 also contribute to achieving goals of other programs.

The goals of NP 306 not only support ARS priorities, but strive to address problems of high national priority. American agriculture faces increasing, intense competition in the global marketplace. Worldwide, agricultural production has increased faster than demand in many areas, resulting in commodity surpluses, low prices, and unreliable profitability. Efforts in U.S. farm policy to remove price supports emphasize the need for American agriculture to move beyond production of ever-larger quantities of ever-cheaper commodities. In response, farmers and ranchers must be able to produce higher-quality products that can be differentiated from lower-value commodities; commodities and co-products must be converted into useful value-added food and nonfood products; and products must be protected from contamination or loss of

quality after harvest to ensure marketability. Research must also be responsive to consumer demands for high quality, safe products; government and consumer pressures to provide products that are "environmentally friendly" or that are produced using processes that are "friendly" to people, animals, and the environment; and the need for a sustainable and profitable agricultural production system. Shifting paradigms wherein biofuels may utilize increasing quantities of crops and other agricultural materials warrant reassessment of new uses and utilization research priorities.

In this program, research is focused on developing knowledge and technology for crop and animal product quality measurement and maintenance or enhancement during storage, processing and marketing; commodity and co-product processing into value-added materials; and new specialty products from crops and animals. Similarly, the marketability and value of commodities can be increased by ensuring that value-added products (such as fresh-cut or minimally processed produce) retain sensory quality, nutritional value (Human Nutrition National Program), and are free from food safety hazards (Food Safety National Program).

PLANNING, REVIEW, AND IMPLEMENTATION OF NP 306

Management of each of the ARS National Programs follows a 5-year program cycle consisting of planning, review, implementation, and assessment. The initial National Program Cycle for the Quality and Utilization of Agricultural Products National Program began with three customer/stakeholder workshops in 1999. The primary purpose of the workshops was to identify problems and issues related to (primarily postharvest) quality and utilization that were of concern to ARS stakeholders, customers and cooperators. The workshops were attended by customers, stakeholders, and partners with interests related to the National Program mission and objectives, along with ARS scientists, engineers, and managers.

Following the stakeholder workshops, the National Program Leadership team overseeing NP 306, working with Agency scientists and engineers, developed an Action Plan to direct the research efforts of the program for 5 years by addressing priority researchable problems identified at the customer/stakeholder workshops. The Plan, released in 2000, includes two components, each addressing a primary area of need identified by participants in the workshops (http://www.ars.usda.gov/research/programs/programs.htm?np_code=306&docid=374).

A follow up planning and coordination workshop attended by ARS scientists and engineers in NP 306 was held in Greenbelt, Maryland in 2003 to assess, revise and improve implementation of the 2000 Action Plan, and to improved communication, coordination, and planning in preparation for peer review of revised project plans in 2004. A summary of the workshop is available on the National Program website (http://www.ars.usda.gov/research/programs/programs.htm?np_code=306&docid=1419).

The next 5-year national program cycle is scheduled to begin with a customer/stakeholder Workshop in June 2008.

HOW THIS REPORT WAS CONSTRUCTED AND WHAT IT REFLECTS

In this report, NP 306 accomplishments and their impacts or potential benefits are organized according to National Program research components and problem areas, as described in the current National Program Action Plan. Because of the broad scope and large number of projects in the Program, we further grouped the accomplishments by broad commodity categories as included under the Action Plan. The NP 306 research components and problem areas are listed in **Appendix A, Action Plan Components, Problems Areas, and Objectives for NP 306, Quality and Utilization of Agricultural Products**.

For the most part, the content of this report is derived from NP 306 scientists who were asked to summarize their project's major accomplishments since 1999 (year of the last NP 306 stakeholder workshop and action plan). This report does not include *all* accomplishments achieved in the national program but rather selected key accomplishments demonstrating impact – significant advancement of knowledge, adoption of methods and techniques, patenting and/or licensing of technologies, and commercialization of technologies - selected by the National Program Leaders who authored this report. As a result, this report encompasses a subset of the total spectrum of NP 306 accomplishments, chosen to illustrate and exemplify the total progress and achievements at the National Program level. Thus, accomplishments may not be described for all planned research activities described in the Action Plan if the research results for those activities were preliminary or inconclusive or if they described research activities or progress without clear potential or actual outcomes or impacts. In some cases this absence of information may reflect a loss of expertise from the project through resignation or retirement and lack of funding to fill the position, or a management decision to proceed in another direction. In some cases, accomplishments may be reported under problem areas that do not align with their description under planned research activities.

NP 306 encompasses 92 current research projects, a list of which is found in **Appendix B, Projects Primary to NP 306**, which is organized according to the geographical location and ARS management unit of the research unit. A list of **Contributing Projects** is also included. It should be noted that the individual research projects may address more than one Research Component and likely address more than one problem area. Also note that all existing projects began more recently than the initiation of the first NP 306 National Program Cycle in 1999.

Exhibit A, which is not appended to this report due to its length, provides a listing of publications by NP 306 scientists and will be available at the meeting for viewing by the assessment panel.

This Accomplishments Report was compiled by Dr. Frank Flora and reviewed and edited by NP 306 executive management team members Drs. Robert Fireovid and David Klurfeld.

Selected Accomplishments and Impacts

Component 1. Quality Characterization, Preservation, and Enhancement

Problem Area 1a. Definition and Basis for Quality

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Characterization of fresh tomato flavor volatiles. The tomato is the second largest vegetable crop in dollar value in the U.S. with a fresh market value of $1.6 billion in 2005. Using chemical and sensory analyses, researchers identified and quantified the 19 most important odorants responsible for fresh tomato flavor. They showed that the differences between highly preferred and less preferred tomatoes were due to variations in the concentrations of certain flavor compounds. Higher amounts of the (*E,E*)- and (*E,Z*)-2,4-decadienal isomers and 4-hydroxy-2,5-dimethyl-3(2*H*)-furanone (Furaneol®) had a positive influence on preference, whereas high concentrations of methional, phenylacetaldehyde, 2-phenylethanol or 2-isobutylthiazole had a negative influence. This fundamental knowledge will help plant breeders and growers to select cultivars with the highest consumer preference. This research was done in collaboration with The Hebrew University of Jerusalem and was supported by a Research Grant Award from BARD, the United States-Israel Binational Agricultural Research and Development Fund **(Albany, CA).**

Discovery of biologically active constituents in almond hulls. Almonds are a major California commodity, generating $2.2 billion in gross sales in 2004. Researchers identified three triterpenoids - betulinic acid, oleanolic acid and ursolic acid - which constituted about 1% of almond hulls. These triterpenoids have significant anti-inflammatory, anti-arthritic, anti-HIV and anti-cancer activity. In further studies, the researchers identified chlorogenic acid,

cryptochlorogenic acid, and neochlorogenic acid (the three chlorogenic acid isomers together comprised about 53.5 mg/100 g hulls) in almond hulls. These compounds exhibit antioxidant and anticarcinogenic properties. The researchers also identified the sterols, stigmasterol and β-sitosterol (18.9 mg and 16.0 mg /100 g hulls, respectively). These dietary plant sterols have been demonstrated to reduce serum cholesterol levels and also may inhibit colon cancer development. These studies indicate that almond hulls with an annual production of over 1.2 billion pounds are a potentially valuable source of these biologically active constituents **(Albany, CA)**.

Bioavailability of citrus limonoids. It has been shown that limonoid glucosides in citrus are active as anti-tumor agents, possess anti-infective properties and act as anti-feedants for insects. ARS researchers, in collaboration with researchers in the Western Human Nutrition Research Center, Davis, CA, discovered for the first time that citrus limonoids commonly present in orange juice are bioavailable to humans up to 24 hours after ingestion. This research supports citrus as an essential component in the human diet. Correlation of the biological activity of citrus limonoids to improving human health also provides incentives to the citrus industry to isolate these compounds from citrus processing by-products **(Albany, CA)**.

Hormonal control of potato tuber wound healing. The regulation and biology of potato wound-healing are of great importance to growers, processors and consumers. Potato tubers that are cut for seed and tubers that are skinned, nicked and bruised during harvest and handling operations must rapidly wound-heal to avoid costly disease and blemish problems. Recently completed research elucidated the involvement of two major stress related hormones in tuber wound-healing. Wounding was found to induce dramatic changes in the accumulation of the plant hormones ethylene and abscisic acid. Although ethylene is known to regulate fruit ripening, wound-induce ethylene and ethylene blocking agents did not affect wound-healing in any measured form. Abscisic acid was found to be important in the regulation of tuber water vapor loss and suberization during wound-healing; regulation of these processes is essential in preventing vegetable desiccation and cell death and in preventing rot by blocking both bacterial and fungal infections. This research is essential in understanding and controlling wound-healing for use in development of protocols to maintain fruit and vegetable quality for consumption **(Fargo, ND).**

Watermelon as a source of lycopene and citrulline. The 2006 Dietary Guidelines for Americans recommends incorporation of fruit and vegetables in the daily diet to prevent obesity and chronic diseases, such as cancer or cardiovascular events. Some fruits and vegetables are considered rich in phytochemicals, which may have additional disease-prevention properties. ARS researchers established that watermelon was an important source of the antioxidant lycopene and of citrulline, an amino acid with potential cardiovascular benefits. Watermelon lycopene was found to be readily absorbed in humans, and watermelon pomace improved cardiovascular health in a rat model study **(Lane, OK).**

Health benefits of pterostilbene demonstrated. Heart disease and malignant neoplasms are the two leading causes of death in the U.S. Experimental, epidemiological and clinical evidence shows that diet and nutrition, specially those rich in fruits and vegetables, have important roles in reducing risks from these diseases. Certain fruit and vegetable phytochemicals, such as phenolic compounds, have been identified as the constituents responsible for the modulation of these diseases. ARS scientists demonstrated pterostilbene as a peroxisome proliferator-activated receptor subtype-alpha (PPARα) agonist. PPARα isoform is predominantly involved in fatty acid and lipid catabolism and import, and activation of genes involved in fatty acid oxidation. Pterostilbene was demonstrated to be a strong antioxidant and a cancer preventive agent in a mouse mammary gland culture assay. Pterostilbene was also identified for the first time as a constituent of blueberries as well as other *Vaccinium* species. These discoveries have had wide media coverage. Reports on the occurrence of pterostilbene in blueberries helped boost the sales of blueberries. In addition to its lipid lowering effect (due to PPARα activation), pterostilbene was also found to prevent the development of colon cancer. This discovery likewise gained wide media coverage. The success of these discoveries will help blueberry growers, in particular, and the public, in general, for having a natural compound that can be developed into pharmaceutical product for use as hypolipidemic and chemopreventive agent. Patents have been filed on lipid lowering and colon cancer preventive properties of pterostilbene, and some companies have expressed interest in licensing these technologies **(Oxford, MS).**

Relationship between chemical structure of food acids and sour taste. Sour taste is one of the basic human taste perceptions and an important quality factor in pickled vegetables. Knowledge of the relationships between the chemical structure of food acids and the intensity of sour taste perception by humans was not sufficient to control the sour taste in food products other than by empirical testing of formulations. ARS researchers demonstrated in both water solutions and in fresh pack dill pickles that perceived sourness intensity is a linear function of the molar concentration of all organic acid species with at least one protonated carboxyl group plus the molar concentration free hydrogen ions. This outcome provided significant new insights about the chemical basis for sour taste which included that (a) common organic acids in foods are all equally sour on a molar basis, (b) that all species of an organic acid with one or more protonated carboxyl groups are equally sour, and (c) that the hydrogen ion is about equal in sour intensity to a protonated organic acid molecule. It was also observed that in a pickle product the sour intensity of the acids is substantially suppressed compared to their sour intensity in simple water solutions. These results will make it possible to predict changes in sour intensity that result from substituting different acids in a product or from changing the pH of the product. More generally, these results provide a new understanding of the chemical basis of one of the basic human tastes **(Raleigh, NC).**

Animal Products:

Fundamental studies on the mechanism of tanning. Tanning or crosslinking of protein molecules in animal hides and skins with salts of the mineral chromium to produce leather, a high value co-product of the meat industry, is a highly developed art, although the scientific rationale is poorly understood. Understanding tanning mechanisms at the molecular level will provide a basis for the development of chrome-free tannages in response to environmental considerations and consumer preferences. ARS researchers have expanded the molecular model of a collagen microfibril, constructed under a previous project, to include the nonhelical regions at each end that are known to participate in formation of native collagen crosslinks, and have begun to evaluate the effects of docking model tanning materials into the less dense (gap) regions of the microfibril. In related research, ARS scientists have expanded the development of a soluble model tanning system begun under a previous project, and developed methods to evaluate the effects at the molecular level of tanning chemistry and tanning-related physical processes (milling, ultrasonics) on soluble collagen, isolated collagen fibrils and collagen in the hide matrix. The success of this research will enable designers of new tanning systems to understand and predict the effects of their process on the molecular and macromolecular structure of collagen prior to production. Industrial and academic research groups are using this molecular model to study the role of water in the tanning processes **(Wyndmoor, PA).**

Cereals, Oilseeds, and Novel Crops:

Enzymes in castor oil biosynthesis. A thorough understanding of how fatty acid composition is controlled in oilseeds will provide the genetic means to alter composition of oils to impart desired properties. ARS researchers, in research supported in part by a CRADA, identified several enzymes that carry out key steps in determining the composition of castor oil biosynthesis. Moreover, they cloned the genes for these enzymes and patented the use of one gene that determines oil yield in seeds. This research thus developed molecular tools necessary to design oils for producing bio-based products **(Albany, CA).**

Effect of serine class endoproteinase activity on barley malting quality. Cysteine-class proteinases had been linked to malting quality through their ability to degrade Hordein, the principal barley storage protein, but essentially no information about the potential roles of other proteinases classes was known. ARS scientists identified major serine class proteinases from malted barley, showed that the serine proteinases can degrade a major barley seed enzyme (beta-amylase) critical to starch mobilization, that serine proteinase activity is correspondingly negatively correlated to the malting quality attribute related to beta-amylase activity across North American malting barley germplasm, and that the serine endoproteinase activity may be regulated *in situ* by endogenous malt proteinase inhibiting proteins. This basic knowledge of the

composition, regulation, and impact of serine class endoproteinase activity on malting quality is a clear demonstration of their importance that had not previously been known or appreciated. This new knowledge will aid our ability to knowledgeably select malting barley varieties with desired, improved malting quality characteristics **(Madison, WI).**

Purification and analysis of soy saponins. A combination of high-pressure extraction and preparative HPLC was used to purify the group A and group B soyasaponins from soy germ as well as quantities of the soy isoflavones, for use as analytical standards and in biological assays. A standardized sample preparation and extraction method was developed for the analysis of the phytochemicals found in soy and processed soy products, which is reproducible in other laboratories. Complete saponin analysis of the extracts prepared from soy germ (hypocots), hulls and cotyledons show that a significant portion of the saponins is concentrated in the germ. The germ contains nearly all the group A soyasaponins, while the group B soyasaponins are nearly equally distributed between the germ and cotyledons. This work has resulted in a reproducible method to identify and quantitate all the saponin forms (A & B) in soybeans and soy products. The impact of dietary saponins in cell culture models and whole animal models is just now being evaluated, and this work will provide research material to determine if the biological activity of the two types of saponins found in soy are similar or different. This has resulted in the publication of several papers on the evaluation of the biological role these phytochemicals play in the prevention of the development of several animal diseases **(Peoria, IL).**

Molecular-genetic basis for wheat kernel texture. Grain hardness, otherwise known as kernel texture, is the single most important trait governing the end-use quality and utilization of wheat. Consequently, kernel texture is one of the primary classifications for world trade in this cereal which provides more direct calories and nutrition to humankind than another. The molecular-genetic basis for wheat kernel texture was discovered and characterized at both the gene and protein level. Hard kernel trait (as opposed to soft) was found to result from defective (mutated) 'puroindoline' genes. Two patents were awarded and a third is pending. A number of genetic stocks and germplasm were developed and released. Several collections of world germplasm were characterized for kernel texture and puroindoline genes. Wild grass relatives of wheat and 'synthetic' (hexaploid) wheats were characterized and new genes were discovered that will facilitate further genetic manipulation of this trait **(Pullman, WA).**

Agricultural Fibers:

Method for predicting the shape of cotton cellulose and other molecules. A method was developed for predicting the shape of cotton cellulose and other molecules, based on extrapolation of high-accuracy structures of smaller molecules. Thus, freely available

information can be used to better understand cotton cellulose structure. This work takes into account the effects of environment on molecular shapes and shows that cellulose will primarily have extended shapes with two to three residues per repeat distance. That is consistent with available experimental data, and provides inferences for the structures in non-crystalline regions of cotton. These regions are expected to dominate in many structure-function relationships for the cotton fiber, and the accomplishment contributes to basic knowledge of the cotton fiber structure **(New Orleans, LA)**.

Understanding moisture effects on cotton properties. Under normal conditions cotton fiber contains about five percent moisture, but its location is unknown. The properties of cotton are profoundly affected by variations in the moisture content, but there is no understanding of the mechanisms, which in turn, depend on the location of the water. In an effort to learn where the water absorbed from the normal atmosphere is located in the cotton fiber, ARS researchers found that the water accumulated in locations that would allow 14 to 17 layers, but there was indication of molecular motion ranging from restricted to relatively mobile. It appears that the water may accumulate on normally unseen layers that occur each night from discontinuities in secondary wall biosynthesis. This question is important because humidified cotton fibers are stronger than dry fibers. There are numerous reasons to better understand the details of the interaction of moisture with cotton. For example, it may be possible to use that knowledge to create or select for fibers that do not actually need moisture to accomplish the same improvements, or it may be possible to develop fibers that would release moisture more quickly when fabrics are being dried. **(New Orleans, LA)**.

Problem Area 1b. Methods to Evaluate and Predict Quality

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Sensor to detect pits and pit fragments in dried plums. The presence of pits and pit fragments in dried plums is a matter of concern for processors and consumers, causing occasional rejection of product by retail chains, as well as injury to consumers and the potential for lawsuits. Detection technologies currently in use, including machine vision and NIR detectors, help reduce the number of pits and pit fragments, but their presence in the final product is still a problem. Through a CRADA with the Dried Fruit Association of California, ARS researchers developed and patented a simple device based on a mechanical sensor that detects pits and pit fragments in dried plums. When used in conjunction with current technology, processors will be able to reduce the pit count in the final product. Licensing of the patent by an engineering firm working closely with the dried plum industry is pending **(Albany, CA).**

Acoustic-based sorting system for pistachios. Current technology that removes closed-shell pistachios from the higher valued open-shell nuts has a high error rate, resulting in large amounts of open-shelled nuts being rejected with the subsequent loss of market value to the processor. An acoustic-based sorting system developed by ARS has been implemented at a pistachio processing plant, and a patent for the system has been licensed by a CRADA partner. Five two-channel machines are operating in the processing plant, with each recovering approximately 1000 pounds per day of open-shelled pistachio nuts that had been incorrectly rejected by the standard technology. This technology is expected to be adopted by the industry in general over the next couple of years **(Albany, CA).**

Method to evaluate the potential for citrus juices to form delayed-bitterness. ARS researchers developed a method to evaluate the potential for citrus juices to form delayed-bitterness. Freeze damage or physical damage to citrus fruit, including juicing, initiates the formation of the bitter dilactone limonoids from non-bitter monolactone precursors. This phenomenon is referred to as delayed bitterness and is a major problem for both fresh fruit and juice producers worldwide. The major limonoids associated with delayed bitterness are limonin and nomilin. The researchers developed a rapid and sensitive method for the quantification of limonin and nomilin precursors: limonoate A-ring lactone (LARL) and nomilinoate limonoate A-ring lactone (NARL). This method provides a valuable tool for citrus growers and juice producers to evaluate the susceptibility of a fruit or juice to delayed bitterness **(Albany, CA).**

Portable firmness measurement device for laboratory and orchard uses. Fruit firmness is a key parameter in the grading standards for the shipping and marketing of apples, and it is routinely measured and monitored by the destructive testing method at various inspection points from orchard to packinghouse and to retailing. Horticulturists, fruit growers, storage operators, and fruit inspectors need a portable, low-cost testing device to measure and monitor the firmness of apples without degrading them. ARS researchers developed a compact, portable device, which measures the bioyield force of a fruit as an indication of fruit firmness, with automated data recording and analysis functions. The device does not degrade the fruit and correlates well with the standard destructive firmness tester. It is suitable for use in orchards, laboratories, and packinghouses. The first version of the device has been used in a horticultural lab, and many researchers expressed great interest in the device for measuring and monitoring the firmness of apples **(East Lansing, MI).**

Method to measure mannitol in sugarcane juice. The delivery of billeted rather than whole-stalk sugarcane to factories is now more predominant in the U.S., but billeted sugarcane deteriorates faster so there is a more urgent need to have a reliable test of sugarcane deterioration at the factory. Mannitol produced mainly from *Leuconostoc* bacteria, has unequivocally been shown to be a more sensitive indicator of sugarcane *Leuconostoc* deterioration than dextran, the

current most popular indicator. Mannitol can now be more easily measured at the factory than dextran, because a quick, easy, reliable and inexpensive enzymatic method was developed by ARS to measure mannitol in press juices from individual loads of sugarcane. This quantitative enzymatic mannitol method could potentially be used in sugarcane method payment formulas for growers. This accomplishment has already had impact with Brazilian sugar technologists using mannitol as an indicator of bacterial contamination in fuel alcohol yeast fermentation, and sugar technologists in France and South Africa are currently measuring mannitol to monitor sugarbeet and sugarcane deterioration, respectively. This accomplishment received a prestigious International Award: "Margaret A. Clarke Best Paper Award" at the International Conference on Sugar Processing Research, Aguas de Sao Pedro, Brazil, 2006 **(New Orleans, LA).**

Models developed to evaluate the performance of aflatoxin sampling plan designs for treenuts. Because of the large variability associated with the aflatoxin test procedure, bulk treenut lots may be misclassified into good and bad categories when the measured aflatoxin concentration is below or above a defined tolerance. Misclassification on lots may cause an economic loss to the industry, disruption of supply, and an increase in the health dangers to the consumer. The first estimates of sampling, sample preparation, and analytical variances associated with the aflatoxin test procedure and the aflatoxin distribution among sample test results was determined for three treenuts - almonds, pistachios, and hazelnuts. The variance and distribution among sample test results was used to develop models to evaluate the performance (number of lots misclassified) of aflatoxin sampling plan designs for each treenut. The U.S. almond industry, which provides 70% of the world's demands for almonds, used the model to develop an industry wide aflatoxin-testing program for almonds marketed in the export trade that would reduce lots rejected upon retesting in the EU. The model is being used by the U.S. delegation to the Codex Committee on Contaminants in Foods to recommend a harmonized sampling plan to detect aflatoxin in all three treenuts traded in international markets. Harmonization will improve trade among nations and improve food safety **(Raleigh, NC).**

Edible coatings affect fruit quality due to their permeability to gases and aroma compounds. Commercial and experimental coatings were evaluated on peppers, oranges, mangoes and apples using resin, polysaccharide or wax formulations of differing permeability characteristics. A method was developed to measure the gas exchange through coatings between the fruit and the environment to predict effects on quality. This information enabled packinghouses to make informed decisions when choosing a coating for a particular commodity. This research led to coating companies blending the less permeable shellac with the more permeable carnauba wax to optimize shine and minimize effect on fruit flavor **(Winter Haven FL).**

Animal Products:

Rapid, accurate, sensitive method for quantitating catfish off-flavors. A rapid, accurate, sensitive method for determining the off-flavor compounds geosmin and 2-methylisoborneol (MIB) in water and in farm-raised catfish was developed. The method has allowed off-flavor research requiring the analyses of large numbers of fish and water samples. The method was used to accurately determine levels of geosmin and MIB that render catfish off-flavor as judged by flavor checkers. The method has the advantage of standardizing the levels of these compounds to differentiate on- and off-flavor catfish and could eliminate the need for professional flavor checkers, who can succumb to sensory overload **(New Orleans, LA).**

Nondestructive testing of leather using acoustic emission. Current testing methods for quality control and assurance of leather are time-consuming and often subjective and destructive (sample cut-outs required). ARS engineers developed dynamic and nondestructive techniques based on acoustic emission (AE), ultrasonic patterns emanating from slight deformations to the sample. The engineers established objective correlations between the AE signals and several physical and mechanical properties. Under a CRADA with a tannery and an AE equipment manufacturer, they showed excellent correlations with softness, stiffness, and the extent of grain wrinkle. Earlier they showed correlations to tensile strength, toughness, "opening-up," fatliquor effectiveness, and tear strength. Using an airborne detector (no contact with the leather), they demonstrated the potential to detect defects such as scratches and scar tissue. Application of AE testing will provide the industry with a nondestructive way to monitor the quality of their product on the production line without concurrent damage to the product **(Wyndmoor, PA).**

Cereals, Oilseeds, and Novel Crops:

Detection method for ricin toxin contamination. The presence of a toxin and a potent allergen make domestic production of castor oil problematic. ARS scientists developed the unique strategy of using gene silencing to block production of the toxin and allergen in the castor seed. They determined the timing in seed development for toxin and allergen gene expression, in order to identify genetic elements that would help to prevent the expression of these genes. They further demonstrated the production of these proteins correlating to expression, including devising methodology for detecting the allergen. In collaboration with other ARS scientists, they developed a uniquely sensitive detection method for ricin toxin contamination, a concern of Homeland Security as the toxin is a threat agent. The castor research is recognized as one of the earliest proactive research efforts in addressing biothreat agents **(Albany, CA).**

Development of NIR spectroscopy for nutritional analysis. Near-infrared (NIR) equations were developed for the evaluation of nutrition content (total dietary fiber, total fat, trans-fat,

calories and /or protein) of intact and ground cereal products for the purpose of nutrition labeling. The amount of nutrition analysis required in the food and feed industry is constantly increasing because of ederal regulations, consumer demand for information, and the increased cost of feed. Thus, NIR and IR methods of analysis are ideal as they greatly reduce the time of analysis and the costs associated with labor and hazardous waste disposal. Near-infrared spectroscopy was found, for the first time, to be accurate for the quality control or process control of total dietary fiber, total fat, calories and protein in cereal food products. Both NIR and FT-IR spectroscopy were proven to be valuable in screening for trans-fat content in those products. This research is applicable to the analysis of the same components in animal feeds and adds to the body of knowledge from which laboratory managers and Research and Development leaders in industry draw. The major feed companies (e.g., Murphy Farms/Smithfield, Purina Mills and Cargill Feeds) are now routinely using NIR technology for quality assurance of their products and are major users of this type of information (**Athens, GA**).

Non destructive moisture sensing of grains. There is a real need for more reliable moisture content monitoring for cereal grains and other agricultural products to prevent spoilage, to maintain high quality, and to improve quality of processed products. ARS engineers developed new techniques for measuring the radio-frequency and microwave dielectric properties of granular materials, and the resultant dielectric properties were correlated with moisture content. Dielectric properties data were obtained on several cereal grains and oilseeds, and density-independent moisture calibration functions of the dielectric properties were explored for reliable prediction of moisture content. Results of the studies were reported and made available for use in government and industry, where interest is high in improving the monitoring of grain moisture content to assist in preserving grain crops, maintaining high quality and improving yield monitoring in precision agriculture. Thus, moisture content can be sensed instantaneously and nondestructively through the dielectric properties. U. S. patents were obtained on the new techniques. A private company has adopted some of the principles in design of a moisture sensor for use on grain combines **(Athens, GA).**

Expanded NIR applications in wheat quality. The use of near-infrared (NIR) spectroscopy in wheat analysis was expanded from the traditional role of proximate analysis to include the measurement of endosperm protein components and physical-chemical properties, as affected by genetics and environment. Specifically, ARS researchers showed that the protein macromolecules that influence functionality, namely glutenin and gliadin, are to a certain extent measurable by this rapid method. The scientists have also demonstrated that this method is able to identify wheat lines that possess a chromosomal translocation from the rye plant (initially developed to instill disease resistance in wheat during development, but at the expense of bread quality). Secondly, the method has been applied to identify wheat lines according to starch amylose level (natural state, waxy state, or an intermediate or partial waxy state) in either hexaploid (bread-making) or tetraploid (durum) wheats. The method can be applied to either

ground meal or individual kernels. These studies have provided core knowledge to other scientists involved in cereal identity preservation research and to manufacturers of grain analyzers who are incorporating these or similar algorithms into NIR instruments that are used to gauge wheat quality. Stemming in part from the scientists' single kernel NIR research, an NIR instrument for sorting of individual wheat seeds was developed by a commercial manufacturer **(Beltsville, MD).**

Micro test for early generation barley malting quality assessment. Historically, barley breeders have had to wait until the equivalent of the F_5 generation in line development to be able to provide enough grain from their experimental lines to be able to evaluate the malting quality attributes of a given cross. ARS scientists developed reduced-quantity procedures to mash and analyze the malting quality of very small quantity (5 individual grains) malt samples, which allows breeders to evaluate the malting quality attributes of lines under development at least three generations (years) earlier, greatly accelerating the pace of line selection. Great interest in and a desire to implement this methodology for the Anheuser Busch germplasm development program was expressed to ARS by the company **(Madison, WI).**

Detection of insect damaged wheat kernels. Detecting insects hidden inside kernels of wheat is important to buyers because internal infestations cause insect fragments in products made from the wheat, or, if the wheat is stored before use, the insect population can increase and damage the grain further. It has been shown that in the United States, more than 95% of insects in railcars of wheat at a mill were hidden within grain kernels and would not be detected by normal procedures. ARS engineers developed methods for detecting insect damaged kernels using near infrared spectroscopy (NIR), acoustic impact emissions, transmittance imaging, electrical conductance, and processing x-ray CT scans. While all these methods have their advantages and disadvantages, one method, electrical conductance, is fast, cost-effective and accurate for detecting live insects in wheat. The method monitors electrical conductance through wheat as it is being milled and detects insect by unique characteristics they create on the conductance signal. A prototype mill was constructed that can process a 1-kg sample in 2 minutes. The system is accurate and low cost, about US$2,000. The mill is currently being evaluated by General Mills Inc. for use at their grain receiving stations **(Manhattan, KS).**

Single kernel NIR development for grain sorting. ARS engineers developed a single kernel NIR system for wheat and other small grains that automatically selects specific kernels with specific traits from populations. This system was commercialized through two CRADAs with Perten Instruments, Stockholm, Sweden. The system utilizes NIR spectroscopy that measures attributes such as protein content, starch levels, or kernel hardness in individual kernels, and then removes those kernels from the sample at a rate of about 1 kernel/2 s. These kernels are then used by breeders throughout the U.S. to develop cultivars with specific traits that will result in crops with improved agronomic performance and improved end-use quality **(Manhattan, KS).**

Single kernel corn and soybean sorting. ARS engineers developed a SKNIR system for corn and other large grains at 10 kernels/s, which is a 10-fold throughput increase over previously available technology. Results show the instrument worked well for measuring corn and soybeans. The new SKNIR system has excellent potential for reducing the time and costs associated with the development of corn hybrids and soybean lines with specific composition or processing traits. The system is currently being used by researchers at the University of Florida, the University of Kentucky, EnaGen Corporation, and the Cimmyt organization **(Manhattan, KS).**

Removing toxins from grains. Grain can be infested with several fungi, some of which produce mycotoxins that pose a health risk and inhibit international trade of the grain. ARS engineers worked with high speed sorting machine manufacturers to develop methods for sorting grain infested with several different fungi. One of the main difficulties in developing methods for sorting products is the choice of optimal filters. They developed a procedure that uses statistics and near infrared spectroscopy as tools for selecting optimal filters for sorting products. Sorting methods have been developed for sorting mycotoxin contaminated corn, wheat, wheat infested with karnal bunt, and pistachio defects. APHIS has used the karnal bunt method for inspecting grain where this disease is suspected. The corn sorting method has been adopted by at least one corn processor and at least one major pistachio processor has used the methods for removing defects in pistachio nuts **(Manhattan, KS).**

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

Monitoring stored grain quality. Instruments have been developed to directly measure grain moisture content, to measure carbon dioxide emissions, and to measure equilibrium moisture content of grain using a relative humidity and temperature sensor and the accuracy of NIR protein measurements for stored wheat was evaluated in field tests. The protein measurements showed the importance of laboratories being vigilant about maintaining the precision of their protein determination procedures. The new monitoring instruments improve the ability to

monitor stored grain conditions and provide earlier warning of developing quality problems compared to existing temperature-based systems. Instruments can either be inserted into grain bulks on the end of a probe, or permanently supported on cables to provide continuous, in situ data for stored grain management and the control of aeration and low-temperature drying systems. Much of the development work was done under two CRADAs with sensor companies. ARS' ongoing relationship with these companies is expected to lead to commercialization of the most promising sensor systems **(Manhattan, KS).**

Rapid method for free fatty acids in oilseeds. The value of oilseeds is affected by free fatty acid levels, which are sensitive to field, harvest, and seed storage conditions. The amount of oil that can be recovered from an oilseed varies with free fatty acid content. Hence, accurate methods to determine free fatty acid content are essential for determining the value of an oilseed sample. ARS scientists developed rapid oil extraction techniques and several modified and new assays to determine the free fatty acid content of crude and refined vegetable oils. A chromatography-based assay that separates and quantifies the individual fatty acids present in the oil was found to correlate with older titration methods. This method has been adopted by the American Oil Chemists' Society as a recommended practice. The technique will be useful to industry and scientists needed to characterize oil by-product quality **(New Orleans, LA).**

Method for predicting the boundary friction property of seed oils. Rapid development of biobased metalworking and other lubricants requires capability to quantitatively predict lubrication properties from chemical structures of biobased ingredients. The model must be able to account for the contribution to the overall friction of the various chemical structures found in typical farm-based oils. In this program, extensive evaluation of existing literature showed that no such predictive models exist. Procedures were then developed for studying the boundary lubrication properties of vegetable oils of varying structures and used to generate wide range of data. The data was then analyzed and used to develop a semi-empirical model for predicting the effect of biobased oil chemical and physical structure on boundary friction. The developed method allows for quantifying the contribution of structural parameters such as type and number of functional groups, degree of unsaturation, and chain length on the adsorption properties of seed oils. The model can be used for selecting biobased oils based on the boundary friction needs of the process for which the lubricant is being developed **(Peoria, IL).**

Methods and analysis of soybean varieties. The development of new plant varieties in a crop is dependent on characterization of plant components and enhancing the essential constituents in the plant. In addition, rapid advancement of a crop requires a coordinated effort to evaluate traits and plant constituents across a number of diverse growing regions experiencing a multitude of agronomic conditions. A rapid accurate and non-destructive method was developed to provide standardized screening of public soybean varieties for oil and protein by near infrared spectroscopy. Characterization of the fatty acid components of soybean oils were provided by a

rapid gas chromatographic method via transesterification of oil on whole seeds. The result of this effort provided a standard constituent analysis data set for over 75 State and Federal agriculture scientists, yearly publications of The Uniform Soybean Tests Northern Region, The Uniform Soybean Tests Southern States and The Northern Regional Uniform Soybean Cyst Nematode Tests, allowing breeders to make selections of soybeans that had improved protein content, oil quality and fatty acid composition **(Peoria, IL).**

Assay for polyphenol oxidase in wheat. Consumers place considerable emphasis on the appearance of wheat foods. The enzyme polyphenol oxidase (PPO) was shown to be a major contributor to wheat food browning and discoloration. A simple whole-kernel assay was developed for screening wheat samples and breeding lines for PPO. This assay received Approved Method status by the AACC International, has been widely adopted around the world, and has facilitated dramatic reductions in PPO levels in new wheat varieties **(Pullman, WA).**

Quality evaluation of peanut breeding lines. The Uniform Peanut Performance Trials are an informal arrangement that has been in place for over 30 years among cooperating scientists in 7 major peanut producing states. It serves as a valuable testing arrangement for U.S. peanut breeding programs to measure the adaptability of potential new cultivars over a wide range of diverse environments. ARS scientists test these samples yearly for sensory characteristics, carbohydrate content, and oil quality parameters (fatty acid profiles and tocopherols). This work has been done each year since 2001 and is continuing. Resulting data is made available to all participants and interested parties through the Unit's website. The usefulness of a working core collection to evaluate attributes of genetically diverse resources such as the U.S. germplasm collection for peanuts is well established. Of the 7432 accessions in this collection, 112 specimens have been designated as the "Core of the Core" of the collection. ARS analyzed 108 of these specimens for amino acid, fatty acid, folic acid, and tocopherol content. This data is being made available to peanut breeders for possible crop improvements in nutritional parameters **(Raleigh, NC).**

Models to detect quality attributes in agricultural commodities. To improve the quality of agricultural commodities, handlers, food manufacturers, exporters, and regulatory agencies must measure various poor quality attributes such as percent foreign material (particularly metal and glass), percent discolored seed, and percent genetically modified seed in lots moving in the market system between buyer and seller. Because of the variability among sample test results, it is difficult to get an accurate estimate of the true level of an attribute in a bulk lot. The variability and distribution among sample test results for percent spotted peanuts, percent foreign material (FM), and percent genetically modified seed, was determined. The measured variability and distribution for each attribute could be accurately predicted by the binomial distribution. The binomial distribution was used to develop models to predict the performance of sampling plans to accurately detect these three attributes in agricultural commodities. The FDA used the

model to develop a sampling program to detect Cry9c protein (StarLink) in shelled and dry milled corn destined for human consumption; the peanut and pistachio industries have used the same model to detect FM in lots destined for the food manufacturer; and the peanut industry has used the model to detect discolored peanuts for the export market **(Raleigh, NC).**

Model developed to detect fumonisin in the corn supply. Fumonisin is a toxic and carcinogenic compound produced by mold that contaminates grain and grain products. Because the FDA wanted to develop advisor limits for fumonisin in grain, a 3-year survey was designed by ARS, implemented by the grain industry, and statistically analyzed by ARS to determine the extent of fumonisin in the U.S. corn supply. The survey data was part of the information used by FDA to establish an advisor limit for fumonisin in grain. In addition, the variability and distribution among sample test results was determined and a model was developed to evaluate the performance of sampling plan designs to be used by the grain industry and regulatory agencies to detect fumonisin in the corn supply. The model will help the grain industry and regulatory agencies design sampling plans to effectively detect contaminated lots and improve consumer safety **(Raleigh, NC).**

Model to detect TCK in export wheat shipments. Because *Tilletia controversa* Kuhn (TCK) is a fungi that infects wheat and reduces yields, China placed a total embargo on U.S. wheat. As part of an USDA/ARS TCK Task Force Team, a pest risk assessment (PRA) model was developed that demonstrated to the Chinese that TCK in U.S. wheat could not become established in wheat growing areas of China. In 1999, China agreed to purchase U.S. wheat as long as shipments didn't exceed a tolerance of 30,000 spores per 50 g of wheat. Using variance and distribution data among sample test results, a model was developed to evaluate the performance of sampling plans to detect TCK in export wheat shipments. The model was used by USDA/GIPSA and the wheat industry to determine the risk of misclassifying lots according the TCK. The PRA has opened export markets in China, Brazil, Mexico, and India for the U.S. industry **(Raleigh, NC).**

Adoption of the solvent retention capacity test in wheat breeding programs. ARS converted wheat cultivar evaluations to fully utilize the solvent retention capacity (SRC) test (American Association of Cereal Chemistry Method 56-11). The SRC test has a number of advantages over other standard flour quality measures. It requires only standard laboratory equipment to complete. Most flour quality tests require specialized instruments that cost $40,000 to $60,000. Presentation of SRC data for plant breeding trials and research work has encouraged its adoption by large and small industry laboratories. Over 3 years ARS has conducted SRC training and outreach programs with laboratory staff from flour mills and commercial bakeries. These annual workshops have been attended by approximately 60 technicians. As a result of SRC has been adopted by a majority of eastern U.S. flour mills that mill soft wheat. In the past 2 years, the laboratory has conducted international training programs in Latin America and China. The SRC

test is an excellent test for quality evaluations in developing countries because of the inexpensive equipment and low per sample cost required for the analysis **(Wooster, OH).**

Agricultural Fibers:

Development of quality standards for flax fiber. Objective standards to judge the quality of flax fiber did not previously exist. Through the 'Flax and Linen' subcommittee of ASTM International, ARS organized and led teams for research and development of a series of standards for judging quality that could be adopted for commerce. Four standards, including three test methods, are now part of the Book of ASTM Standards. They include: a standard on technology, test method for color, test method for fineness, and test method for shive in cleaned fiber. The methods have been used to characterize enzyme-retted, dew-retted, and commercial samples for quality. Recently, the shive method was employed to characterize commercial fibers produced by Schweitzer-Mauduit International - the lone flax fiber industry in North America headquartered in Alpharetta, GA and working in Canada and North Dakota - for sale into various industries **(Athens, GA).**

Instrumental measurement of cotton stickiness. Stickiness in cotton is one of the two highest priority problems facing the cotton industry today that can literally stop a gin or spinning mill, and there is currently no good way to detect it. A calibration and prototype new high resolution near-infrared instrument was developed that is suitable for the prediction of sticky cotton. This will provide an online detection method to permit remediation steps to solve a problem that has cost the cotton industry $200,000,000 over a 4-year period in just Texas, Arizona, and California. This impacts every level of the cotton industry. It has been employed by Messa Gin, Las Cruces, NM in the evaluation of cotton modules for stickiness **(Athens, GA, Clemson, SC)**.

On-line determination of cotton lint trash. Advanced process control is of considerable interest as it has the potential for both reducing operating costs in the cotton gins as well as minimizing fiber loss and improving fiber quality by avoiding unnecessary cleaning. A new cotton processing contamination sensor for use in on-line determination of cotton lint trash was designed based on a computer vision system to measure varying levels of cotton gin trash, in real-time, to provide a measurement of the amount and type of each contaminant. For the particular contaminant level, it has been estimated that the producers stand to gain $3-$7 per bale through reduced lint waste by optimally setting their machinery dynamically to avoid over-cleaning of the cotton fiber. At an estimated 20-30 million bales produced annually, this savings stands to dramatically benefit the cotton industry. Given the novelty of this sensor, a U.S. patent was obtained, and the technology transferred to Continental Eagle Corp. Current sales of unit have now surpassed $1 million and have been currently sold and deployed in the U.S., Greece,

and Africa under the trade-name brand of Continental Eagle-Eye for use in automatic control for their LouvreMax adjustable lint cleaner **(Lubbock, TX).**

Low cost microwave cotton bale moisture sensor. In recent years, cotton moisture restoration is becoming more prevalent. Recent research indicates that when moisture is added back to the bale in excess of 7%, quality degradation occurs in long-term storage. After extensive basic research into moisture sensing technologies for use in cotton gins, a low cost microwave cotton bale moisture sensor was developed. Significant improvements were gained over the current state of the art in this sensing technology by relating the moisture in the bale directly to the electrical permittivity of the material, thereby providing a universal standard by which to judge the moisture content of cotton bales. A U.S. patent was awarded and the technology transferred to industry and is currently being marketed and deployed in gins throughout the U.S. Cottonbelt **(Lubbock, TX).**

Assessing "white specks" in cotton fiber and fabric. The white speck problem results in an estimated $200 million annual loss to the textile industry. Defined as undyeable clusters of undeveloped cotton fibers, white specks appear on the surface of dark dyed fabrics containing these undeveloped cotton fibers. Working in conjunction with the Australian Cotton Board, the International Textile Center in Lubbock, TX, the University of Texas of Austin, ARS scientists studied the propensity for forming white specks in a large collection of cottons from fiber to fabrics. With a Specific Cooperative Agreement with Fabrate, LLC, a materials handling system for evaluating sample fabrics for levels of white specks was built. The system incorporates the automated version of Autorate, an image analysis system for measuring white specks that is unbiased for different operators. A fully automated version of this system performed very well in evaluating white specks **(New Orleans, LA)**.

Improved HVI testing model developed for cotton. Cotton fiber properties change when the environmental conditions change; therefore cotton testing needs to be performed under a strictly controlled condition, which carries a high cost. Jointly with USDA Agricultural Marketing Service, and Cotton Incorporated, HVI (High Volume Instrument) testing under non-standard atmospheric environments was studied. The results confirmed previous findings that there are consistent changes of strength and moisture content of cotton with changing environments. However, when the HVI is calibrated at the non-standard environments prior to measuring fiber strength and length, these values tend to be independent of changing moisture content. The results lead to the possibility of a correction model, which reduces the stringent requirements for conditioning **(New Orleans, LA).**

New method to measure short fiber content in cotton. Short Fiber Content (SFC), defined as the weight percentage of fibers shorter than ½ inches, impairs yarn quality and increases

production cost. The current cotton classification does not prove the SFC because of its high variations and difficulty to measure accurately. ARS scientists found that a new length parameter, Lower Half Mean Length (LHML), estimated cotton short fibers very well and predicted spinning performance and yarn quality equally well, but has much low measured variation. Effort is focused on developing an algorithm to calculate LHML from HVI testing. The outcome will enable better evaluation on cotton length quality **(New Orleans, LA)**.

Database of cotton and cotton product qualities. A Fiber Quality Evaluation Laboratory (FQEL) and a database of cotton and cotton products qualities were developed by ARS scientists. The environment control of the FQEL exceeds the requirement by American Society for Testing and Materials (ASTM) standard, and the accuracy and precision of the test results were verified by national and international round trials. A large amount of data on all materials (fiber, sliver, roving, yarn, fabric) is incorporated into the FQEL database. The database on cotton quality relevant to its textile processability and product quality helps cotton breeders to select varieties with superior product quality and textile manufacturers to select suitable cotton for their products **(New Orleans, LA)**.

Problem Area 1c. Factors and Processes that Affect Quality

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Factors affecting apple scald. Superficial scald is a costly storage disorder of apples and pears. It affects only certain varieties and the mechanism is not clear, although a link with oxidation products of the natural chemical α-farnesene is evident. A series of studies determined genetic and storage factors involved in the incidence and severity of scald. The gaseous ripening hormone ethylene was shown to play a key role in scald induction. Both low oxygen storage and treatment with a blocker of ethylene action, 1-MCP, inhibited ethylene production and synthesis of α-farnesene in the skin of stored fruit. It was also found that ethylene induced expression of AFS1, a gene encoding the last enzyme of the α-farnesene synthesis pathway. Finally, it was shown that scald susceptibility of apple and pear varieties is generally linked with high levels of internal ethylene and accumulation of α-farnesene and its oxidation products. This work provided the fresh fruit industry with crucial data on the use of 1-MCP to control scald and indicated that knock out of the AFS1 gene should make fruit of scald-susceptible varieties resistant to scald **(Beltsville, MD).**

Quality evaluation of new fruit genotypes. ARS researchers evaluated the quality of unique new genotypes such as ‘GoldRush’ apples, orange-fleshed honeydews, long storage/ultra firm

melons, high β-carotene tomatoes and Hannah's Choice blueberries. The instrumental and sensory quality characteristics of these new genotypes were compared to their commercial counterparts and found to have quality characteristics that were often better than their commercial counterparts. These sensory and instrumental quality evaluations are a major step in gaining public acceptance of these highly promising genotypes and in increasing the overall quality and variety of fruits in the marketplace. The research directly contributed to increased acceptance and production of 'GoldRush' apples and orange-fleshed honeydews within the United States and to increased sales of superior tasting ultra firm melons during the winter season **(Beltsville, MD).**

Processing and storage research results in improved potato germplasm. Variations in potato process product quality for chips and fries due to disease and sugar accumulation result in large major storage losses costing producers and processors hundreds of millions of dollars annually. ARS research directed toward the identification of new and improved germplasm with superior storage and processing characteristics was expanded to include eleven cooperating public university potato breeding programs (ND, MN, MI, OH, NB, WI, ID, MA, NY, TX and CO). This research directly contributes to new potato variety releases by providing standardized storage, processing and analysis of advanced breeding clones submitted by public potato breeding programs. All protocols, storage conditions, and analytical methods used have been standardized in accordance with current industry practices and are therefore invariant. Between 14,000-15,000 evaluations on elite breeding clones are conducted each year. All data from these assessments are made publically available and are used by breeders to eliminate/select clones for eventual release or for future crossing programs. In the past five years, this facility's evaluations have been a contributing factor in many of the new varieties releases, including Dakota Crisp, Dakota Diamond and White Pearl **(East Grand Forks, MN).**

Flavor changes due to infection by Huanglongbing (HLB or citrus greening) disease. ARS researchers, in collaboration with a citrus processor, performed sensory analysis to determine if/when fruit from trees infected with HLB exhibits off flavor. Juice from healthy and HLB-infected orange trees were tested using a sensory panel and results showed that for two orange varieties, there was a difference between HLB-infected and healthy juices ranging from sweeter to overripe for the infected fruit. This work is important for juice processors to predict the effect of this new and spreading disease on orange juice flavor and will aid orange juice processors in predicting juice quality when incorporating HLB-infected oranges into bulk juice **(Winter Haven, FL).**

Causes of apple physiological disorders. Because of the genetic diversity of the tree fruit industry, the seasonal variation in microclimate during the 6-month growth cycle, and the time in storage approaching 12 months, the requirements for quality optimization are both myriad and complex. Moreover, pre- and postharvest environmental conditions necessary to maintain high

fruit quality for extended times are often quite narrow and intolerant. Given the normal variation in fruit development and ripening, this intolerance manifests as physiological disorders--internal and/or external symptoms of stress from which the fruit cannot recover without apparent blemish or defect. In certain years, commodity loss from physiological disorders can exceed 20%. ARS research led to new knowledge concerning biochemical and molecular causes of physiological disorders, such that curative technologies have been developed and implemented. The most recent example concerns the disorder known as lenticel breakdown (LB) on 'Gala' and 'Fuji' apples that, for 3 years, has topped the priority list of the Washington Tree Fruit Research Commission. ARS researchers elucidated the dynamics of fruit epidermal tissue—how the apple peel stretches, grows and responds biochemically and structurally to changes in environmental conditions. Indeed, it is the fruit's response to sustained, high summer temperature that is the primary cause of LB. They found by applying low rates of natural vegetable oils and waxes during periods of high ambient temperature before harvest, the disorder was reduced by as much as 50%. In a billion dollar industry, reducing loss by 10% is quite fruitful **(Wenatchee, WA).**

Organic vs. conventional produce quality. Claims that organic produce is better tasting and more nutritious than non organic (conventional) produce are largely unsubstantiated. This is due mainly to a lack of rigor in matching common production variables of both production systems; such as microclimate, soil type, previous crop, irrigation source, plant age, and cultivar. When ARS scientists matched the aforementioned common production variables in a 3-year trial of commercially-grown conventional and certified-organic red-fruited grapefruit, compared at early- mid- and late-season maturity indices, it was revealed conventional fruit was better colored, higher in lycopene, less tart, lower in the bitter principle naringin, and better tasting than organic. But organic fruit had a commercially preferred thinner peel, was higher in vitamin C and sugars, and lower in the drug interactive bergamottin compounds and the negative health compound nitrate. This research lead to the establishment of guidelines for scientifically conducting organic vs. conventional comparison studies currently used by USDA Cooperative State Research, Education and Extension Service in judging soundness of grant proposals for funding **(Weslaco, TX).**

Animal Products:

Processes affecting leather quality. Three processes are used in tanneries to soften leather. Two are mechanical--staking (repeated jabbing) and milling (dry tumbling), and the third is the application of fatliquors (softening oils). There has been little understanding of how these processes work and affect one another. ARS engineers determined the relationship between fatliquor concentration and drying rate as well the resultant leather's physical properties. They discovered an intricate effect of fatliquor on the softening behavior of staking; without fatliquor, staking actually stiffens the leather. They showed that the concentration of fatliquor, not the type

of fatliquor, directly affects the physical properties of leather. They determined that addition of polyethylene glycol humectants retained moisture and prevented overdrying and embrittlement of leather. They also showed that milling causes a significant decrease in stiffness while hardly changing mechanical strength and toughness; microscopy revealed that milling produces a more open fiber structure, a necessity for soft leather **(Wyndmoor, PA).**

Cheese whey protein enhanced snacks. The potential use of cheese whey proteins in expanded snack products was limited by the lack of understanding of its physical interactions with other food materials such as starches, which reduced expansion in extruded products such as corn snacks blended with proteins. Corn snack products blended with unmodified whey proteins were usually shrunken and tough to chew. ARS scientists determined that if blended corn and whey protein products were extruded under high shear and low moisture conditions, the resulting product would be expanded and crunchy. It was discovered that the protein enriched snack products can contain up to 35% whey proteins and still maintain crunchiness. Further research in this area led to a patent-pending process that has been licensed by Harden Foods, Inc., which markets such products in the U.S. under the label, Muscle Puffs™. Harden is also producing Muscle Puffs™ cheese balls made from texturized whey protein isolate for BOSS (Bob O'Leary Sports Science), a national distributor of sports nutritional foods in Scranton, PA. Sales of Muscle Puffs reached $4 million in 2006 **(Wyndmoor, PA).**

Cereals, Oilseeds, and Novel Crops:

Improved rice milling. ARS researchers, with support from the California Rice Research Board, developed an innovative cooling method for rice milling equipment and determined recommendations for lowering milling temperatures and pressures. These newly developed rice milling procedures significantly improve the consistency and accuracy of rice sample milling. Use of slightly lower milling and polishing weights improves the head rice yield without changing the degree of milling of milled rice. Based on this research the USDA Grain Inspection, Packers and Stockyards Administration (GIPSA) changed the grading procedures for medium grain rice in California. The implementation of new standards will result in significant economic gains for rice farmers and processors **(Albany, CA).**

Peanut curing decision support system developed. Most peanuts harvested in the U.S. are mechanically cured at a central processing facility to reduce the moisture content to safe storage levels and to preserve flavor and milling quality. Commercial curing facilities simultaneously manage as many as 150 individual batches of peanuts, requiring intensive labor to monitor peanut moisture, dryer performance, and queues of peanuts in various stages of processing. ARS scientists developed a computer model and inventory system to manage the buying facility by tracking individual loads of peanuts from their arrival at the facility through curing until they are

released for official grading. The decision support system estimates total drying time and current moisture content, suggests sampling intervals for moisture determination, and alerts the manager when loads should be removed from the dryer and moved to the next phase of processing. The program has been released as part of a software suite and is utilized at approximately 5% of peanut curing facilities in the U.S. All users have reported reduced labor requirements, increased utilization of equipment, and increased product uniformity **(Dawson, GA).**

Temperature routines developed for peanut curing. Temperatures at which peanuts are cured affect flavor and milling quality, uniformity of curing, and variable costs of drying. Routines to calculate the desired curing temperature based on outside temperature and humidity were developed. These routines allowed for the development of automated controls that will control peanut drying equipment. Companies have developed and installed distributed control systems utilizing these routines at approximately 10% of the peanut curing facilities in the southeastern U.S. Users report significantly reduced fuel costs for curing, reduced labor requirements, and improved peanut quality **(Dawson, GA).**

Best management practices for peanut storage aeration. After curing and marketing, peanuts are stored in bulk warehouses ranging in capacity from 2,000 to 12,000 tons. In recent years, the harvest has been compressed from over 2 months to less than 3 weeks in some cases. When these massive warehouses are loaded that rapidly, excessive moisture and heat must be dissipated and removed from the storage environment to prevent mold growth and potential aflatoxin contamination. Aeration systems and control parameters were adapted from bulk storage recommendations for small grains and tested. This research resulted in recommendations for designing and operating peanut aeration systems. Best management practices including peanut storage aeration have been published in an industry association handbook **(Dawson, GA).**

Quality assessments of wheat breeding lines. Wheat is the world's most important crop, in terms of both total acreage planted and human consumption. New wheat varieties represent opportunities for greater yield, higher and more consistent quality, greater resistance to diseases and pests (resulting in reduced use of pesticides), and a consistent supply of high quality raw material for the baking and processing industries. Wheat breeding requires crossing superior parents and then evaluating large numbers of progeny. A new wheat cultivar requires 13-15 years to develop and is released at a cost of nearly $1 M. Without intrinsic quality evaluation, long range breeding programs in the U.S. will face the risk of releasing a wheat cultivar of unknown quality with serious economic impact on the milling and baking industry. Tens-of-thousands of experimental wheat progeny from early to late generations were thoroughly characterized by regional ARS wheat quality laboratories for milling, baking and end-use qualities. The majority of U.S. released varieties (all wheat classes) are impacted by the four ARS Wheat Quality Laboratories and related research programs. Superior wheat varieties have

been cooperatively developed and released and have been grown on millions of acres **(Fargo, ND, Manhattan, KS, Pullman, WA, Wooster, OH).**

Identity preserved (IP) grain handling. Inadvertent commingling during grain handling reduces the desired level of purity of grain, impeding efforts to preserve the identity of specialty grain lots, but no data previously existed on the amount of commingling that occurs in grain elevators. ARS engineers measured the levels of commingling when receiving two types of grain using single receiving pits and other standard equipment at a country elevator and at an ARS research elevator, and developed models to predict commingling in this equipment. One of the U.S. publications of these results was picked up by a European grain industry magazine and republished there. This information is being used to develop new methods in our continuing IP grain handling program and is also being used by extension engineers at Purdue University in their modeling programs used to help grain elevator operators improve their grain handling **(Manhattan, KS).**

Organic versus traditionally-grown rice. Organic rice is perceived by the consumer to be safer, fresher, healthier, and better tasting than conventionally-grown rice. Perception of differences in sensory quality between organically- and conventionally-grown rice could be influenced by preference. This research determined whether there is a scientific basis for the claims that organic rice tastes better. When cooked, rice grown organically was higher in slickness than that grown conventionally, as explained by its lower protein content. No differences in flavor were observed between the organically- and traditionally-grown rice. These results are useful for industry consumers in marketing and purchasing traditionally- and organically-grown rice **(New Orleans, LA).**

Roasting increases peanut allergenicity. Immunoglobulin E (IgE) from the blood of allergic individuals was found to bind roasted peanut extracts at 90-fold higher levels than to raw peanut extracts. Upon roasting, major peanut allergen Ara h 1 was shown to form covalently crosslinked trimers making it much more stable than Ara h1 in raw peanuts. Ara h2, another major allergen, also became vastly more stable, possibly due to intramolecular crosslinks. Both were shown to be resistant to digestion. The research demonstrated that biophysical modifications during roasting contribute to enhanced allergenic properties of peanut proteins. These results make an important contribution to understanding the relationship of the structure of a protein to its function as an allergen. Although it had been established that food allergens are resistant to digestion, until this research, there was no clear comprehension of the reasons for this 20-year old observation **(New Orleans, LA).**

Expeller pressed soybean oils provide good frying quality and low *trans* fats. Expeller pressing to extract oil from oilseeds is an alternative technology to conventional hexane extraction. ARS scientists found that expeller pressed soybean oil had better frying stability and

the fried food had longer shelf life than soybean oil extracted with hexane. In analyses of the composition of the expeller pressed soy oil, ARS researchers measured high levels of Maillard reaction products formed because of the heating during expeller extraction. These products are well known antioxidants that probably helped to improve the stability of the expeller pressed oil and the food fried in it. In addition, expeller pressed low-linolenic soybean oil exhibited significantly better oil and fried food stability than did expeller-pressed soybean oil with normal linolenic levels. Many small oil processors in the U.S. are starting to use expeller extraction as an alternative to hexane extraction of the oil. Innovative Growers, an Iowa company, is currently using expeller pressing to extract low linolenic soybeans. In frying applications, both expeller pressed soybean oil and expeller pressed low linolenic soybean oil are alternatives to hydrogenated oils but without the unhealthful trans fats **(Peoria, IL).**

Peanut blanching helps shelf life. Peanut dry blanching employs a mild dry heat treatment to loosen and remove skins. Peanuts lose their skins during roasting but there are applications in which blanching before roasting is desirable. However, industry consensus has been that blanching before roast significantly damages shelf-life. ARS scientists conducted studies that clearly showed that blanching peanuts before roast is not only harmless, but is actually beneficial for shelf-life. This publication has been used by industry to justify process changes **(Raleigh, NC).**

Agricultural Fibers:

Acceptable restored moisture level for ginned cotton. Results of a moisture restoration trial at ginning and spinning were compiled and published by ARS for use as an educational tool for ginners and to establish an acceptable moisture level for ginned cotton. A moisture level of 7.4% or less was determined to be acceptable for ginned lint in order to minimize fiber damage and processing problems. ARS researchers came to this conclusion after conducting tests on a commercial gin with a commercially available moisture restoration system and varying levels of moisture were added to the ginned lint. Storage studies were then performed on the lint to evaluate fiber and yarn properties. The results of this effort determined that restored moisture above 8% resulted in deteriorating fiber quality and poor yarn properties. As a consequence, the National Cotton Council established a level of 7.5% moisture as the highest level of restored moisture acceptable at ginning **(Clemson, SC, Las Cruces, NM).**

Deterioration of cotton quality during storage. In the past, the U.S. cotton crop was consumed primarily by the domestic textile production market. In recent years, however, cotton sales have shifted to foreign textile production markets, primarily in China. As a result, the U.S. cotton crop may be subjected to extended periods of storage, either in warehouses or within shipping containers, without benefit of temperature control. A study investigating the effects of

this extended storage upon the quality characteristics of the resulting yarns produced following storage indicated that storage of cotton bales for at least 2 years leads to a significant reduction in yarn strength as well as an increase in yellowness, both of which are associated with inferior quality. Unless action such as temperature control is taken to mitigate the effects of storage, the potential impact of such storage-induced deterioration is that U.S. cotton may come to be perceived as being inferior in quality to cottons which have not been subjected to extended storage **(Clemson, SC).**

Quality assessment determines that ginned cotton bales are free of live boll weevils. A concern was raised, both by USDA Animal and Plant Health Inspection Service and foreign cotton buyers, that ginned bales of U.S. cotton could be vehicles of boll-weevil infestation into previously weevil-free countries or areas. Cooperative research showed that live boll weevils would not survive seed cotton cleaning, drying, and feeder-cleaner, nor would they survive being compressed in a full-weight Universal Density (standard U.S. bale package) cotton bale. This work has been used by other USDA agencies and cotton marketing organizations and has resulted in sales of U.S. cotton (or reduced import restrictions) to several countries, including Peru, Egypt, and Ecuador, that hitherto had not purchased cotton from the U.S. because of fear of boll weevil infestation, or these countries had required expensive and hazardous methyl bromide fumigation prior to and/or following bale shipment. The result is a savings of $12 per bale, or millions of dollars, to the U.S. cotton industry. **(Las Cruces, NM, Lubbock, TX)**.

Problem Area 1d. Preservation and/or Enhancement of Quality and Marketability

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Improved sugar clarification processes. After conducting numerous clarification studies at various Louisiana sugarcane factories, ARS scientists developed improved sugar clarification processes which solved the problems associated with the use of the traditional cold lime clarification process which was not able to remove the new overloads of impurities at the factory from billeted cane. From 1999-2006, 92% of Louisiana factories had adopted intermediate or hot lime clarification processes. Additionally, two factories in Florida and one in Texas have adopted hot lime clarification. As a result of this research, it has been conservatively estimated that Louisiana factories are saving over $3.8 million annually from lower sugar loss and lime consumption. This accomplishment received numerous national awards including the 2006 USDA –ARS Superior Technology Transfer Award and the 2007 Federal Laboratory Consortium National Award for Excellence in Technology Transfer **(New Orleans, LA).**

Post harvest treatments adopted by California fruit industry. After harvest, mold fungi cause fresh citrus and table grapes to rot if not protected. Effective practices to control rot were developed that would satisfy the needs of both conventional and organic growers, including using biological control, natural coatings, thermal treatments, generally-recognized-as-safe (GRAS) substances, ethanol, ozone, lime sulfur, and conventional and reduced-risk fungicides. From this work, citrus producers adopted one or more of these technologies; most of them now have integrated the use of hot water combined with other substances during the packing process. The fresh grape industry adopted one technology universally, which is the precise control of sulfur dioxide dose during fumigation to limit sulfite residues in grapes and to stop gas releases to the environment, while elements of the other projects are in some use or under commercial evaluation. The practicality of the use of ozone by the citrus and table grape industries was established and commercial adoption of ozone facilitated **(Parlier, CA).**

Research on 1-MCP use on apples commercialized. Commercialization of 1-MCP (methylcyclopropene) provided a new tool to storage operators for management of fruit quality in the postharvest environment. For example, availability of the commercial 1-MCP product SmartFresh® has added considerable flexibility to postharvest chemical treatments, storage temperatures and temperature regimes, storage atmospheres, and planned storage duration based on fruit maturity at harvest. Post-storage impacts of 1-MCP use at harvest on handling and packing procedures have also become apparent with commercial use. Primarily due to slower loss of firmness in many cultivars, marketing programs have also been impacted as the tails of the manifest (large/small sizes, lower color grades) can be held longer in cold storage after packing. Continuing widespread use of 1-MCP is indicative of its commercial utility. ARS research facilitated the commercialization of SmartFresh for the deciduous tree fruit industry **(Wenatchee, WA).**

Calcium sprays improve melon quality. Calcium content in melons such as cantaloupes and honey dew is critical in maintaining harvested fruit quality and extending marketable shelf-life. However, calcium levels in melons quickly decline as fruit develops on the vine, which in turn hastens postharvest fruit softening and restricts overseas distribution of U.S. grown fruits. For years research by others utilizing calcium salts (e.g., calcium-chloride) were either not effective or caused discoloration, making the melons un-salable. ARS researchers using a food grade organic complexed-calcium compound treatment, established a prescription protocol whereby spraying fruits on-the-vine, specifically during fruit growth, improved harvested fruit exterior and interior firmness, marketability, disease resistance, calcium concentration, sugar content, self-life (long enough for ocean shipment to Europe and Japan), and consumer acceptance. This research received a 2006 ARS Technology Transfer award and is currently being used on over 160,000 acres worldwide, with individual growers estimated to be earning an additional $100 per acre and in some cases as much as $3,000 per acre, resulting in a net impact to industry of an

additional $16 million earnings per year. This does not include the added savings due to increased shelf-life resulting in less waste and more fruit being sold at the retail level, nor does it reflect the decrease in fruit rejection claims due to improved quality and shipping **(Weslaco, TX).**

Improved phytonutrient contents in melons. The ability to significantly enhance the three most important human health promoting phytonutrients (beta-carotene, ascorbic acid, and folic acid) in melons was established by ARS scientists using divergent germplasm, specific environmental inputs, and physicochemical assays. A study of multiple hybrid/inbred lines of melons, grown on high vs. low mineral content soils, and harvesting divergent germplasm fruits at discrete commercial size classes, demonstrated that a 3- to 11-fold content increase in these human-health phytonutrients can easily be realized by any commercial grower. Specific melon cultivars, determined by ARS scientists as being superior in phytonutrients, are being grown by regional melon growers in South Texas. This accomplishment led to the ARS scientists, in cooperation with medical doctors from the University of Texas, to establish the first U.S. Hispanic Nutrition Research and Education Center in the border region of Texas where nutritionally enriched fruits are used in feeding studies to improve indigent population health **(Weslaco, TX).**

Potassium improves cantaloupe quality. Netted muskmelon (cantaloupe) fruit quality – specifically ascorbic acid, β-carotene, total free sugars, and soluble solids concentration (SSC) - is directly related to plant potassium (K) concentration during fruit growth and maturation. However, during fruit growth soil K fertilization alone is often inadequate due to poor root uptake and competitive uptake inhibition from calcium and magnesium. ARS scientists, supplementing soil fertilizer K with foliar-applied K during melon fruit development, increased firmness (26%), sugar content (20%), ascorbic acid (18%), β-carotene (17%), and K (14%) compared to non-treated fruit. This is the first documented proof of K's direct effect on firmness. Differences between K sources were minimal but when applied in combination with a surfactant, K's positive effects were even greater. These quality improvements resulted in a simple management tool: foliar sprayed K using commercial K compounds with a surfactant, applied to either adequately or poorly rooted fertilized plants. Currently, this technology is being used on over 80,000 acres worldwide, resulting in an estimated net impact to industry of additional $8 million earnings per year **(Weslaco, TX).**

An organic-compatible method to sanitize whole fruit was developed which reduced microbial populations on both the intact fruit and subsequent fresh-cut products. Oranges and mangoes were treated with peroxyacetic and/or citric acid and processed into fresh-cut products. Peroxyacetic acid out-performed the commercial chlorine sanitizer and is compatible with the organic label. In addition, peroxyacetic acid reduced the canker bacteria on citrus, which prevents shipment of citrus to other citrus growing areas. This research will enable packing houses and fresh cut operations to make informed decisions when choosing a sanitizer for intact

fruit. This sanitizer and protocol are now being used in some fresh-cut facilities and packing houses **(Winter Haven, FL).**

Organic-compatible shellac coating for use on citrus and apples. The current commercial shellac coatings are not compatible with the organic industry due to use of morpholine in their formulations. ARS scientists developed an organic-compatible shellac coating for use on citrus and apples substituting morpholine with ammonia, while maintaining the high gloss characteristics that make shellac coatings so popular. As a result, the citrus industry is now using organic shellac coatings **(Winter Haven FL).**

Animal Products:

Hydrodynamic pressure processing tenderizes meat. Consumer studies have repeatedly shown that meat tenderness is the predominant attribute influencing product satisfaction and that consumers are willing to pay more for guaranteed tender meat. Unfortunately, meat tenderness is highly variable and difficult to control. ARS scientists developed a technique for tenderizing various muscle food products using high energy shockwaves by hydrodynamic pressure processing (HDP). Numerous studies demonstrated that HDP causes instantaneous improvements in tenderness by up to 50% and decreases the need for extended aging tenderization, a conventional technique used by the meat industry that requires high energy costs due to prolonged refrigeration of meat. Research showed that high energy shockwaves enhance tenderization due to aging and other postmortem processing techniques that reduce tenderness variability and provide the consistently tender meat desired by both consumers and processors. CRADA agreements were established with Hydrodyne, Inc., Spectra Research, Inc., and Sparktec, Inc. to evaluate commercial development and feasibility. Trust agreements were established with Foster-Miller, Inc. and U.S. Army Natick Laboratory, and SCAs' established with Naval Surface Warfare Centers (Carderock and Indian Head) **(Beltsville, MD).**

Cereals, Oilseeds, and Novel Crops:

Development of 'waxy' wheat. Starch is the major constituent of wheat grain and is comprised of mostly linear amylose and highly branched amylopectin. When starch is solely amylopectin, it is referred to as 'waxy' (the name coming from the observation that waxy corn kernels' appearance was somewhat waxy). Waxy wheat is not known to occur naturally in nature, however the necessary genes can be assembled through traditional breeding. Scientists developed, released and registered the first waxy wheat variety in the U.S., 'Waxy-Pen'. This variety was exclusively licensed to the Washington State University Research Foundation and an exclusive sub-license was granted to West Bred LLC. Food innovators have been provided

dozens of samples for trials. Research and development activities attracted two back-to-back CRADAs with a major cereal processing food company. Commercialization activities are underway. The aquaculture feed industry has also taken interest and commercial pilot-scale trials are currently underway **(Pullman, WA).**

Agricultural Fibers:

Roller ginning technology maintains U.S. competitiveness and cotton quality. ARS scientists demonstrated in the laboratory and later in a commercial gin plant, utilizing a full size rotary-knife roller-gin stand, that sustained ginning rates could be maintained of 4 bales/hour for upland cotton and 6 bales/hour for Pima cotton without increased fiber damage or excessive ginning roll temperatures. This significant improvement in ginning rate resulted from a number of ARS-developed improvements in roller ginning technology. Before these improvements, rotary-knife roller ginning rates for upland and Pima cotton were limited to approximately 1 and 1.5 bales/hour respectively. As a result, upland cottons in the U. S. are normally processed through saw gins, even though roller ginning cotton results in a fiber, regardless of the variety, that has better length and nep properties than comparative cottons processed through a saw gin stand. Machine harvested U. S. cotton competes in a world market with high quality hand harvested foreign cottons. The increased rotary-knife roller ginning rate could significantly increase the quality of ginned upland cotton in the U.S. Successful commercialization of this technology will enable U. S. upland cotton producers to deliver a higher quality fiber to world markets. This hot rod roller ginning technology was commercially prototyped for several commercial gins for the 2006 ginning season by a U.S. gin machinery manufacturer. The number of hot rod roller gins for the 2006 crop year has since doubled for the 2007 crop year **(Las Cruces, NM)**.

Component 2. New Processes, New Uses, and Value-Added Foods and Biobased Products

Problem Area 2a. New Product Technology

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Novel continuous casting technology for fruit and vegetable wraps. New processing technologies and products could help increase utilization and consumption of fruits and

vegetables by American consumers. ARS researchers developed and patented a novel continuous casting technology to produce 75% to 100% fruit and vegetable wraps and worked with an industrial CRADA partner to commercialize the films for a variety of final product applications. One of the applications is the use of the films as healthy, colorful alternatives to the seaweed wrap "nori" on sushi products, such as Sunny California rolls that are now being sold at Trader Joe's wrapped in ARS developed carrot ginger films. In addition, the films have been sold commercially as glaze sheets for hams and turkeys, as well as for a variety of uses by up-scale restaurants. The industrial CRADA partner received a large business loan from the San Joaquin Valley Revolving Loan Fund to build the plant in Stockton, CA, an area of high unemployment. ARS is working with them to begin production by Spring 2008, bring jobs to the area, while manufacturing novel, healthy fruit and vegetable films for consumers **(Albany, CA).**

Fruit health bars from pears and other fruits. To meet the need for new processing technologies to increase utilization and consumption of fruits by American consumers, ARS researchers developed and licensed a technology for forming 100% fruit health bars from pears and other fruits to add value and create new markets for pears and other fruits. Through a CRADA the industrial partner has been commercially producing the bars in a plant in North Bonneville, WA, an area of high unemployment since late 2002 and forty new jobs have been created. The impact of this grass roots effort of pear growers has expanded beyond pears by the introduction of a line of apple based bars and more recently lines of berry based and organic fruit bars. This research has increased grower profits while assisting consumers around the globe in meeting their daily requirements for fruits and vegetables through the development of these healthy, convenient 100% fruit bars **(Albany, CA).**

Health benefits of citrus limonoids. ARS researchers are investigating the influence of citrus liminoids on blood concentration of cholesterol and inflammatory response in humans through collaboration with the Western Human Nutrition Research Center, Davis, CA. Through a trust agreement funded by a major beverage manufacturer, this study is examining the metabolism, safety, and efficacy of increased intake of citrus limonoids by human subjects. The study will determine their health benefits, particularly the effects on serum lipids and markers of inflammation. Concurrently, methods for the sub-pilot plant scale isolation of limonoid glucosides are being developed and various citrus waste streams are being evaluated as potential feedstocks for the isolation of limonoid glucosides **(Albany, CA).**

Novel modified polysaccharide from cane and beet sugar. Every year the United States imports millions of pounds of gum arabic, an important food and industrial hydrocolloid, from the Middle East. ARS researchers developed a modified bacterial gum using safe food-grade bacteria and cane or beet sugar as a feedstock. The resulting family of complex carbohydrates, alternan and modified alternan, show great promise as substitutes for imported gum arabic, as well as nutritional food fiber additives. Research resulted in two journal publications, two

patents, two pending patents, and a pending Material Transfer Agreement with a major U.S. food processor. The patented technologies have been licensed by the private sector for applications as diverse as test kits and food supplements **(Peoria, IL).**

Polymethoxylated flavones demonstrated as a potential high value byproduct of orange juice processing. The profitability of the U.S. citrus industry is limited to a large extent to the low cost of orange juice solids, and the lack of meaningful income from the peel waste, which represents half of the entire fruit crop. A traditional profitable byproduct has been the citrus bioflavonoids, mainly sold as a nutraceutical with anti-inflammatory properties. Research was conducted which elucidated the mechanism of the anti-inflammatory actions of the citrus polymethoxylated flavones (PMF), and this study provided the basis for a licensed patent. Three subsequent animal studies have verified the anti-inflammatory actions *in vivo*, and has helped support plans for future clinical trials.

Research also demonstrated that these compounds were able to block LDL-cholesterol production and secretion by human liver cells. These studies led to a patent. The PMFs were shown to significantly decrease blood serum triglyceride levels via the inhibition of key lipid biosynthesis enzymes in human liver cells, and by activating the peroxisome proliferator activating receptor, a key nuclear receptor regulating fatty acid catabolism. This research provided key validation and elucidation of the actions of these citrus compounds, and has bolstered the production and sales of the nutraceutical, Sytrinol, an effective alternative to the widely prescribed statin drugs **(Winter Haven, FL).**

Characterization of structure-function relationships of plant cell wall polysaccharides. ARS scientists developed a sophisticated analytical system for determining the global structure of pectin, arabinoxylan and other plant cell wall polysaccharides. The multi-detector system simultaneously measured molecular weight, size and viscosity of polysaccharides. Atomic force microscopy was used to confirm the accuracy of the size measurement. The physical properties measured by this system were used to optimize extraction conditions to produce both orange pectin with high gel strength and corn fiber arabinoxylan with high oil-in-water emulsifying power. In the course of these studies, fundamental knowledge concerning the structure of pectin in aqueous solution and sugar acid gels as well as arabionxylan in beverage products was discovered. The U.S.-based, world's largest pectin producer has adopted this method for determining the quality of pectin **(Wyndmoor, PA).**

New pectin-based product technology for bone and connective tissue repair. ARS scientists fabricated porous three-dimensional scaffolds from pectin or other polysaccharides and polylactic acid. The simple, environmentally-friendly method produces a strong scaffold that is more accessible to biological tissue growth compared to previous materials used for bone or connective tissue repair. The technology is patent pending, and a CRADA was established with

a major biomedical product company interested in licensing the patent. It is anticipated that adoption of this technology will have an economic impact on the regenerative biomedical industry. This new use for pectin converts an existing medium-value by-product of low-valued citrus peel into a unique high-valued medical product **(Wyndmoor, PA).**

New pectin gels for controlled drug release. ARS scientists discovered that pectin interacts with the colonic epithelial surface based on its charge and charge density. This structure-function relationship was used to design a series of new controlled- release drug delivery systems. These systems include: the use of pectin gel for treatment of mucosal irritation and infectious diseases; the development of a pectin/protein composite hydrogel for colon-specific drug delivery; and a pectin gel used for fragrance release in aromatherapy and transdermal drug delivery. Based on this technology, ARS established a CRADA with the U.S. Army Medical Research Institute of Infectious Diseases, and a collaborative research contract with the Chemistry Institute of the Tajikistan Republic funded by the State Department **(Wyndmoor, PA).**

Animal Products:

Structured lipid products. Nutraceutical lipids represent one of the fastest growing segments in the food ingredients market. Because of extensive expertise in lipid modifications, ARS researchers, in collaboration with an industry partner, developed technology to produce structured triacylglycerols (TAG), from commodity type fats and oils. The lipid products were obtained using a combination of fractionation techniques to selectively isolate desired triglycerides using either low-temperature crystallization or solvent fractionation of the TAG present in such oils and fats as poultry fat or marine oils. The same fractionation techniques were then applied to the free fatty acids obtained from the oils or fat so as to concentrate the desired fatty acids into a single fraction. The desired structured lipids were then synthesized enzymatically using acyl or positionally selective lipases to produce a series of structured lipids that were shown by the collaborator to have beneficial cholesterol-lowering effects when administered as dietary supplements to hypercholesteremic subjects. Two jointly owned patent applications were filed on this technology by the collaborator **(Wyndmoor, PA).**

Carbon dioxide solvent extraction of agricultural proteins. A technology was developed that uses the environmentally benign solvent carbon dioxide (CO_2) as a substitute for acids that are commonly used to separate and isolate proteins. The technology extracts proteins from large quantities of milk, or any solvent containing a precipitable solute. The protein does not require washing which conserves water and the CO_2 is easily removed from the whey and can be reused. The process was awarded a U.S. patent. The process was licensed in 2000, and a plant was constructed to produce corn and soy protein isolates using the process **(Wyndmoor, PA).**

Polymerase-chain-reaction (PCR) methods to detect, clone and characterize genes for bioplastic synthesis and degradation. Traditional methods of identifying microorganisms capable of producing bioplastics called polyhydroxyalkanoates (PHA) are time-consuming and nonspecific. ARS scientists developed rapid and specific genetic testing procedures based on PCR technology to screen for genes responsible for bioplastics synthesis in bacteria. The ARS scientists successfully applied these methods in their laboratory, resulting in the identification of many new bacterial strains previously not known to synthesize either hard (short-chain-length-) or soft/tacky (medium-chain-length-) PHA bioplastics at or higher than 30°C. The methods also provide DNA-sequence information, which greatly facilitates the subsequent cloning and characterization of the complete operon including the PHA-degrading gene of the bioplastic biosynthesis pathway. As a result, numerous PHA operons have been cloned and characterized by the ARS scientists. The ARS-developed technology has been widely adopted by the research community worldwide not only to study the biology of PHA biosynthesis but also to characterize the ecology of microbial communities. Numerous inquiries and requests for advice have been received from investigators seeking to adopt the methods in their research. The pioneering work has inspired other researchers to develop variations of the ARS-developed methods for screening microbial populations. Two collaborative research activities with overseas academic institutions were established to apply the methods in their research projects. One of these collaborative works has resulted in the granting of an Organization for Economic Cooperation and Development postdoctoral fellowship award to the collaborator to further the study at ARS **(Wyndmoor, PA).**

Biologically active milk proteins. Bovine milk proteins incorporate several peptides that display beneficial biological activities including antimicrobial and hypotensive effects. These bioactive peptides may be produced by enzymic (trypsin, pepsin) digestion of caseins and lactoferrin present in milk. In addition, many strains of lactic acid bacteria (LAB) produce natural antimicrobials (bacteriocins) or generate bioactive peptides from milk proteins during the industrial production of cheeses and other fermented dairy foods. ARS researchers developed synthetic genes corresponding to an 11-amino acid antimicrobial and a 12-amino acid hypotensive peptide for transport into LAB. Researchers then developed strategies for producing bioactive food ingredients (antimicrobial and hypotensive peptides) introduced into LAB or alternative microbial systems in whey. A sensitive and rapid assay system was developed to identify LAB cultures that produce antimicrobial and bioactive peptides. Production conditions were optimized for the broad-spectrum antibacterial pediocin that has potential for applications as a biopreservative and is awaiting FDA approval as a food ingredient effective against listeria contamination. The evaluation of a variety of parameters established the suitability of whey-based media for the large-scale production of pediocin and possibly other biopreservatives. Researchers also demonstrated that the selection of compatible LAB starter cultures (streptococci and lactobacilli) permits pediocin synthesis directly in milk, thus making possible the enrichment

of fermented dairy foods with a natural biopreservative under industrial production conditions. Information and materials have been exchanged with a university cooperator **(Wyndmoor, PA).**

Microparticulation improves functionality of whey proteins. To improve the functionality of whey proteins, ARS scientists developed a process for changing the structure from the folded globular state to an open stretched conformation through new shear extrusion techniques. Using microparticulation, the scientists reduced the particle size of milk proteins to less than 20 microns and improved the gel strength of the proteins, thereby creating new uses for whey proteins in syrups. Microparticulation made it possible to derive the same strength (viscosity) of gel with whey proteins from different sources, a task that was impossible before. This new process expands the use of milk proteins and minimizes variations in quality and functionality. The dairy industry is using this knowledge to improve the quality and constancy of their products **(Wyndmoor, PA).**

Cereals, Oilseeds, and Novel Crops:

Performance standards developed for guayule latex. Commercial applications of guayule latex require it to meet performance specifications for physical and chemical properties. In partnership with the industrial producer of guayule latex, a new ASTM specification requiring low protein content (<200ug/g rubber) and absence of *Hevea* antigenic proteins (ELISA n.d.) was developed. Meeting these specifications help ensure medical products made from guayule latex are safe for people with Type I IgE-mediated *Hevea* latex allergies. CRADA supported research demonstrated that guayule natural rubber latex, in early commercial production by the USDA licensee, is consistently of high molecular weight, consistently of low total protein content in the latex, relative to *Hevea* latex, and demonstrates remarkable consistency in particle size and size distribution. In 2006, twenty-three lots of commercially produced guayule latex met all 11 ASTM chemical and physical property specifications for Category 4 Latex **(Albany, CA).**

Improved functionality of guayule latex. Low protein guayule latex lacks high levels of nitrogen known to accelerate rubber crosslinking (curing) in *Hevea* rubber compounds. Under equivalent formulations and test conditions, the cure rate and cure state of guayule latex natural rubber in a model glove formulation was found to be lower than that of *Hevea* natural rubber and comparable to synthetic polyisoprene. However, formulations designed to accelerate cure were developed, and successfully demonstrated crosslink density for guayule rubber equivalent to that typically found in *Hevea* latex formulations **(Albany, CA).**

Health benefits of soluble dietary fibers. Overweight and obesity are epidemic in the U.S. and often precursors to diabetes, hypertension, and cardiovascular disease. While it is known that weight loss can rapidly improve biomarkers of metabolic disease, consumers find it difficult to

decrease caloric intake and/or exercise. ARS researchers demonstrated that in spite of high fat and high caloric intake, test animals fed soluble dietary fibers have reduced plasma cholesterol, glucose, insulin, blood pressure and do not become insulin resistant. Increased excretion of fats and their components suggest that soluble dietary fibers may inhibit fat digestion and/or the rate of fat absorption thus decreasing caloric intake and stress on the liver and other organs to properly metabolize fat. Three patent applications have been filed in support of a 4-year CRADA project with a large chemical company related to this topic **(Albany, CA).**

Slowly digestible starches. The concept for slowly digestible starches was pioneered and processes were developed for producing slowly digestible rice products. The first process was accomplished by cooking, debranching and cooling starch under optimum conditions. The second process used heat moisture treatments and the third process utilized amylose-lipid complexes. This research was the basis of CRADA's with two companies for the development of slowly digestible starch products. In addition, these technologies were adapted by another company that is currently marketing a diabetic product based on the work. After the publication of results, several patents have been filed around the world which use these technologies in some form or other. This work also triggered research on breeding crops for slowly digestible starch **(New Orleans, LA).**

Genes cloned in industrial oils biosynthetic pathway. The bottleneck to efficient production of value-added industrial oils by plants reflects the fact that many of the enzymes present in traditional oilseed crops do not efficiently use the novel oil intermediates. ARS scientists focused on the engineering of the complete enzyme system needed to produce tung oil (a model industrial oil) in yeast cells or traditional oilseed crops. A significant accomplishment was the cloning of five genes that are required for the initial synthesis of eleostearic acid, the primary fatty acid found in tung oil. The key enzymes in this part of the pathway are members of a class of enzymes known as fatty acid desaturases (FADs). The ARS scientists on this project are collaborators in the EPOBIO United States/European Community Oilseed Flagship Project, which is an international network of scientists focused on the production of industrially important oils in seeds. A grant was recently funded in Europe for 4 years at approximately 10 million USD per year. Thus, current and future activities of this project will benefit greatly from the progress of and further collaborations with the US-EC Oilseed Project **(New Orleans, LA).**

Development of novel environmentally safe agricultural fungicides is crucial for the continued protection of food and feed. ARS scientists showed that certain naturally occurring insect and plant proteins were potent fungicides against phytopathogenic and toxigenic *Aspergillus* and *Fusarium* species. They discovered and patented CAY-1, a potent fungicide in cayenne pepper. An NIH SBIR Phase 1 grant (2003) was awarded MycoLogics, Inc. (Aurora, CO) to further study its fungicidal and mammalian cytotoxic properties. This study showed that CAY-1 was also active *in vitro* against human pathogenic fungi but not toxic to 55 mammalian

cell lines at fungicidal levels. Brodex, S.A., (Spain) found CAY-1 prevented citrus rot caused by *Penicillium* spp., and superior to Imazalil, currently used to prevent *Penicillium* rot.

ARS colleagues have shown CAY-1 lethal to mosquito larvae. At NIH, CAY-1 was also shown effective, *in vitro*, against dermatophytic fungal pathogens of immuno-compromised patients. Animal testing at NIH is planned. Researchers at Children's Hospital (New Orleans) are currently studying CAY-1 for activity against *Candida* and *Cryptococcus* (human pathogens) and CAY-1 interaction with *Candida* cell walls (wild type and mutants).
Researchers have shown CAY-1 effective, *in vitro,* against fungi, including the grape pathogen, *Greeneria uvicola* (causative agent of bitter rot), isolated from diseased grapes. As requested by Dr. Jon Takemoto, (Dept. of Biology, Utah State University), ARS is currently testing syringomycin-E, a potent bacterial fungicide, against these grape fungal isolates. Finally, ARS has partially completed experiments showing certain volatile compounds present in healthy soybeans are highly lethal to *Aspergillus* and *Fusarium* conidia **(New Orleans, LA).**

Soy-based fillers effective reinforcer in rubber products. For practical applications (tires, seals, dampers, etc), carbon black derived from petroleum or natural gas is the dominating filler used to reinforce crosslinked rubber materials. ARS scientists found that some renewable materials such as dry soy protein and carbohydrates are rigid and can be used as rubber reinforcements. Soy products including soy protein isolate, defatted soy flour, soy protein concentrate, and soy spent flakes were incorporated into rubber latex to form composites that showed substantial reinforcement effects as measured by rheological and mechanical methods. The technology was repeated and a processing method developed by a collaborator (Bridgestone) whose results indicated defatted soy flour enhances rubber modulus. Other collaborations are in place with Goodyear and Michelin. The new information on the structure-property relationship of these composites indicates a cost-effective use of agricultural materials to improve mechanical properties of elastomers **(Peoria, IL).**

Structurally strong polymers from soybean oil. ARS researchers prepared soybean oil based composites by cross-linking epoxidized soybean oil with a readily available epoxy resin and five different gelling agents. The cross linking structure was shown to be a key factor in the properties of the resulting product. The polymer has been shown to be ideal for use in the Solid Freeform Fabrication (SFF) method of making structures. The SFF method can make shapes without molds and opens the potential for a broad range of new applications, such as in automotive, construction, aircraft, and military industries. The combination of natural fibers with soybean oil produces composites that have the performance and price characteristics allowing them to compete with petrochemical alternatives. The project has led to a patent and CRADA with Advanced Ceramics Research, Inc. **(Peoria, IL).**

Improved production of lactic acid by Rhizopus. The fungus Rhizopus is frequently used to ferment sugars to lactic acid. This natural product has long been utilized by the food industry and has also found use in the manufacture of environmentally-friendly products, including biodegradable plastic, poly-lactic acid (PLA), and the chlorine-free solvent, ethyl lactate. In order to allow the market potential of lactic acid to continue expanding at a rapid pace, it is important that the production costs are minimized by the development of new and improved technologies. Techniques developed by ARS have allowed targeted genetic modification to increase yields of lactic acid and decrease production of unused by-products. This work resulted in two CRADA's with a major lactic acid producer and the licensing of ARS technology in 2003. The use of this technology in lactic acids production facilities could significantly decrease costs, thereby benefiting both the agricultural community and the consumer **(Peoria, IL).**

Low-glycemic sweetener from sugar and corn syrup. ARS scientists developed complex carbohydrates from sugar and corn syrup which are being used as low-glycemic sweeteners. The relevant ARS technology was licensed to the private sector, and the ingredients are now being nationally marketed in sports drinks and food for diabetics. The ARS/industry team which developed and commercialized the technology was recognized with an ARS technology transfer award in 2007 **(Peoria, IL).**

Methods for producing new cyclic tetrasaccharide. A new enzyme system was discovered by ARS scientists that makes cyclic sugar molecules. Technologies were developed to produce and assay the enzymes. A large Japanese firm used these technologies to discover an improved process for making the cyclic sugar directly from starch in a single step. The cyclic sugar is now being investigated as a fat-reducing agent in foods, and as an ingredient in several medical formulations. ARS owns the U.S. patent on this novel compound **(Peoria, IL).**

Fantesk: stable dispersions of starch and vegetable oil with multiple applications. Most surface active agents that are used to obtain stable dispersions of oil in water are expensive, toxic and non-biodegradable, which precludes their use for many applications. Researchers discovered that stable, oil/water dispersions having useful properties can be rapidly and economically prepared by passing mixtures of oil, water and starch through a steam jet cooker at high temperature and pressure. Jet cooking is a rapid, inexpensive method for preparing aqueous starch dispersions and is well established in the starch industry. Basic research has shown that coalescence of micrometer-sized oil droplets is inhibited by a thin layer of starch that forms around each oil droplet during jet cooking. Starch and vegetable oils (such as those derived from corn and soybeans) are produced annually in billion pound quantities. Conversion of vegetable oils and starch into new value-added starch/oil composites will benefit the American farmer by increasing the economic value of these agricultural commodities. The name Fantesk^{TM} has been given to these products, and patents covering these new compositions have been issued. The co-

jet cooking of starch and oil represents a new processing method, and is resulting in the development of new product technology.

Research under the Fantesk umbrella has led to the following spin-off technologies with many more potential applications: (1) Crystalline, micron-size particles of complexed amylose that are formed when starch is jet cooked in the presence of fatty acids. End use applications for these materials are currently being investigated. (2) Hydrophilic starch-based coatings that can be applied to water-repellant plastic surfaces (e.g., polyethylene) to make them more receptive to water-based dyes and inks and to eliminate the build-up of static electricity. The researchers have obtained U.S. patents on this technology, and research is continuing under a CRADA.

Starch-lipid composite technology has proven to be a powerful platform for new product development, and ongoing improvements and discoveries are expected to provide many new biobased applications in such areas as food safety, green chemistry, bioremediation and biocontrol, edible food packaging, anti-static coating, insecticide spray, nano-emulsions, etc. **(Peoria, IL).**

Estolide technology for biobased lubricants. ARS researchers developed estolide-based biobased lubricants using domestic crops. Estolides have excellent physical properties that exceed other biobased materials and their mineral oil counterparts in the marketplace. The structures of the estolides allow them to work in extreme temperature zones while remaining oxidatively stable. They also have outstanding lubricating ability which leads to less friction and wear. As a result, road tests have shown lower emission outputs and increased fuel economy. Lastly, the cost of producing estolides will make them very competitive against synthetic lubricants produced from imported petroleum. One license for the ARS estolide technology was granted in May 2007 with commercial products expected in the market soon **(Peoria, IL).**

Evaluation of industrial crops. To help reduce our dependence on foreign oils, ARS researchers evaluated a host of new industrial oilseed crops (cuphea, lesquerella, pennycress, milkweed, and coriander, as well as others) in broad-based collaborations with breeders, agronomists, etc. Cuphea has good potential for detergents where it will supply the main active component, lauric acid. Cuphea saw limited commercial production (1000 acres) in 2006. Pennycress is a winter annual that rotates with soybeans and can be used as a biodiesel feedstock. Pennycress's life cycle is predominately winter/spring and full season soybeans can be grown after its harvest; this will allow the U.S. farmer to produce fuel in the winter and food or feed in the summer **(Peoria, IL).**

Novel media for enzymatic modification of lipids discovered. Enzymatic transformation of commodity triglycerides and phospholipids by selective unsaturation or hydroxylation, can increase the value of these lipids. Such redox (oxidation/reduction)-based transformations are

not economically viable by conventional means. ARS researchers were the first to demonstrate that ionic liquids would support such enzymatic reactions and that enzymes could be coupled to modified electrodes for the purpose of directly supplying electrons to enzyme processes in ionic liquids **(Peoria, IL).**

Starch-based materials with controllable and tunable properties. ARS researchers developed novel responsive starch-based films which shrink with increases in relative humidity. They demonstrated that various types of starches and plasticizers could be used. It was shown that glycerol, a byproduct of biodiesel production, functions as well as urea as a plasticizer. Analysis of shrinkage results taken at different relative humidities showed that results for a range of starch-polymer-plasticizer combinations could be reduced to a single shrinkage-relative humidity curve. This analysis allows prediction and control of shrinkage properties based on composition, which is essential for developing new uses for starch-based biomaterials. Starch-based materials with controllable and tunable properties provide new opportunities for biobased materials derived from agricultural products. There is currently industrial interest in these films for a variety of applications **(Peoria, IL).**

Computer modeling of solvated carbohydrates. Various models of glucose (the structural building block of starch and cellulose) with water were simulated using state of the art computer methods. These structural studies of solvated carbohydrates are the first detailed examinations which describe how water changes conformational preferences, or shape, in amylose- and cellulose-like compounds. This work increases our fundamental knowledge of carbohydrate-water interactions, and provides the basis needed for improved understanding and utilization of carbohydrate-based biomaterials and feedstocks. These results have been rapidly accepted and are now routinely cited in publications by other computational chemists **(Peoria, IL).**

Thermoplastic starch-carbon black blends with up to 40% by weight carbon black were prepared by extrusion. Films were evaluated for their electrical conductivity and mechanical properties. Conductivity increased with increasing carbon black up to an optimum level after which it decreased. Strength and stiffness increased with increasing carbon black content while extensibility decreased. The materials retained their conductance values after 21 days of ageing. Strength and stiffness increased significantly with ageing time. These results demonstrate that starch-based materials with useful levels of conductivity and mechanical properties can be easily prepared using conventional processing methods. Several companies have expressed interest in these materials **(Peoria, IL).**

Rheological properties of peanut flours. Peanut flours are commercially available high-protein, low-fat functional food ingredients prepared from roasted, defatted peanut seed. Rheological properties of ingredients are critical to a formulated food's functionality; however, this data was lacking in the published literature for peanut flours. Accordingly, ARS

characterized some key rheological properties for aqueous dispersions of commercially available peanut flours. Viscoelastic changes of these dispersions upon heating were documented to be a function of roast intensity and residual oil content within the flours. This information suggests that a range of desirable textures can be imparted to formulated foods upon peanut flour addition. **(Raleigh, NC).**

Synthesis of long-chain dicarboxylic acids. Fatty acids common to fats and oils are sparingly used in the synthesis of polyester or polyamide polymers because of their limited reactive sites for further chemical reaction. To overcome this obstacle, researchers developed a catalytic approach to the direct production of diacids from common oils and fats such as soybean and rapeseed oils. The process is environmentally benign since the method does not require solvents or other reagents. The method uses a very small amount of catalyst to convert the vegetable oil- and animal fat-derived fatty acids into diacid products in high conversions and high yields. This process represents an effective and efficient route to the synthesis of these dicarboxylic acids, which are potentially useful intermediates for the production of biodegradable polyesters and polyamides. A CRADA for the expressed purpose for doing this was initiated with a major oleochemical supplier **(Wyndmoor, PA).**

Low/high caloric lipids. ARS scientists produced a series of structured lipids (SLs) as potential low-calorie fat substitutes by substituting short-chain fatty acids for the long-chain fatty acids common to hydrogenated vegetable oils. Both chemical and enzymatic approaches were used in synthesizing these novel lipid products and their physical and thermal properties were determined. The fat substitutes prepared using the enzymatic approach were found to have better melting profiles. High energy SLs contain both long-chain and medium-chain fatty acids within the same triglyceride molecule, since studies have shown that such SLs have clinical advantages over using simple triglyceride mixtures. Researchers in collaboration with university partners conceived new enzymatic routes to produce such SLs. During the course of the studies the researchers developed several rapid liquid chromatographic methods that easily detected and quantitatively determined the new lipid substitutes and supplements. The methods have since become seminal as evidenced by their incorporation into several books on analytical methods in lipid analyses **(Wyndmoor, PA).**

Identification of structure/function relationships in corn fiber gum. How a neutral polysaccharide like corn fiber gum could serve as an excellent emulsifier is a mystery, as most known emulsifiers contain either hydrophobic lipid or protein subcomponents. ARS researchers discovered that even highly purified corn fiber gum still contains measurable (but small) levels of phenolic acids, lipids and proteins. These functional groups were identified in corn fiber gum (CFG) and then isolated and chemically characterized. The results showed that these functional groups may be responsible for the emulsifying abilities of corn fiber gum. In addition, these phytochemicals are present in CFG in sufficient quantity that they may provide some

nutraceutical value. This research revealed information that elucidated new relationships between chemical structure and physical function. In addition, new functional compounds in agricultural products were identified and characterized. As a result of these pioneering studies, more than 15 major and small food, beverage, and food ingredients companies have expressed interest in CRADA's with the ARS researchers **(Wyndmoor, PA).**

Agricultural Fibers:

Chronic wound dressings. With the recent decline of the U.S. cotton textile industry the future use of domestic cotton in specialty textiles will be dependent on market growth in smart and interactive textiles, which have a projected growth rate of 36% by 2009. Medical and military textile sales, which are subsets of that rapidly growing market, will grow even faster. ARS researchers have developed medical and military textiles including, chronic wound dressings, decontamination wipes, hemostatic and antibacterial clothing, and bedsore prevention bed sheets. Development of a cotton-based chronic wound dressing has resulted in patenting, licensing, and FDA approval for use in chronic wound patients. The dressing is based on a technology that removes harmful proteases from the wound, and targets a patient population nationally of 5 million in addition to an international patient population. Bringing the chronic wound dressing from bench to bedside has served as a toehold to springboard the other medical and military cotton-based products that will come from both non-woven and textile fabrics developed by ARS, and representing high volume end uses **(New Orleans, LA).**

Problem Area 2b. New Uses for Agricultural By-products

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Granular activated carbons from agricultural by-products. Granular activated carbons made from coal are used commercially in wastewater treatment and environmental remediation to remove organics and chlorine from water. Metal cation contaminants, however, must be removed via relatively expensive methods such as precipitation or ion exchange. ARS researchers developed a method for conversion of low cost agricultural by-products (e.g., shells, hulls, stems, hard wood, etc.) to granular activated carbon via a steam, carbon dioxide, or phosphoric acid activation method at elevated temperature. The effectiveness of these materials to adsorb cations was tested with copper ions and other metals. The adsorption capacity of the carbons exceeded or matched the commercial alternatives. The processes were patented and technology transferred via CRADA's with industrial partners for treatment of drinking water; for treatment of waste water; and for use as analytical adsorbents **(New Orleans, LA).**

New use for orange peel in commercial pectin production. Using new rapid extraction methods, ARS scientists enabled the production of food grade pectin from orange peel with comparable quality to commercial pectins. Previously, food grade pectin was produced from lemon and lime peel. A CRADA was developed with the world's largest pectin producer, based in the U.S., and the industry adopted orange peel as a new source of food grade pectin. The economic impact for the industry was considerable as two new pectin manufacturing plants opened in Brazil utilizing orange peel exclusively. While no domestic commercial pectin production currently exists, it is anticipated that as new rapid pectin extraction methods develop, it will be possible to convert the millions of tons of U.S. orange peel produced annually into higher value pectin-based products instead of their current use as low value cattle feed **(Wyndmoor, PA).**

Animal Products:

Value-added adsorbent product from manure. About 350 million pounds of animal manure is produced in the U.S. every year. ARS researchers created a novel value-added adsorbent product from manure in the form of granular activated carbon, which can be used to remove metal cations and organics from waste water and air. The process is best described as a pyrolysis process in which the material is heated under a controlled atmosphere to create either activated or not-activated carbons. The best results have been obtained from the use of turkey or broiler (chicken) manure. In addition to being low cost, the manure-based carbons are superior to commercial activated carbons and can help alleviate the environmental problems associated with manure disposal. Three patent applications are under review and several companies have signed confidentiality agreements to further investigate the potential of the technology **(New Orleans, LA).**

Natural proteinaceous fillers for leather. To make leather uniform, tanners typically fill the hide with petroleum-derived materials. In response to increasing demand for biobased products, ARS researchers demonstrated that gelatin (a byproduct of leather production) when enzymatically crosslinked with sodium caseinate, ovalbumin, or whey (low cost byproducts of the food industry) produced biopolymers with unique properties. These mixed polymerized proteins, when applied to partially processed hides, were evenly distributed throughout the hide; more importantly, they were not removed by washing. As a result, the subjective properties of the leather were improved. Thus, value is added to waste products from multiple agricultural sources by making products that have potential use in the leather-making process. A work plan with a commercial partner for further development of biobased fillers for leather is under preparation **(Wyndmoor, PA).**

Alternative feedstocks for ester production. A major obstacle that impedes the wider use of fatty esters is the cost of the fat or oil feedstock from which they are produced. One way to overcome this problem is to use lower cost feedstocks to make the esters. Animal fats and rendered fats such as yellow and brown greases are lower-cost feedstocks and hence are attractive candidates for producing oleochemical esters. The problem with these materials when using conventional technologies for making esters, however, is the high free fatty acid content of the greases. Researchers examined the use of lipases, both free and immobilized, as catalysts for the production of esters from oils, fats, and other rendered materials such as restaurant and brown greases. The progress demonstrated led to a collaborative study with a major enzyme supplier to employ their commercial lipases in construction of an immobilized enzyme bioreactor for ester production from high free fatty acid containing fats and oils. Because the bioreactor method produces less byproducts, it results in a higher purity ester **(Wyndmoor, PA).**

Cereals, Oilseeds, and Novel Crops:

Ion exchange materials from plant by-products. Ion exchange materials are used commercially to remove positive ions (e.g., cadmium, zinc, nickel, mercury, and lead) in wastewater application or metals recovery. These materials are often expensive and there is a need to develop alternatives. ARS researchers developed a process by which plant by-products (from flax, cotton, soy, sugarcane, etc.) were converted to an inexpensive ion exchange material via a reaction with citric acid. Effectiveness was evaluated by metal ion adsorption studies in batch and continuous experiments, and production costs for the new material were also estimated. The technology was transferred via CRADA to a partner who developed a product, BioSorb 100, for removal of toxic metals from waste water. The technology was then transferred from that partner to another concern for manufacturing and marketing. ARS also used the technology to create filter mats made from flax and cotton by-products that are currently evaluated by another cooperator **(New Orleans, LA).**

Phytochemicals in oilseed residues. Scientists identified and quantitated chemical components in residual seed meal left over after the extraction of oil and/or other valuable components. The byproducts from corn, milkweed, field pennycress, sicklepod, and a number of crucifer species have been shown to have biocontrol activity against weeds. Both the biofumigant activity of glucosinolates in crucifer species and the herbicidal activity of vegetable oil biodiesels have been demonstrated. Postemergence contact herbicidal activities of biodiesels from several oilseed sources were examined for potential use to control broadleaf weeds in turfgrasses. These results indicate that biodiesels may be useful as environmentally friendly contact herbicides in turfgrasses, as there are few contact herbicides options available for the homeowner market which will not cause turf injury **(Peoria, IL).**

Fermentation of biomass derived sugars to produce lactic acid. Global lactic acid production exceeds 130,000 metric tons per year and demand is expected to increase to meet expanded use of lactate as a feedstock for polymers and solvents. Market growth for lactate as an industrial chemical will be very sensitive to its selling price. Glucose is currently used as the feedstock for production of lactic acid by fermentation. Lignocellulosic agricultural biomass might offer a less expensive feedstock than glucose for producing lactic acid. However, conversion of lignocellulosic biomass to lactic acid is problematic because sugars prepared from them are a mixture composed primarily of glucose and xylose. Xylose is a pentose that is not fermented by most lactic acid bacteria, including commercial strains. A series of recombinant *Escherichia coli* strains were developed that ferment sugar mixtures and selectively produce L-lactic acid. Three of these recombinant strains were further engineered so that they had the ability to simultaneously ferment glucose and xylose. The best of these strains produced lactic acid in high yields in fermentations containing mixtures of glucose and xylose. The research contributes to the development of a cost-effective biobased method for production of lactic acid from agricultural biomass feedstocks **(Peoria, IL).**

Development of novel methods for production of enzymes. The transformation of low-value plant residues and by-products into valuable commodities is economically constrained largely due to the costs and technical problems associated with biomass saccharification. Development of more efficient methods to produce enzymes used in this process is a crucial step in overcoming these technological hurdles. ARS researchers developed several novel methods to express enzymes of industrial interest in fungal and plant systems. Much of this research includes the development of molecular engineering techniques to finally allow expression of desired proteins in the fungus Rhizopus, which is currently accepted as an industrially robust organism. This work resulted in a CRADA with a major biotechnology company and numerous academic collaborations. The impact of this work could be a significant benefit to numerous markets relying on conventional methods of enzyme production **(Peoria, IL).**

Improved soy meal plywood glue recipes using ground soy meal have been developed by ARS scientists that deliver improved plywood glue formulations. The results from this research will result in increased usage of soy protein-based glues by removing viscosity related problems in the plywood production industry. This technology is currently used in commercial production of plywood by an industrial cooperator **(Peoria, IL).**

Gycerol, soy molasses and other coproducts in the production of bioproducts. Commercial success of microbial bioproducts such as polyhydroxyalkanoate (PHA) bioplastics and sophorolipid biosurfactants depends heavily on the total production costs. Since feedstock cost is one of the most important factors in determining the total cost of fermentative production of bioproducts, there is a high interest in developing various inexpensive coproduct streams and byproducts of industrial processes into fermentation feedstocks. At the same time, the recent

increase in biodiesel production has resulted in a glut of glycerol supply - a coproduct of the commercial biodiesel production process. Similarly, strong demand in the food sector for soy protein isolates and concentrates has brought about a surplus of soy molasses. There is thus an urgent need to develop new uses for these coproducts. ARS researchers have uniquely linked the two needs by devising bioprocesses that utilize crude glycerol from biodiesel production and soy molasses to produce PHA and sophorolipids. The outcome of this research is expected to lower the costs of these microbial bioproducts and to valorize the low-value industrial coproducts. This ARS technology is the subject of a patent application and part of a CRADA with an industrial partner. Many inquiries from domestic and overseas private and public institutions have been received. Invitations to present talks in international conferences and to write a review paper, magazine articles and book chapters ensued. This ARS research was highlighted in several reports in scientific journals on the current trends of coproduct utilization **(Wyndmoor, PA).**

Agricultural Fibers:

Cotton-based hydromulch. Approximately 2.5 million tons of gin waste (byproducts) are produced across the Cottonbelt of the United States each year. The waste creates a financial liability to the cotton gin and producer. Research was conducted to develop processes and evaluate several target products that could economically transform the cotton gin byproducts into usable products; thereby creating an additional revenue stream for the ginners and producers. One of the most successful products developed in this research was a value-added process to turn cotton gin byproducts into a high performance hydromulch for the 'green' industry. The process was developed, tested, and refined. The technology was transferred to industry. The transfer of this technology resulted in the first commercial cotton-based hydromulch. The hydromulch is now being offered by nearly 70 distributors worldwide. The current cotton-based hydromulch products are selling in the range of $10 to $40 per bag ($200 to $800 per ton). The value-added processes resulted in a revenue stream where a financial liability once existed **(Lubbock, TX).**

Problem Area 2c. New and Improved Processes and Feedstocks.

Fruits, Vegetables, Tree Nuts, and Sugar Crops:

Infrared dry blanching technology. New efficient processes for blanching fruits and vegetables are needed to expand markets and add value to these healthy foods. A novel infrared dry blanching technology that does not require addition of steam or water in the blanching process was invented by ARS researchers. A patent was filed and a license is being negotiated to

produce many kinds of value-added, fruit and vegetable products in an energy-efficient manner which preserves the nutrition and quality of the final products. One CRADA is currently active to further explore this technology and the research is supported by the California Energy Commission **(Albany, CA).**

Sequential infrared freeze drying produces high quality dried fruit and vegetable products. New energy efficient processes for drying fruits and vegetables and their co-products are needed to increase consumption of these healthy foods. In addition new drying technologies support cost effective production of shelf-stable processed foods in the U.S., enhancing the ability of American agriculture to compete in the global marketplace. ARS researchers, in collaboration with a CRADA partner, developed and patented a new technology to efficiently process high quality dried fruit and vegetable products. The technology is called sequential infrared freeze drying and has been applied to strawberries, blueberries, bananas and other fruits. Final product quality is equal if not better than traditional freeze dried fruits and the energy use is significantly reduced resulting in significant cost savings. The products are being tested by a large commercial cereal manufacturer and the patent license is being negotiated **(Albany, CA).**

Continuous microwave sterilization and aseptic packaging of sweetpotato puree. ARS scientists developed a novel process to sterilize and aseptically package vegetable puree using a continuous-flow, microwave heating system. Further studies are in progress to validate the process for microbial safety, as well as to expand its application to other fruit and vegetable purees. This technology provides a new process to convert sweetpotatoes and other highly nutritious fruits and vegetables into shelf-stable functional ingredients suitable for use in a variety of formulated food products. Expansion of the market for sweetpotato puree would provide farmers with a market for 40% of the sweetpotato crop, which currently is left in the field because of small size or poor shape that makes them unsuitable for sale. Both national and international patent applications have been filed. The technology has been licensed and a processing plant is under construction to use this technology for production of shelf-stable sweetpotato puree **(Raleigh, NC).**

Ethanol and limonene from citrus residue. A process to liquefy and convert the sugars and cellulose present in citrus residue to contain ethanol at the 4-5% level was developed and scaled at large pilot plant. The process removes and recovers the limonene as a valuable co-product and enzyme costs for the process have been reduced to less than $1.00 for each gallon of ethanol produced and the process looks to be economical with production of limonene as a co-product. The research was done with a CRADA partner and 3 patent applications have been filed with joint ownership between USDA and the CRADA partner. The CRADA partner has expressed an interest in pursuing exclusive licensing of the technology **(Winter Haven, FL).**

Flash extraction of pectin from citrus peel and sugar beet pulp. ARS scientists developed new and improved methods for the rapid extraction of pectin that reduced heating time from an hour or more to single minutes. The process was patented, scaled-up, a provisional patent filed, and a continuous method developed. As judged by its physical properties, the flash extraction methods produced food grade pectin from orange peel of comparable quality to commercial pectin, as well as producing high quality sugar beet pectin. A large pharmaceutical company patented the use of orange peel flash-extracted pectin in vitamin C tablets that had improved hardness (less breakage) compared to tablets formulated with conventional pectin. It is projected from its physical properties that flash-extracted sugarbeet pectin will have excellent emulsifying properties in processed foods. Adoption of this technology has potential to be more cost effective and environmentally benign compared to traditional processes **(Wyndmoor, PA).**

Animal Products:

Films made from agricultural materials have the potential to replace petrochemical –based films in food and nonfood applications; however, most protein films dissolve readily in water which limits their use. Films made from CO_2-casein derived from milk using the patented process developed by ARS engineers, yielded a product that is sparingly soluble in water and is much less permeable to water than films made from the milk product, calcium caseinate. It was shown that CO_2-casein film is a more effective moisture barrier for food use than calcium caseinate film, a film made from milk protein using acid precipitation. The CO_2-casein film is also an excellent oxygen barrier and may replace synthetic materials in timed-release applications. Because of the many requests for samples of the films, a new process was developed for continuous production of protein-based films and a patent was filed. This is the first new technology that provides the ability to manufacture films from an agricultural protein. Several Material Transfer Agreements have been filed and ARS researchers are working with industry collaborators to modify the films for various food and nonfood applications **(Wyndmoor, PA).**

Rapid oxidative dehairing in the abattoir. Hair removal is one of the first steps of converting a hide into leather. It is traditionally achieved using toxic sodium sulfide. Sulfide-induced rapid dehairing of whole carcasses in a meat packing plant, primarily as part of a pathogen reduction program, was developed under a CRADA. ARS researchers subsequently developed an effective new system that uses alkaline hydrogen peroxide assisted by potassium cyanate. Hide quality was uncompromised. The new system was integrated into a CRADA for evaluating several carcass treatments for pathogen reduction. All approaches were effective. This investigation will benefit the meat packing industry by producing hides that are free of hair, attached manure, and dirt; hair-free hides, in turn, allow quality inspection and early-stage hide splitting (which

has the potential for savings in the amount of processing chemicals and processing time downstream in the tanneries) **(Wyndmoor, PA).**

Biopolished, shrink-resistant wool. Consumer and military acceptance of domestic wool in garments and upholstery is limited, in part, because of skin irritation (prickle) and a tendency for wool to shrink when laundered. Traditional methods alleviating these problems use chemicals of environmental concern. ARS researchers developed, patented, and licensed a benign alternative, a combined oxidative and enzymatic process that achieves simultaneous bleaching, biopolishing, and shrinkage control of wool fabrics. The success of this work will enable producers of domestic woolen textiles to satisfy the desire of the consumer and the uniformed services for comfortable garments made of natural fibers and processed in an environmentally benign way. The first license for the ARS technology was granted in August 2007 **(Wyndmoor, PA).**

Extruded cheese whey proteins. Changing the structures of whey proteins on the molecular level can enhance utilization of dairy components in extruded products, such as snack foods. The potential use of extruded cheese whey proteins as new ingredients was realized through an improved process developed using a twin-screw extruder. Globular whey proteins were sheared, denatured and stretched in the extruder resulting in a new ingredient, texturized whey proteins. Using this new texturization process, whey proteins were modified making them doughy, expandable and stretchable. The texturization process improves whey protein digestibility, foaming and gelling properties, and facilitates expansion of food products extruded. A manufacturer who licensed the technology from ARS has demonstrated the use of texturized whey proteins to boost the protein content of different products. The licensee of this technology expects worldwide sales of this product to exceed $50 million in the next 5 years. The ARS/industry team which developed and commercialized the technology was recognized with an ARS technology transfer award in 2007 **(Wyndmoor, PA).**

Cereals, Oilseeds, and Novel Crops:

Food containers from wheat and corn starch. Single-use items, such as food wraps, utensils, plates and bowls, are typically made from petroleum-derived plastics, such as polystyrene. A wide array of food service items including plates, burger boxes, trays and wraps were derived from wheat and corn starch and commercialized with a CRADA partner. Commercial production continues under license at several packaging plants, with market penetration at retail outlets throughout the U.S. These new bioproducts enabled by ARS researchers significantly reduce costs for making the food service products and provide a new niche market for cereal starches and fibers **(Albany, CA).**

Starch foam microspheres as coatings. Starch foam microspheres and film coatings and envelopes were developed for delivery of volatile plant oils, such as 2-heptanone, that control parasitic mites in honeybees. Parasitic mites, specifically varroa mites, are threatening the honeybee industry which directly and indirectly accounts for $14 billion of agricultural products. The starch-based microspheres coated with benign, edible films were developed by ARS researchers, field-tested at the Hayden Bee Labs, AZ and are being commercialized by a CRADA partner. Preliminary field trials suggest that these films/foam composites could have a large impact on the honeybee industry by improving honey yields by as much as 20%, potentially preventing colony collapse **(Albany, CA).**

Biobased products for the home. ARS researchers, under a CRADA with Clorox, developed a wide array of patented innovations for the home products industry including; (1) biobased cleaning products, (2) new charcoal briquette formulations containing agricultural by-products, (3) odor-removing non-woven substrates, and (4) biodegradable cleaning substrates that are "flushable" and still effective at scrubbing. The use of eco-compatible plant polymers in cleaning products and charcoal will help create "greener", more economical products for Clorox. For example, the new charcoal formulations, marketed under the Kingsford brand, are projected to save Clorox up to $5 million this year. These materials also provide new markets for surplus crops, and reduce our Nation's carbon footprint **(Albany, CA).**

Packaging materials from straw and recycled fibers. With the ban on burning rice straw and other agricultural residues, packaging materials derived from straw and recycled fibers were developed by ARS researchers and commercialized by CRADA partner, Regale **(Albany, CA).**

New patented wheat separation process. Typical commercial wheat milling – separation of wheat gluten protein from starch – is very water- and energy-intensive, adding costs that negatively impact international competitiveness. A novel process that employs refrigerated ethanol as the separation fluid within a relatively standard milling operation was invented and shown to produce improved wheat protein. With the emergence of bioethanol refining from grains and the probable extension to wheat as a feedstock, the radically new methodology is finding industrial acceptance since it capitalizes on the ethanol available within a biorefinery operation, and only requires ethanol separation equipment already inherent in the biorefinery operation. Thus, the high-value ethanol produced acts, first as a water-saving solvent in the process and then is sold as a biofuel. In 2006 a grant with collaborating scientists was initiated to investigate modifications of the method and in 2007 this work was the basis of a CRADA to explore biorefinery operation in places where water is not readily available. Gluten produced by the cold ethanol method was more effective in flour fortification than commercially available gluten produced by standard aqueous methods **(Albany, CA).**

Commercial production of guayule latex, from crops grown in the United States, was achieved in 2006, following successful pilot plant and production level implementation of a process design based on USDA-licensed patents. ARS provided assistance to a CRADA partner in equipment selection and optimization for the first pilot bioprocessing plant, demonstrated and implemented alternative solvents for a green aqueous latex extraction process, and optimized the process through analysis of shrub, latex production, resin co-product, and waste streams. Annual production of 800,000 pounds rubber was achieved in 2006; the industrial partner plans to break ground on a 10-fold larger production plant in 2008. The team leading and implementing this success was nominated for a 2007 Technology Transfer Award **(Albany, CA).**

Pure rice starch and functional protein. An environmentally-acceptable, cost-effective, rapid technology was invented for separating rice starch and protein by high pressure treatment with water. This process yields pure rice starch with high recovery, as in conventional processes, but with the added benefit of a value-added protein. Since the protein is not treated with peptide bond-breaking agents, it has better flavor and functional properties than that produced by alkali processes and is suitable for human consumption. Commercialization was pursued with a CRADA partner through Phase I and II Small Business Innovative Research (SBIR) grants. Under the Phase II SBIR grant, the full process was scaled-up in a test facility in 2004. A patent was issued and the CRADA partner was granted an exclusive license. The licensee is currently developing collaboration with an ingredients company to set up a manufacturing facility in the U.S. This technology will re-establish a rice starch industry in the U.S. and reduce the $40 million of imported starch **(New Orleans, LA).**

Quick-cooking brown and wild rice. A novel process was invented for significantly increasing the rate of hydration of food crop seeds without loss of the nutrients in the bran layers of the seed. In this process, the seed of interest is bombarded with parboiled rice flour at a force sufficient to create microperforations in the water resistant outer coat of the seed. This significantly increases the rate of hydration of the seed and hence, in the case of brown and wild rice decreases cooking time up to 66%. The process reduces the cost of producing quick-cooking brown and wild rice products and does not have the environmental issues associated with water usage in conventional processes. A patent was issued. A licensee of the technology designed and built a continuous system for production of the products by another licensee. Additional companies have recently shown interest in the technology **(New Orleans, LA).**

Enhanced phytase. Plants sequester most of their phosphorus as phytic acid. The increased utilization of soybean meal and other plant meals in swine and poultry feed has created a need for a more effective phytase. Both swine and poultry lack an effective digestive phytase to hydrolyze this anti-nutrient and free up the phosphate for their nutritional needs. ARS researchers, in collaboration with Cornell University scientists, engineered an enhanced phytase with 266% greater hydrolysis of soy phytate and increased thermostability. Feed trials have

established that the new phytase has significantly higher activity in animals than a currently marketed phytase. Since the molecular modifications are made on a commercially produced phytase, which was previously isolated and first characterized by ARS, no new production fermentation regime or facilities are required to make this technology available to the public **(New Orleans, LA).**

Healthy food ingredients from grains. Aging diseases and obesity are now costing the U.S. about $100 billion per year for medical treatment and lost wages. Further, poor eating habits are known to be related to many aging and health-related problems, including heart disease, diabetes, and obesity. Generating new healthy grain products will improve American diets by reducing calories and increasing dietary fibers. ARS researchers generated new calorie replacement technologies with health contributing attributes, using cereal grains and their by-products. Four products, called the Trim technologies, were invented, patented, and licensed to industrial organizations and are having a large impact on preventing aging diseases and other chronic diseases and are creating new jobs and new markets for grain.

The four Trim technologies developed were: Oatrim, Z-Trim, Nutrim, and Calorie-Trim (also called Control-Trim). All Trim technologies have been licensed resulting in manufacturing plant constructions. Oatrim technology was the first technology transferred to three large companies for wide use in consumer foods. Later, Nutrim technology was exclusively licensed and it too achieved a remarkable expanding market requiring plant expansions. More recently, a cellulosic biopolymer, called Z-Trim (prepared from agricultural by-products) was licensed to FiberGel Technologies (now Z-Trim Holding Inc). The impact has been the commercialization of the Z-Trim product with the construction of manufacturing plants.

During the past 2 years, a fourth TRIM product, Calorie-Trim (also called Control-Trim) was developed and licensed. The Calorie-Trim product was found to provide beneficial properties to chocolate by replacing cocoa butter with the Trim product. The Calorie-Trim decreased the chocolate fat content and added a soluble fiber substance known as beta-glucan that confer cholesterol lowering properties. The new Trim also reduces the trans fat take-up by batters used for frying foods. All these Trim technologies have created industrial products that have achieved sizable markets and which are making substantial health improvements in the American diet **(Peoria, IL).**

Soy based industrial fluids. The U.S. consumes more than 2.5 billion gallons of lubricants and industrial fluids per year, of which more than 95% are petroleum-based. ARS researchers developed soy based lubricant formulations which are now being used as hydraulic oils and metalworking fluids. In order to meet performance requirements the inherently poor oxidative stability and low temperature properties of soybean oil was overcome through chemical modification, use of additives and diluents. Efforts to understand the chemical structure of

soybean oil, and how it affects lubricity, were modeled and the results were used to enhance soybean oil properties. Using green technology, scientists made high performance lubricants, hydraulic fluids and greases. The scientists also studied the biodegradability of the compounds, an important consideration in environmentally sensitive areas. The project generated two U.S. patents, and two additional patent applications are under review. In a CRADA agreement, Alcoa successfully tested 150 gallons of USDA's soy oil based metalworking fluid in their pilot plants at Reno, NV, and Lancaster, PA. The USDA's bio-based lubricant outperformed the petroleum-based lubricant in all areas, and is considered a very attractive alternative for use in their plants. Larger scale trials are underway. Further CRADA partners which have received and are testing soy based lubricants are Caterpillar Corp. and Anderson Development Company. Another example is the soy oil based elevator hydraulic fluid technology which was developed based on a request from the National Park Service (Statue of Liberty, Ellis Island, NY). The soy based hydraulic fluid has been used successfully in the Statue of Liberty's elevator for nearly 5 years. Based on this technology development activity, the ARS team has been awarded the Federal Laboratory Consortium 2004 award for "Excellence in Technology Transfer." The hydraulic elevator fluid technology has been transferred to Agrilube Inc., OH **(Peoria, IL).**

New skincare products from vegetable oil. **N**ew high value applications for commodity oilseed crops can raise their value for the American farmer and agribusiness. Researchers examined biocatalytic technologies to modify vegetable oil to produce new and high-value products with enhanced cosmeceutical and nutritional attributes. Isolated enzymes were used to catalyze the transformation of vegetable oils without additional solvents, avoiding environmental concerns. Project researchers developed and patented novel glycerides incorporating a biobased UVA/B-absorbing moiety (ferulic acid). iSoyTechnologies Incorporated licensed this platform technology to create a range of new consumer products in collaboration with project scientists working under the auspices of a CRADA with the Biotechnology Research and Development Corp. Initial products came to retail shelves in 2007 (the Peter Thomas Roth line of skincare products). Many of the largest personal-care product companies in the world are currently evaluating the use of these materials in their offerings, working with project scientists to craft materials with properties selected to meet specific needs **(Peoria, IL).**

Commercial applications of Fantesk starch-oil dispersions. The food industry has recognized the ability of Fantesk™ (a uniquely stable jet cooked starch-oil dispersion) to deliver oil-soluble flavors and to improve sensory properties of low-fat foods. ARS researchers carried out food applications research under CRADAs with three different food companies which hold licenses. One of these partners is test marketing low-fat meat products containing Fantesk™ to improve tenderness, flavor and juiciness. Target markets include the USDA school lunch program, as well as other institutional and national scope markets. A large scale manufacturing facility is in place to provide needed production capacity.

Another company holds a license to Fantesk™ for use in seed coating formulations. The wax and rosin used as the lipid components in these Fantesk™ products slow imbibition of water to the seed, protecting the seeds from excess moisture when planting is carried out in early spring when soil temperatures are too low for rapid germination.

Researchers worked with two companies under CRADA's to investigate the use of Fantesk™ products as water-based lubricants for oil well drilling and for food-related applications (e,g., spray-on lubricants for waffle irons). A company has licensed Fantesk™ for this second area of application. Tests have also shown that Fantesk™ formulations can be used as spray-on lubricants for metal-forming applications.

A company has licensed the Fantesk™ technology for the preparation of skin creams and lotions and for the application of pharmaceuticals and other active agents to the skin surface. Fantesk™-based antibacterial lotions for use by food service, medical, and law enforcement personnel are currently being test marketed. These lotions retain their antibacterial properties even after several hand washings. A production facility has been set up in Peoria, IL to produce these lotions and other products. A Fantesk™-based aqueous sunscreen was developed by jet cooking starch with SoyScreen™, a natural product made from soybean oil and ferulic acid that was developed and patented by ARS scientists. The Fantesk™-based delivery system for this sunscreen was the subject of a new patent application **(Peoria, IL).**

Corn-based sorbitol citrate polyesters as antiscalants. Polyacrylic acid (PAA) is a non-degradable, petroleum-based polymer which is used in large amounts for water treatment. Under a CRADA with Folia, Inc., ARS researchers prepared novel sorbitol citrate polyesters and copolymers of aspartic acid in a rapid and efficient manner using reactive extrusion. Like PAA, these water soluble, negatively charged biopolymers were shown to inhibit precipitation of hard water salts (such as calcium carbonate). Replacing a non-degradable, petroleum based polymer with biodegradable sorbitol citrate will reduce potential toxicity to people and the environment, reduce the need for imported petroleum, and create higher value products from corn. The novel biopolymers are being evaluated by several companies to prevent hard water deposits in detergents, oil drilling, etc. **(Peoria, IL).**

New hydrogenation methods for low *trans* fat oils. The growing awareness and concern over the levels of *trans* fats in foods has increased the demand for foods low in these compounds. The traditional methods used for the hydrogenation of fats and oils results in partially hydrogenated oils that are as much as 40% *trans* fat. ARS researchers developed two new methods for producing partially hydrogenated oils low in *trans* fat. The methods use "off the shelf" catalysts and are compatible with current industrial hydrogenation plants. The hardened oils produced by these methods are intended as blending stocks for the manufacture of shortenings and margarines which would be low enough in *trans* fat to be labeled "zero-trans."

The success and adoption of this technology would greatly reduce the level of *trans* fat in foods without the need for changes in the industrial methods of hydrogenation. A CRADA is in development with a major producer of hydrogenated fats **(Peoria, IL).**

Biobased process for producing mannitol. Industry is searching for a biobased process to produce mannitol (a low-calorie sugar alcohol widely used in foods, pharmaceuticals, medicines, and chemical industries) to replace the problematic low yield chemical process currently used. ARS researchers developed a fermentation process for production of mannitol from corn sugars using a lactic acid bacterium obtained from the ARS Culture Collection. The process has been scaled up to 30 liters, the purity of the product has been established, and the private sector partner in this project has obtained FDA approval of the process and the product. The new process offers an attractive alternative to the chemical production process and utilizes inexpensive corn-derived sugars and nutrients **(Peoria, IL).**

Esters of soy oil soapstock. Soapstock, a coproduct of edible oil refining, is a plentiful, inexpensive, but very underutilized source of lipid for potential conversion to oleochemicals. Researchers developed and patented an efficient route to convert soapstock into high-acid oils which are then esterified. Numerous inquires have been fielded regarding this technology. The first step, conversion to high-acid oil, was adopted commercially, resulting in the sale of greater than 20 million pounds of that product to date **(Wyndmoor, PA).**

Oxygenated vegetable oils as "green" plasticizers. Epoxidized vegetable oils (largely epoxidized soybean oil) account for about 15% of the approximately one billion pounds of the current domestic plasticizer market. Recent regulations, however, would ban a dominant petrochemical-derived plasticizer from most end uses. Epoxidized oils are an alternative to the latter material and hence are poised to attain a larger share of the plasticizer market. Fats and oils are traditionally converted to epoxy plasticizers with peracids under a costly and hazardous procedure that also degrades the epoxidized oil. Alternatively, peroxygenase enzymes also convert unsaturated fatty acids to epoxy deriviatives. Researchers isolated this enzyme from an inexpensive source, oat seeds (*Avena sativa*). The purified enzyme can use hydrogen peroxide as an oxidant for oxygenating unsaturated fatty acids. Polyunsaturated acids, such as linolenic acid, formed predominantly mono- and diepoxide. The purified enzyme was immobilized onto synthetic membranes and used to epoxidize unsaturated fats and oils to produce high levels of epoxidized materials. This new process provides a green method for producing plasticizers from oils and fats **(Wyndmoor, PA).**

Eco-friendly corn wet milling process. An enzymatic corn wet milling process that reduces or eliminates the need for sulfur dioxide (a hazardous processing agent) was successfully developed and patented by ARS scientists. This process uses proteases to treat the corn kernels prior to fractionation. In collaboration with commercial enzyme suppliers, the researchers also tested a

large number of proteases to identify an enzyme that could be available in sufficient quantities for commercial use. In order to minimize the amount of enzyme (the biggest hurdle to commercialization) the scientists optimized the milling process and the associated enzyme application steps, resulting in a 10 fold reduction in the amount of enzyme required to obtain starch yields equivalent to the conventional wet milling process. Process models of the process were developed and show additional reductions in enzyme requirements when applied to a continuous commercial operation. These reductions make the wide scale adoption of this new environmentally friendly process one step closer to meeting the stringent requirements of the corn refining industry.

A commercial plant trial of the enzymatic wet milling process was conducted at a 200 metric ton per day facility in Malaysia by ARS researchers in cooperation with researchers from the University of Illinois under a Specific Cooperative Agreement. Previous trials had been done in small batch operations and could not be used to demonstrate the effectiveness using a continuous system. Modifications were made and a series of conventional runs were conducted prior to switching the facility to run using the enzymatic process. Five separate enzymatic runs were conducted and yields and coproducts collected for analysis from the conventional and enzymatic runs. Starch yields were found to be significantly higher using the enzymatic process when compared to the conventional starch yields and coproducts were not found to be significantly different in composition. This successful demonstration will allow other wet milling facilities to better evaluate the enzymatic wet milling technology and determine the economic advantages relative to the current process. The patented process has now been licensed by a major enzyme manufacturer who is working with the ARS researchers to conduct additional commercial trials. **(Wyndmoor, PA).**

World's first publicly available corn wet milling process and cost model. Researchers working on advanced corn wet-milling research had no validated and publicly available wet mill process and cost model with which to understand the operations of current wet mills and to understand how proposed changes in technology might affect the existing process. ARS researchers developed a process and cost model, using data gleaned from public information and industry contacts. The model has now been validated by most of the major wet millers in the U.S., including ADM, Tate and Lyle, Cargill, and Penford. These models were originally created in Aspen+® computer simulation software and Microsoft Excel® spreadsheets, but have been updated and transferred to a more user friendly model using Super ProDesigner® software and can now be used by a broader range of people. This model has been of exceptional value to the ARS Research Unit's Enzymatic Milling Program which developed an enzymatic process to replace toxic sulfites from wet milling. The model will also be of major value to researchers over the world doing work in this area. The model is regularly updated and available upon request. Over one hundred copies have been distributed to industry, academia and other government agencies **(Wyndmoor, PA).**

High phytosterol corn fiber oil. During the wet milling of corn kernels, the major product is starch, but the corn kernel is also fractionated to produce corn germ (the embryo) and corn fiber (non-digestible cell-wall polysaccharides). In turn, commercial corn oil is produced by pressing and/or hexane extraction of corn germ. ARS scientists developed a process to produce an oil by extracting corn fiber with hexane (or supercritical carbon dioxide). They discovered that the composition of corn fiber oil was very unique and it contained very high levels of phytosterols (plant sterols). Phytosterols have recently received much attention because they have been shown to lower LDL ("bad") serum cholesterol when they are consumed in the diet. There has been a tremendous amount of interest in this corn fiber oil technology. The corn fiber oil patent was licensed by Monsanto and then MBI, Inc, but both encountered obstacles during development, primarily, competition from manufacturers of phytosterols from cheaper sources. However, the work on this project, documented by numerous groundbreaking peer-reviewed publications, spawned major projects by the leading U.S. corn refiners, who are now developing improved ways to recover phytosterols from corn fiber. The ARS work on corn fiber oil and its unique functional lipid components led to the development of corn kernel oil (the combination of corn germ oil and corn fiber oil) which contains relatively high levels of lutein and zeaxanthin, which are thought to be important for eye health, and for slowing the progression of age-related macular degeneration. Production of whole kernel oil is currently being considered as a potential new product by a Midwestern corn processor **(Wyndmoor, PA)**.

Corn fiber gum. ARS scientists developed a simple, inexpensive process to produce a food-grade gum (arabinoxylan polysaccharide) from corn fiber. They determined the structure of the polysaccharide and isolated it from a number of different byproducts from the corn wet milling industry. They also characterized its molecular weight, viscosity, and other physical properties. Through a CRADA with a major food ingredients company, they developed additional methods to isolate and purify corn fiber gum and lower the cost of production. The patent on this technology is co-owned by ARS and the cooperator, National Starch and Chemical Company **(Wyndmoor, PA)**.

Agricultural Fibers:

Development of enzyme-retting methods for flax. Retting (i.e., separation of fiber from non-fiber components in flax) is required in the initial processing step to obtain commercial fibers for textiles and composites, but current methods do not produce high and consistent quality fibers. ARS research resulted in protocols with specific enzymes and additives that produced high and consistent quality fibers from a variety of flax types (fiber and linseed types) and tailored properties that could apply to particular industries. Research showed that enzyme-retting was an effective retting method and is being used to further research in developing a flax fiber industry for the U.S. and specifically is being integrated with pilot plant processing. Enzyme-retting will be required to produce high quality flax fibers that compete with synthetic fibers in composites.

A small number of researchers are using these technologies to ret flax and other bast plants **(Athens, GA).**

Cotton/flax blends successfully produced in plant trials. Processing flax into a blended cotton/flax yarn at commercial production rates and subsequently processing the yarn into commercial fabric was successfully accomplished. This accomplishment is significant because it demonstrates that domestically grown flax fiber which has been cut to match the staple length of cotton is viable on a commercial scale for textiles. ARS researchers, in partnership with Inman Mills, organized a commercial scale trial to implement the use of cotton/flax blend yarns developed by ARS to produce commercial quantities of fabric for shirting material and denim. The yarn was woven on high-speed weaving machines at a high efficiency and resulted in fabrics with a unique appearance and improved fabric feel without compromising the fabric strength. The success of this effort demonstrates that domestically grown flax fiber is a good alternative natural fiber source that provides enhanced fabric characteristics for domestic textile mills, will provide a competitive advantage in the global textile market, and should result in increased amounts of U.S. produced cotton sold for denim garments **(Clemson, SC).**

Improved flow of cottonseed for dairy feed rations. Handling of fuzzy cottonseed has been a problem for small to mid-size dairies using whole cottonseed in their feed rations. Fuzzy cottonseed cannot be stored in conventional grain bins or hoppers. Making cottonseed handle and flow like grain would enhance its marketability. One means of making cottonseed more flowable was developed by Cotton Incorporated, and was termed Easiflo^{TM} Cottonseed. ARS scientists refined the Easiflo^{TM} Cottonseed process so that coating of cottonseed could be done economically on a commercial scale. The ARS technology has been transferred to several interested parties in the industrial sector. The work performed by ARS engineers helped solve the problems resulting from scaling up the process, reduced the operating cost for the commercial plants down to the required level, and increased plant processing rates up to design levels. As a result of this work, approximately 100,000 tons of Easiflo^{TM} cottonseed is marketed each year at a $30 to $40 premium to fuzzy whole cottonseed **(Lubbock, TX).**

New yarn manufacturing processes. To promote value-added utilization of cotton, several new yarn manufacturing processes and the unique fabrics made therewith were developed by ARS researchers. Based on six U.S. patents awarded to ARS, six foreign patents in Mexico, China, Israel, Japan, the European Union (EU), and Canada were published since 1999. Two patents on ring-core-spinning technologies were licensed to an American company **(New Orleans, LA).**

Union dyeing of wool-cotton blends. The marketing of wool/cotton blended textiles is impeded by the lack of a simple system for achieving "union dyeing," the equal uptake of dye by each fiber component. ARS researchers determined that cationic resins, of the type applied to increase the strength of paper and to convey dimensional stability to wool, were effective

pretreatments for promoting such union dyeing. The best system was identified and experimental parameters were established for maximum shade depth and colorfastness. Under several agreements, the technology was transferred to woolen mills. The success of this work will encourage the resin producer and its distributors to promote the union dyeing technology to the textile industry **(Wyndmoor, PA).**

CONCLUDING REMARKS AND CHARGE TO ASSESSMENT PANEL

This national program is one of the largest and most diverse in ARS. Although the dollars per scientist is low relative to most other national programs, NP 306 scientists produced 9% of all ARS peer reviewed publications in 2006 and account for approximately one-third of the Agency's active Cooperative Research and Development Agreements. In the first cycle of ARS peer review, NP 306 project plans scored above the ARS average and were second highest among the six national programs with 50 or more projects. It should be emphasized that the preceding accomplishments were selected to reflect the Program's productivity and thus do not describe all accomplishments and activities in the Program.

The external assessment panel is asked to assess whether the selected accomplishments in this report significantly advance the mission and address projected outcomes/impacts of NP 306 (**APPENDIX C**), and the planned research activities described in the action plan. Suggested evaluation criteria are offered in **APPENDIX D**.

APPENDIX A: Action Plan Components, Problems Areas, and Objectives

NP 306, Quality and Utilization of Agricultural Products

Component 1. Quality Characterization, Preservation, and Enhancement

Problem Area 1a. Definition and Basis for Quality

- Identify attributes that define quality of agricultural products.
- Develop better understanding of relationships between composition and component molecular structure and end-use quality and function and sensory characteristics.
- Assess quality trends and needs of agricultural products in global markets.

Problem Area 1b. Methods to Evaluate and Predict Quality

- Develop rapid, non-destructive methods for detection and measurement of physical/chemical quality attributes and quality defects.
- Develop automated, high-throughput on-line grading, sorting, and packaging systems for agricultural products.
- Develop methods to evaluate the performance of sampling plans to measure quality characteristics of agricultural commodities shipped in bulk.
- Develop and utilize multispectral techniques, imaging and image analysis, and methods incorporating information technology and artificial intelligence for further improvement of processing and grading.

Problem Area 1c. Factors and Processes that Affect Quality

- Determine influence of pre-harvest factors on quality, including genetics, production practices and environment.
- Determine influence of post-harvest factors on quality, including storage, handling, grading, and processing.
- Evaluate effects of safety and environmental protocols on quality of foods.

Problem Area 1d. Preservation and/or Enhancement of Quality and Marketability

- Develop strategies to enhance intrinsic product quality and consistency.
- Improve storage technologies which maintain quality and nutrition and increase shelf life.
- Enhance nutritional value of agricultural products.
- Investigate use of antagonistic yeasts and bacteria for antimicrobial effects to enhance safety and reduce spoilage.
- Develop environmentally friendly strategies for plant and animal pathogen control.
- Minimize effects of pest infestation and food-borne risks on trade of agricultural products.

Component 2. New Processes, New Uses, and Value-Added Foods and Biobased Products

Problem Area 2a. New Product Technology

- Identify and characterize functional compounds and components in agricultural commodities and their byproducts.
- Improve understanding of the relationship between composition, molecular structure, and physical state and end-use functionality of these compounds and components.
- Use new knowledge of product properties and component interactions to develop functional intermediates or products.

Problem Area 2b. New Uses for Agricultural By-products

- Identify and characterize by-product components for potential value-added products.
- Convert low value agricultural residues into higher value products.

Problem Area 2c. New and Improved Processes and Feedstocks.

- Develop improved and new techniques and technologies to convert agricultural products into value-added foods and biobased products.
- Improve/develop processes and technologies that are environmentally benign.

APPENDIX B: Project Listing

Projects Primary to NP 306

Project No.	Project Title	Lead SY	Location
Food Technology and Safety Laboratory			
1265-41000-001-00D	New Technologies To Improve And Assess Meat Quality In Muscle Foods	Morse Solomon	Beltsville, Maryland
Instrumentation and Sensing Laboratory			
1265-44000-007-00D	Optical Properties Of Small Grains For Rapid And Objective Assessment Of Quality And Safety	Stephen Delwiche	Beltsville, Maryland
Produce Quality and Safety Laboratory			
1275-43000-009-00D	Molecular Genetic Approaches For Improvement Of Produce Quality	Bruce Whitaker	Beltsville, Maryland
1275-43440-002-00D	Integrated Approach To Quality Maintenance And Evaluation Of Intact And Fresh-Cut Produce	Robert Saftner	Beltsville, Maryland
Dairy Processing and Products Research Laboratory			
1935-41000-063-00D	Protein Processing Using High-Pressure Gases And Supercritical Fluids	Peggy Tomasula	Wyndmoor, Pennsylvania
1935-41000-064-00D	Development Of Lactic Fermentation Bacteria For The Production Of Bioactive Food Ingredients	George Somkuti	Wyndmoor, Pennsylvania
1935-41000-065-00D	New And Improved Processes For Texturizing Milk Components	Charles Onwulata	Wyndmoor, Pennsylvania
1935-41000-071-00D	Processing Methods For Hispanic-Style Cheeses With Unique Functional Properties	Diane Van Hekken	Wyndmoor, Pennsylvania
Crop Conversion Science and Engineering			
1935-41000-068-00D	Valuable Polysaccharide-Based Products From Sugar Beet Pulp And Citrus Peel	Arland Hotchkiss	Wyndmoor, Pennsylvania
1935-41000-070-00D	Enzyme-Based Technologies For Milling Grains And Producing Biobased Products And Fuels	David Johnston	Wyndmoor, Pennsylvania

Project No.	Project Title	Lead SY	Location
1935-41000-066-00D	Production Of Value-Added Lipids, Biofuels, And Biobased Products From Fats And Oils	Thomas Foglia	Wyndmoor, Pennsylvania
1935-41000-067-00D	Integrative Processes For The Bioconversion Of Fats, Oils And Their Derivatives Into Biobased Materials And Products	Daniel Solaiman	Wyndmoor, Pennsylvania
1935-41440-013-00D	New And Efficient Processes For Making Quality Leather	William Marmer	Wyndmoor, Pennsylvania
1935-41440-014-00D	Sustainable Technologies For Processing Of Hides, Leather, Wool And Associated Byproducts	Eleanor Brown	Wyndmoor, Pennsylvania
1935-41440-015-00D	Characterization, Processing And Novel, Non-Feed Uses For Proteinaceous Rendering Byproducts	William Marmer	Wyndmoor, Pennsylvania
Soft Wheat Quality Research Laboratory			
3607-43440-005-00D	Genetic Bases For The Biochemical Determinants Of Wheat Quality	Edward Souza	Wooster, Ohio
Food and Industrial Oil Research Laboratory			
3620-41000-112-00D	Improved Functional Food Oils Via Novel Processing Technologies	Gary List	Peoria, Illinois
3620-41000-117-00D	Chemical Systems For Soybean Oil Conversion To Industrial Products	Sevim Erhan	Peoria, Illinois
3620-44000-047-00D	Enhancing Flavor Quality And Oxidative Stability Of Edible Vegetable Oils With Phytochemical Antioxidants	Kathleen Warner	Peoria, Illinois
Plant Polymer Research Laboratory			
3620-41000-119-00D	Nonfood Utilization Of Cereal And Soy Based Co-Products	Gordon Selling	Peoria, Illinois
3620-41000-108-00D	Advanced Starch-Based Materials For Non-Food Applications	Julious Willett	Peoria, Illinois
3620-41000-114-00D	Modification Of Natural Polymers By Thermo-Mechanical Processing	Randal Shogren	Peoria, Illinois
Cereal Products and Food Science Research Laboratory			
3620-41000-120-00D	New Metalworking Fluids From Bio-Based Materials	Girma Biresaw	Peoria, Illinois
3620-41440-019-00D	Improved Isolation, Modification, And Functionality Of Grain Proteins For New Product Development	Abdellatif Mohamed	Peoria, Illinois

Project No.	Project Title	Lead SY	Location
3620-44000-048-00D	Viscoelastic Properties Of Bio-Based Elastomeric Composites	Lei Jong	Peoria, Illinois
3620-41000-116-00D	Health Promoting Foods: Enzymatic Modified Cereals And Their Carbohydrates	George Inglett	Peoria, Illinois
3620-41000-111-00D	Preparation, Properties, And Commercial Applications Of Starch-Lipid Compositions Prepared By Steam Jet Cooking	George Fanta	Peoria, Illinois
Microbial Genomics and Bioprocessing Research Laboratory			
3620-41000-113-00D	New Microbial Systems For Utilization Of Glycerol And Plant Lipids	Ching Hou	Peoria, Illinois
New Crops and Processing Technology Research Laboratory			
3620-41000-115-00D	Industrial Products From New Crops	Steven Cermak	Peoria, Illinois
3620-41000-125-00D	Characterization, Production, And Utilization Of Phytochemicals From Agricultural Products	Mark Berhow	Peoria, Illinois
3620-41000-126-00D	Biocatalytic Functionalization Of Plant Lipids	Joseph Laszlo	Peoria, Illinois
3620-43000-006-00D	Coordinated Analysis Of Soybean Breeding Germplasm	Terry Isbell	Peoria, Illinois
3620-41000-128-00D	Critical Fluids For Processing Agrimaterials	Fred Eller	Peoria, Illinois
Bioproducts and Biocatalysis Research Laboratory			
3620-41000-110-00D	Pathway Engineering Of Fungi For Improved Bioprocess Applications	Christopher Skory	Peoria, Illinois
3620-41000-130-00D	Developing Bioconversion Processes For High-Value Carbohydrate Products	Gregory Cote	Peoria, Illinois
Sugarbeet and Bean Research Laboratory			
3635-43000-004-00D	Technologies For Assessing And Grading Quality And Condition Of Cucumbers And Tree Fruits	Renfu Lu	East Lansing, Michigan
Cereal Crops Research Laboratory			
3655-43440-004-00D	Improving The Quality Of Malting Barley Through Improved Selection Criteria And Quality Analysis Of Breeding Lines	Mark Schmitt	Madison, Wisconsin

Project No.	Project Title	Lead SY	Location
U.S. Dairy Forage Research Center			
3655-41000-004-00D	Value-Added Products From Forages And Biomass Energy Crops	Paul Weimer	Madison, Wisconsin
Commodity Protection and Quality Research Laboratory			
5302-43000-032-00D	Emerging Technologies To Maintain Postharvest Quality And Control Decay Of Fresh Commodities	Joseph Smilanick	Parlier, California
Processed Foods Research Laboratory			
5325-41440-004-00D	Processing And Biotechnological Improvement Of Foods To Prevent Obesity Related And Other Degenerative Diseases	Wallace Yokoyama	Albany, California
5325-41000-050-00D	Characterization And Control Of Nutritional And Sensory Properties Of Raw And Processed Grains, Legumes, And Vegetables	Gary Takeoka	Albany, California
5325-41000-060-00D	New Technologies To Process Value-Added, Healthy Foods From Fruits And Vegetables	Tara Mc Hugh	Albany, California
5325-41430-009-00D	Improving Citrus Nutritional Properties And Quality To Benefit Human Health And Enhance Citrus Utilization	Andrew Breksa Iii	Albany, California
Crop Improvement/Utilization Research Laboratory			
5325-21000-012-00D	Developing A Domestic Source For Production Of Ricinoleate And Other Industrial-Use Fatty Acids	Thomas Mckeon	Albany, California
5325-41000-043-00D	Development Of Domestic Natural Rubber-Producing Industrial Crops Through Biotechnology	Colleen Mcmahan	Albany, California
Bioproduct Chemistry and Engineering Research Laboratory			
5325-41000-044-00D	Development Of Agriculturally-Derived Biopolymer Composities For Non-Food Applications	Gregory Glenn	Albany, California
5325-41000-047-00D	Technologies Enabling Enhanced Product Quality, Product Opportunities, And Energy Efficiency In Grain Biorefining Systems	George Robertson	Albany, California
Plant Mycotoxins Research Laboratory			
5325-44000-007-00D	Sorting Agricultural Materials For Defects Using Imaging And Physical Methods	Ronald Haff	Albany, California

Project No.	Project Title	Lead SY	Location
Wheat Genetics, Quality Physiology and Disease Research Laboratory			
5348-43440-004-00D	Enhance Wheat Quality And Utilization In The Western U.S.	Craig Morris	Pullman, Washington
Physiology and Pathology of Tree Fruits Research Laboratory			
5350-43000-005-00D	Enhance Market Quality, Reduce Postharvest Loss, And Increase Utilization Of Deciduous Tree Fruits	Eric Curry	Wenatchee, Washington
Grain Quality and Structure Research Laboratory			
5430-44000-016-00D	Characterization Of Grain Biochemical Components Responsible For End-Use Quality	Michael Tilley	Manhattan, Kansas
5430-44000-017-00D	Enhanced End Use Quality And Utilization Of Sorghum Grain	Scott Bean	Manhattan, Kansas
5430-44000-018-00D	Enhancement Of Hard Winter Wheat Quality And Its Utility	Bradford Seabourn	Manhattan, Kansas
Engineering Research Laboratory			
5430-44000-015-00D	Objective Grading And End-Use Property Assessment Of Single Kernels And Bulk Grain Samples	Thomas Pearson	Manhattan, Kansas
5430-43440-005-00D	Improved Handling And Storage Systems For Grain Quality Maintenance And Measurement	Mark Casada	Manhattan, Kansas
Cereal Crops Research Laboratory			
5442-21440-004-00D	Oat Quality Improvement	Douglas Doehlert	Fargo, North Dakota
5442-43440-008-00D	Enhance Hard Spring And Durum Wheat Quality And Utilization	Gary Hareland	Fargo, North Dakota
Sugarbeet and Potato Research Laboratory			
5442-21430-004-00D	Improving Potato Market Quality Through Postharvest Physiology	Jeffrey Suttle	Fargo, North Dakota
5442-43440-007-00D	Evaluation Of Processing And Storage Capabilities Of New And Established Potato Germplasm	Martin Glynn	Fargo, North Dakota
Crop Quality and Fruit Insects Research Laboratory			
6204-43000-014-00D	Enhancement Of Postharvest Quality Of Fruits And Vegetables And Evaluation Of Commodity Treatments Of Quarantined Pests	Gene Lester	Weslaco, Texas

Project No.	Project Title	Lead SY	Location
Cotton Production and Processing Research Laboratory			
6208-21410-005-00D	Harvesting And Ginning Processes To Enhance The Profitability Of Stripper Cotton	Gregory Holt	Lubbock, Texas
Genetics and Production Research Laboratory			
6222-21430-001-00D	Physiological And Genetic Basis Of Postharvest Quality And Phytonutrient Content Of Fruits And Vegetables	Penelope Perkins Veazie	Lane, Oklahoma
Cotton Ginning Research Laboratory			
6235-41000-006-00D	Ginning And Processing Research To Enhance Quality, Profitability, And Textile Utility Of Western Cottons	Sidney Hughs	Las Cruces, New Mexico
Cotton Ginning Research Laboratory			
6402-41440-005-00D	Develop, Enhance And Transfer Gin Technology To Improve Fiber Quality And Profits	Richard Byler	Stoneville, Mississippi
Natural Products Utilization Research Laboratory			
6408-22430-003-00D	Discovery And Development Of Natural Products For Control Of Plant Diseases In Agriculture	David Wedge	University, Mississippi
6408-41000-006-00D	Chemistry Of Natural Products For Pest Management And Crop Development	Agnes Rimando	University, Mississippi
Cotton Structure and Quality Research Laboratory			
6435-44000-069-00D	Improved Cotton Quality Measurements	James Rodgers Iii	New Orleans, Louisiana
6435-44000-070-00D	Structure And Moisture As Determinants Of Commercially Important Cotton Fiber Properties	Alfred French	New Orleans, Louisiana
Cotton Chemistry and Utilization Research Laboratory			
6435-41000-094-00D	Value Added And High-Volume Cotton Products And Processes	Navzer Sachinvala	New Orleans, Louisiana
6435-41430-004-00D	Chemical Modifications Of Cotton Textiles	Judson Edwards	New Orleans, Louisiana
Commodity Utilization Research Laboratory			
6435-13410-003-00D	Develop Enhanced Phytases For Animal Feed And For Incorporation Into New Plant Cultivars Requiring Less Phosphorus Fertilizers	Edward Mullaney	New Orleans, Louisiana
6435-41000-087-00D	Enzymatic Processes For Increasing Industrial Utilization Of Vegetable Oils	Jay Shockey	New Orleans, Louisiana

Project No.	Project Title	Lead SY	Location
6435-41000-088-00D	Agricultural By-Products As Adsorbents For Environvental Remediation	Kjell Klasson	New Orleans, Louisiana
6435-41000-095-00D	Characterization And Improvement Of Sugar Industry Process Units Impacted By New Production Practices	Gillian Eggleston	New Orleans, Louisiana
6435-41000-096-00D	New And Expanded Uses Of Oilseed Products And By-Products	Mike Dowd	New Orleans, Louisiana
Food and Feed Safety Research Laboratory			
6435-41000-097-00D	Discovery Of Antifungal Compounds From Low Value/Underutilized Crops And Crop Co-Products	Anthony De Lucca Ii	New Orleans, Louisiana
Food Processing and Sensory Quality Research Laboratory			
6435-44000-068-00D	Improving The Sensory Quality And Shelf Life Of Fresh-Cut Fruit Products	Elaine Champagne	New Orleans, Louisiana
6435-43440-020-00D	Reducing The Allergenic Properties Of Peanuts	Si Yin Chung	New Orleans, Louisiana
6435-44000-067-00D	Crop Sensory Quality: Basic Understanding And Instrumental Assessment	Casey Grimm	New Orleans, Louisiana
6435-41000-092-00D	Developing Novel Processes For Incorporating The Unique Nutritional Amd Functional Properties Of Rice Into Value-Added Products	Elaine Champagne	New Orleans, Louisiana
Peanut Research Laboratory			
6604-41430-002-00D	Post Harvest Measurement And Management Systems To Improve Peanut Quality And Us Competitiveness	Christopher Butts	Dawson, Georgia
Quality and Safety Assessment Research Laboratory			
6612-44000-022-00D	Flax Fiber For Value-Added, Bio-Based Products	Danny Akin	Athens, Georgia
6612-44000-024-00D	Sensing Moisture Content And Quality Of Grain And Other Agricultural Products By Dielectric Properties	Stuart Nelson	Athens, Georgia
6612-44000-025-00D	The Advancement Of Spectroscopic Sensors/Chemometric Analysis For Quality Assessment Of Fiber, Grain, And Food Commodities	David Himmelsbach	Athens, Georgia
Quality Improvement in Citrus and Subtropical Products Laboratory			
6621-41000-011-00D	Enhanced Utilization Of Carbohydrates And Polysaccharides From Citrus Processing Waste Streams	Wilbur Widmer	Winter Haven, Florida

Project No.	Project Title	Lead SY	Location
6621-43000-001-00D	Enhancement Of The Quality And Microbial Stability Of Fresh Fruits And Vegetables With Edible Coatings And Other Surface Treatments	Elizabeth Baldwin	Winter Haven, Florida
6621-41000-012-00D	Recovery Of Value-Added Products Pertaining To Health And Food Uses From Citrus Processing Waste	John Manthey	Winter Haven, Florida
6621-41440-003-00D	Enhancement Of Fruit And Fruit Product Flavor Quality Using Analytical/Sensory Methods	Kevin Goodner	Winter Haven, Florida
Market Quality and Handling Research Laboratory			
6645-44000-009-00D	Improve The Detection Of Quality Attributes And Chemical Agents In Agricultural Commodities	Thomas Whitaker	Raleigh, North Carolina
6645-43440-009-00D	Development & Maintenance Of Flavor & Shelf-Life In Peanuts Through Improved Handling, Processing And Use Of Genetic Resources	Timothy Sanders	Raleigh, North Carolina
Food Science Research Laboratory			
6645-41000-005-00D	Improved Processes For Cucumbers, Cabbage, Sweetpotatoes, And Peppers To Make High-Quality, Nutritious Products And Reduce Pollution	Roger Mcfeeters	Raleigh, North Carolina
Cotton Quality Research			
6655-41440-003-00D	Fiber Quality Measurements, Processing Efficiency And End Use Quality	Gary Gamble	Clemson, South Carolina

Projects Contributing to NP 306

Project No./Primary NP*	Project Title	SY	Location
Produce Quality and Safety Laboratory			
1275-42430-010-00D NP 303	Improved Knowledge Of Virulence Factors To Develop Postharvest Decay Control Strategies	William Conway	Beltsville, Maryland
Crop Conversion Science and Engineering			
1935-41000-069-00D NP 307	Aqueous Enzymatic Extraction Of Corn Oil And Value-Added Products From Corn Germ Produced In New Generation Dry-Grind Ethanol Processes	Robert Moreau	Wyndmoor, Pennsylvania
1935-41000-072-00D NP 307	Economic Competitiveness Of Renewable Fuels Derived From Grains And Related Biomass	Kevin Hicks	Wyndmoor, Pennsylvania
Microbial Genomics and BioProcessing Research			
3620-22410-009-00D NP 301	Management And Genetic Characterization Of Agricultural And Biotechnological Microbial Resources	David Labeda	Peoria, Illinois
Crop Bioprotection Research			
3620-22410-010-00D NP 304	Production, Stabilization, And Formulation Of Microbial Agents And Natural Products	Mark Jackson	Peoria, Illinois
3620-41000-123-00D NP 307	Genomics And Engineering Of Stress-Tolerant Microbes For Lower Cost Production Of Biofuels And Bioproducts	Patricia Slininger	Peoria, Illinois
Fermentation Biotechnology Research			
3620-41000-118-00D NP 307	Industrially Robust Enzymes And Microorganisms For Production Of Sugars And Ethanol From Agricultural Biomass	Bruce Dien	Peoria, Illinois

Project No./Primary NP*	Project Title	SY	Location
3620-41000-122-00D NP 307	Cost-Effective Bioprocess Technologies For Production Of Biofuels From Lignocellulosic Biomass	Badal Saha	Peoria, Illinois
Bioproducts and Biocatalysis Research			
3620-41000-121-00D NP 307	Microbial Catalysts To Produce Fuel Ethanol And Value Added Products	Kenneth Bischoff	Peoria, Illinois
Food and Industrial Oil Research			
3620-41000-124-00D NP 307	Improving The Performance Of Alternative Fuels And Co-Products From Vegetable Oils	Sevim Erhan	Peoria, Illinois
Cereal Crops Research			
3655-21000-044-00D NP 302	Metabolism And Analysis Of Cereal Phytochemicals	Mitchell Wise	Madison, Wisconsin
Crop Improvement/Utilization Research			
5325-21430-011-00D NP 302	Production Of Wheat Germplasm With Enhanced Baking Quality	Ann Blechl	Albany, California
5325-43000-026-00D NP 302	Molecular Analysis Of Effects Of Environment On Wheat Flour Quality And Allergenic Potential	William Hurkman	Albany, California
Bioproduct Chemistry and Engineering Research			
5325-41000-046-00D NP 307	Evolutionary Enzyme Design For Improved Biorefining Of Crops And Residues	Dominic Wong	Albany, California
Physiology and Pathology of Tree Nuts Research			
5350-22000-016-00D NP 303	Systematics Of Alternaria Spp. Associated With Tree Fruits And International Commerce	Rodney Roberts	Wenatchee, Washington
Small Grains and Potato Germplasm Research			
5366-21000-021-00D NP 301	Seed Chemistry Genetics	Victor Raboy	Aberdeen, Idaho
Grain, Forage, and Bioenergy Research			
5440-21000-025-00D NP 301	Genetic Improvement And Evaluation Of Hard Winter And Spring Wheats	Robert Graysbosch	Lincoln, Nebraska

Project No./Primary NP*	Project Title	SY	Location
Integrated Cropping Systems			
5447-41000-002-00D NP 307	Fiber Extrusion To Improve Use And Production Of Ethanol Byproducts	Kurt Rosentrater	Brookings, South Dakota
Genetics and Production Research			
6222-22000-006-00D NP 303	Integrated Pest Management Systems For Conventional And Organically Produced Vegetable Crops	Benny Bruton	Lane, Oklahoma
Cotton Structure and Quality Research			
6435-21440-003-00D NP 302	Molecular Analysis Of Development To Improve Cotton Fiber	Barbara Triplett	New Orleans, Louisiana
Peanut Research			
6604-64000-006-00D NP 207	Irrigation, Crop Rotation And Tillage Technologies And Decision Support Systems For Peanut Production	Marshall Lamb	Dawson, Georgia
Egg Safety and Quality Research			
6612-41420-014-00D NP 108	Egg Processing Safety, Quality And Security	Deana Jones	Athens, Georgia

*National Programs:

108 – Food Safety
207 – Integrated Agricultural Systems
301 – Plant Genetic Resources, Genomics and Genetic Improvement
302 – Plant Biological and Molecular Processes
303 – Plant Diseases
304 – Crop Protection and Quarantine
307 – Bioenergy and Energy Alternatives

APPENDIX C: Projected Outcomes/Impacts

NP 306, Quality and Utilization of Agricultural Products

Mission Statement

To enhance the economic viability and competitiveness of U.S. agriculture by maintaining the quality of harvested agricultural commodities or otherwise enhancing their marketability, meeting consumer needs, developing environmentally friendly and efficient processing concepts, and expanding domestic and global market opportunities through the development of value-added food and nonfood products and processes.

Projected Outcomes/Impacts

The Quality and Utilization of Agricultural Products National Program will generate new knowledge, technologies, and processes to expand markets for U.S. agricultural products and make U.S. agriculture more competitive in the global economy. More specific outcomes anticipated during the next 5 years include, but are not limited to:

- New knowledge derived from improved understandings of the structure, properties, metabolism, and function of crop and animal components, particularly carbohydrates, proteins, and lipids, will generate development of a variety of new food, feed, and industrial products.
- Enhanced fundamental knowledge regarding the interactions between harvested commodities and organisms causing disease, spoilage, and quality loss will lead to new and improved technologies for control or elimination of postharvest insects and microorganisms that adversely affect the quality and marketability of agricultural commodities and products.
- Better understanding of the inherent mechanisms that govern quality maintenance and useful storage life in animal products and in harvested horticultural and agronomic crops will allow for genetic manipulation to improve desired traits, plus improved processes to extend the life of desirable traits.
- Improved knowledge regarding the genetic and biochemical control of value-added traits in plants and animals will allow for the development of improved animal products and plant varieties, and also create the potential for high-value designer crops.
- Rapid and improved grading methods will be developed to measure quality parameters and critical processing and end-use properties of agricultural commodities, issues of great importance to the marketing of American farm products. Better grading technology will provide an expanded basis for marketing by quality, with appropriate pricing for high-quality products.
- Improved products and processes to extend the useful life of products during storage will reduce waste, improve efficiency, and allow new uses that are not now feasible.
- New technologies to convert commodities and processing byproducts into important value-added products such as fat substitutes, high-quality animal feeds, improved textiles, pharmaceutical ingredients, enzymes, and cosmetics will fill demonstrated needs.
- New high-value biomaterials, such as biodegradable plastics, adhesives, lubricants, and natural rubber from domestic plants, will be created and made available. The new materials will fill specific needs such as reducing the bulk of inert, non-biodegradable plastics currently going to landfills or reducing dependence on imports. They will also diversify the economic base of agriculture and stabilize income streams for farmers.

APPENDIX D: Suggested Retrospective Assessment Criteria

Quality and Utilization of Agricultural Products National Program (NP 306)

Was new information discovered which better elucidates relationships between (chemical) structure and (physical) function?

Were new functional compounds (i.e., phytochemicals, prebiotics, bioactive peptides, hydroxy fatty acids) in agricultural products identified and characterized?
Were these compounds evaluated or used to develop functional intermediates or products?

Were new or improved methods/technologies to measure or assess quality of agricultural products developed? Adopted for use or commercialized?

Were new or improved grading and/or sorting methods for agricultural products developed? Adopted for use or commercialized?

Were new or improved strategies/technologies to maintain quality of agricultural products developed? Adopted for use or commercialized?

Were new uses developed for agricultural by-products? Adopted for use or commercialized?

Were new technologies developed and employed in the development of new or improved foods, fibers or biobased products? Adopted for use or commercialized?