

## **FY 2012 Annual Report for National Program 306, Quality and Utilization of Agricultural Products**

National Program 306 (NP 306) focuses on post-harvest quality and utilization of agricultural commodities and products and addresses Strategic Goal 2, Objective 1, Performance Measure 2.1.2 (Develop cost effective, functional industrial and consumer products, including higher quality, healthy foods, that satisfy consumer demand in the United States and abroad) of the ARS FY 2006-2011 Strategic Plan.

The NP 306 Action Plan for 2010-2015 consists of three components – Foods, Fibers, and Biobased Products. Selected accomplishments in fiscal year 2012 for each component are reported below.

### **1. Foods**

**Milk processing plant simulator lowers greenhouse gas emissions.** Life-cycle assessments of on-farm and off-farm fluid milk production greenhouse gas emissions found on-farm activities generated 70 percent of the emissions due to methane from cows and manure. Off-farm activities: milk processing, packaging and refrigeration, contributed 30 percent. Significant reductions in greenhouse gas emissions for off-farm processors are practical only if processors know the energy hotspots in their plants and if the costly upgrades will reduce greenhouse gas emissions. ARS scientists at Wyndmoor, Pennsylvania, partnered with dairy processors, creating a computer-based model of the fluid milk process to lower greenhouse gas emissions. This model can offer multiple ways of making changes in individual processing plants, and instantly calculate both greenhouse gas reductions and costs of implementing the changes. The model has been distributed to over 100 processors in the U.S. and should help the dairy industry realize its goal of reducing greenhouse gas emissions by 25 percent per gallon of milk by the year 2020. Update: The tech transfer continues, and simulator is on the recently established website [http://www.ars.usda.gov/main/site\\_main.htm?modecode=19-35-47-00](http://www.ars.usda.gov/main/site_main.htm?modecode=19-35-47-00).

**Packaging insert that fight decay of fresh produce.** Decay of fresh produce, especially small fruits like strawberries and blueberries which cannot be washed, contributes to a short postharvest shelf life. ARS scientists at Fort Pierce, Florida, in collaboration with an industry partner, Worrell Water Technologies, developed small, single use packets which when inserted into packaged fruit release an antimicrobial vapor (Curoxin®) that surrounds the fresh fruit. This vapor extended the postharvest shelf life of blueberries and strawberries by maintaining fruit firmness, reducing water loss and decay, and maintaining color and overall quality. It was also used to treat citrus fruit infected with citrus canker. Canker is a problem for the fresh citrus market, as fruit coming from groves where canker is found cannot be marketed internationally. Packets containing the vaporizing compound placed inside containers of citrus significantly reduced bacterial canker counts. The antimicrobial vapor packets are being tested in pilot studies with commercial packing houses and could save the international fresh produce industry over \$1 billion annually in costs incurred by postharvest losses. Application is now being expanded to California grapes.

**New healthy functional foods from oats.** Oat studies revealed that the ‘soft-solid’ characteristics of various oat carbohydrates (beta-glucan) provided creamer, less runny properties valuable for developing new functional foods such as yogurt, instant puddings, custard, batter, smoothies, and ice cream. ARS scientists at Peoria, Illinois, developed the oat concentrates which appear to have great potential for health concerned consumers. An industrial partner has licensed this ARS-patented functional food from oats for the production of Calorie-Trim, and Nutrim. Z-Trim is licensing this product for expanded markets including USDA’s school lunch program.

**White grape seed-flour may lower cholesterol and weight gain.** ARS scientists at Albany, California, and industry partner, Sonomaceuticals, LLC, found that intake of grape seed flour from white wine chardonnay grapes (a waste or low-value byproduct of wine making), but not red grapes or grape skins, prevented increases in plasma cholesterol and weight gain in hamsters on a high-fat diet similar to the typical American dietary intake. Chardonnay seed flour’s anti-inflammatory compounds are among the highest concentration of any food ingredient, and the seeds are a natural byproduct of the California winemaking industry. Patent applications have been filed by the industry partner, and discussions specifically looking at additional hamster trials lowering low-density lipoproteins (LDL cholesterol) and reducing triglyceride fat accumulation in liver cells (fatty liver disease) are underway, and human clinical trials are being planned. This research has the support of a dedicated food-grade drying and processing facility in Santa Rosa, California. The industry partner has created additional agricultural jobs and established a new industry. Winegrowers have contributed letters of support. Scientific results were presented at the American Chemical Society’s annual meeting in Philadelphia, 2012.

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

**Anthocyanin gene in strawberry fruit is identified.** Dietary intake of health-promoting bio-nutrients such as anthocyanins, the compound that causes strawberries to be red and blueberries to be blue, is recommended by the USDA as part of a healthy diet. One way to increase the intake of bio-nutrients like anthocyanins is to develop new lines with higher concentrations of these compounds. It was discovered by ARS scientists in Beltsville, Maryland, that the last step in synthesis of anthocyanins involves the attachment of sugar by an enzyme called UGT. The UGT1 gene in strawberry was cloned, and its function was found to be located only in the fruit

and was required for anthocyanin accumulation. This finding provides strawberry breeders and plant geneticists a single target gene that can be easily controlled to increase accumulation of health-beneficial anthocyanins in strawberry fruit making strawberries redder, and more attractive. A long-range benefit of this research is a reduced incidence of chronic health problems in the U.S. that cost many billions of dollars annually.

**High anti-oxidant, high fiber, wheat-free, sorghum bread formula.** Wheat-free foods often contain high levels of purified starches and refined flour which limits their nutritional properties. To improve the nutritional profile of wheat-free sorghum bread, ARS researchers at Manhattan, Kansas, developed a sorghum bread formula containing whole sorghum flour plus added sorghum bran that contained high levels of tannin. Bran is high in fiber and tannins are known to be potent anti-oxidants, thus this formula resulted in bread with high levels of dietary fiber and anti-oxidants. The resulting breads had 140 percent more fiber and a six fold increase in ORAC value (oxygen radical absorbance capacity – a measure of antioxidant strength) compared with the sorghum formula with no added bran. In addition, a consumer taste panel detected no significant difference between sorghum bread with bran vs. bread without bran.

**Easier analytical method for verifying the presence of whole-grain ingredients in foods.**

The industry proxy for confirming the presence of whole-grain ingredients in foods are alkyl-resorcinols, but the current assay for alkyl-resorcinols utilizes techniques involving slow and tedious extraction of samples followed by derivatization. ARS researchers in Wyndmoor, Pennsylvania, developed relatively easy methods based on (1) a new extraction method which simplifies sample preparation and speeds up extraction time and (2) reverse-phase HPLC, which does not require derivatization and avoids interferences by tocopherols and tocotrienols (vitamin E compounds) commonly found in foods. *[research done under NP213]*

**Effect of gene-by-environment on tomato flavor.** Interest is growing among U.S. consumers who wish to purchase fresh tomatoes with improved red color (lycopene), and taste (combination of sugars, vitamin C and acid). ARS scientists in Albany, California, grew tomatoes of different shapes (genotypes) in three different U.S. states (environments) and estimated heritability for lycopene being the least genetically controlled and acid being the most genetically controlled. This study is useful in identifying optimal environments for specific tomato genotypes and for breeders to manipulate in order to improve tomato color and taste for consumers.

**Effect of chemical fertilizers and pesticides on orange quality.** ARS researchers in Albany, California, in collaboration with University of California Davis, found that foliar application of fertilizers or pesticides significantly effects the sugar, amino acid and organic acid composition of juice in mandarin oranges and that these differences are perceived by consumers. Direct application of agricultural chemicals to leaves of trees can reduce the amount needed and subsequent runoff while improving taste quality of orange juice.

**Identifying juice from HLB-infected trees.** Citrus greening (HLB) is a growing problem in U.S. orange groves, and so orange juice processors want to determine whether off-flavors in juices may be due to the presence of juice from HLB-infected trees. ARS researchers in Albany, California, and Ft. Pierce, Florida, in collaboration with University of California Davis, identified nitrogen-containing metabolic markers that distinguish juice from healthy trees and

juice from HLB-infected trees. Industry can use these markers to determine whether juice they are purchasing contains product from HLB-contaminated trees.

**Improving chicken meat quality.** ARS scientists in Athens, Georgia, in collaboration with university and industrial collaborators, developed optimal practices for carcass scalding and chilling so as to both control pathogens (measured by Salmonella plate count) and maintain quality (measured by pH, moisture content, color, texture and water-holding capacity) in deboned chicken breast fillets. In particular, they showed that air chilling produced more tender product (vs. water-immersion chilling) whereas scalding temperature has relatively little effect. They also showed that marinade uptake and retention is not affected by the age of chicken breast fillets, a finding that should encourage greater industry use of marinades to tenderize poultry meat. Further, they found that indicators of breast meat quality (e.g., muscle fiber size, muscle fiber number, muscle degeneration) in various broiler lines were uncorrelated to breast meat yield; this result highlights the importance of selecting for breast meat quality and not just meat yield.

**Improved device for egg inspections.** ARS researchers in Athens, Georgia, developed a portable candling device to check egg quality in retail stores. Candling devices illuminate the inside of an egg to identify blood spots or inclusions, and illuminate cracks, dirt or fecal matter on the shell. USDA-Agricultural Marketing Service inspectors are using the new device, which is more accurate and uses low-temperature LED lights; old candling devices required an AC source and used hot incandescent lights.

**Beta-carotene in orange-fleshed melon is more bioavailable than that in carrots.** ARS scientists in Beltsville, Maryland, in collaboration with university partners, determined the human availability of beta-carotene from digested orange-fleshed melons and carrots. Although carrots are four times higher than the richest melon fruit in beta-carotene the amounts absorbed were the same. The reason was discovered to be the type of plant structure (chromoplast) in melon compared to carrot. Beta-carotene is a fat soluble nutrient and melon chromoplast are fatty (globular) in structure promoting beta-carotene availability, whereas, carrot chromoplasts are hard (crystalline) in structure limiting human availability of beta-carotene. Thus, although melons are four-times less concentrated in beta-carotene than carrot, melon is on par with carrot as major dietary source of bioavailable beta-carotene (provitamin A).

**Heirloom collard, mustard and kale plants are exceptionally rich in healthful vitamins.** Heirloom populations of leafy green brassica crops (collard, mustard and kale) have been grown in isolation for centuries by ‘seed-saver’ farmers in the southeastern U.S. ARS scientists in Beltsville, Maryland, investigated vitamins C, E, K, folate (B<sub>9</sub>), and beta-carotene (provitamin A) concentrations in heirloom populations of leafy greens from collard, mustard and kale and found these plants to be exceptionally dense in essential human vitamins with younger leaves more dense in vitamins than older leaves. These differences reveal opportunities for genetic improvement through plant selection and breeding in commercial leafy-green brassicas.

**Microgreens are nutrient dense.** Colorful, attractive and unique microgreens (vegetable and herb seedlings harvested at the very young ‘seed’-leaf verses the older ‘true’-leaf stage are finding growing sales for soups, salads, sandwiches, and meat dishes at high-end eateries. ARS

scientists in Beltsville, Maryland, in collaboration with university partners, assayed 26 different species of vegetable and herb microgreens for critically important human health nutrients vitamins C, E, K, carotenoids and beta-carotene (provitamin A). Compared to older 'true'-leaf tissue in the same species, microgreens were as much as 400 times more nutrient dense. These same ARS scientists significantly extended shelf life of microgreens by optimizing postharvest storage temperature (5 °C) and package atmosphere (elevated CO<sub>2</sub> and reduced O<sub>2</sub>). They also determined that adding calcium during germination of broccoli microgreens substantially increased yield (size) and extended storage life by 2-3 days. The use of calcium for extending shelf life is now being evaluated for other microgreens and the underlying genetic/biochemical mechanisms behind this calcium effect is under investigation.

**Increasing storage life of edible flowers.** Consumer demand for edible flowers (carnations and snapdragons) is growing substantially, but they only last for 3-5 days in conventional packaging. ARS scientists in Beltsville, Maryland, determined storage conditions for edible flowers that maximized storage life. Specifically, they determined that storing under modified atmosphere (elevated CO<sub>2</sub> and reduced O<sub>2</sub>) and slowly-released 1-methylcyclopropene maintained flower quality for 14 days which will result in substantial savings for commercial florists, caterers and restaurants, and consumers.

**Nitrogen availability is the major determinant of nutritional content in organically versus conventionally-grown produce.** Many consumers believe that organic produce is more nutritionally healthful than its conventionally-grown counterpart. ARS researchers in Beltsville, Maryland, found that the nutritional quality of both organically- or conventionally-grown produce depends mostly on the form of soil nitrogen and its release-rates. In organic production systems nitrogen is poorly available, due to its slow release rate from the breakdown of organic matter, generally resulting in more ascorbic acid (vitamin C), sugars, and phenolic (antioxidant) compounds in the plant. Whereas, in the conventional system, nitrogen is immediately available, generally resulting in higher chlorophyll (greener) and carotenoid content in the plant; as well as higher yields.

**Small-scale peanut processing for developing countries.** Most peanuts grown in developing countries are lost to post-harvest rotting because the small farmers in these countries lack equipment to dry, shell, size or separate peanuts quickly after harvest. The Meds and Foods organization built and deployed in Haiti a small-scale dryer designed by ARS researchers in Dawson, Georgia, for small-scale peanut processing. The equipment reduced post-harvest losses by ~75 percent. These same researchers also developed a small-scale device to shell, separate and size peanuts and which is being used in Haiti to produce Medica Mamba, a peanut butter-based ready-to-use therapeutic food for treating malnutrition in children.

**New device to enable automated control of peanut dryers.** Control of peanut drying in industrial processes requires repeated laboratory analyses of shelled and cleaned kernels in order to measure kernel moisture. ARS researchers in Dawson, Georgia, developed a rapid, portable, low-cost instrument to measure in-shell moisture content quickly on the factory floor. The instrument, which uses RF (radio frequency) technology, is being commercialized for controlling peanut dryers; and a fruit processor is now working with these same ARS researchers to utilize

the RF device to control fruit drying processes and possibly to detect pits remaining in dried fruits more accurately and economically.

**Effects of production and processing conditions on oat beta-glucan.** Beta-glucan, a type of fiber found in oats, has been shown to help lower blood cholesterol. However, the effects on beta-glucans from changes in growing or post-harvest processing conditions were largely unknown. ARS scientists at Fargo, North Dakota, in collaboration with North Dakota State University, determined that oats grown during a wet season have higher beta-glucan content. These same researchers also determined that the molecular structure in beta-glucan changes depending on whether the oats are grown under relatively wet or dry conditions. These researchers also compared the two types of heat treatments used in the processing of oats and found that steam-heating beta-glucans may enhance the ability of beta-glucans to lower blood cholesterol more so than dry heating.

**Improving food safety for point-of service juicers.** ARS scientists at Ft. Pierce, Florida, with the support of the State of Florida, developed a standard operating procedure (SOP) and created a teaching video for sanitizing table-top, point-of-service juicers. These same researchers also found that point-of-service juice contains more peel oils, lower pectin, more active enzymes, higher volatiles, and higher terpenes than conventionally-processed, prepackaged juice. These are all qualities that improve taste and health benefits of citrus juice.

**Improving quality in strawberries and blueberries.** Breeding new cultivars of fruits with superior sensory attributes (e.g., crispness and firmness) is hampered by the need for time-consuming and expensive human sensory panels to assess these attributes. ARS researchers at Ft. Pierce, Florida, in collaboration with the University of Florida, developed effective correlations between readings from a commercial texture analyzer and sensory attributes as measured by sensory panels. This correlation is now used by blueberry breeders to select superior cultivars based simply on data from the commercial analyzer. These same researchers also developed a method involving the detection of volatile compounds released by fruit to identify when strawberries and blueberries should be harvested so as to maximize consumer-perceived quality. These researchers also developed, in collaboration with the University of Florida, a sweeter and richer-tasting strawberry cultivar (Winterstar™). The cultivar has been commercialized and will be used to produce 5 percent of Florida's 2012-2013 crop.

**Predicting flour quality for breadmaking.** ARS scientists in Manhattan, Kansas, in collaboration with a nonprofit wheat marketing organization (Plains Grains Inc.), developed a rapid method to predict flour quality for bread making. The new method is 66 percent faster than the current method, requires only 1 gm of sample, and exhibits higher correlation to bread loaf volume. The method is currently being assessed for use in the annual Hard Winter Wheat Crop Survey. These same scientists also modified the standard method for measuring dough extensibility so that it could assess small samples of flour, and should be especially useful to wheat breeders. The modified method also reduces mix time and simplifies sample preparation. Further, these scientists, along with ARS researchers in Fargo, North Dakota, scientifically validated the ability of the traditional visual method for assessing quality of wheat kernels (percent vitreous kernel content) to correctly estimate protein content and predict bread making quality of resulting flour.

**Fate of wheat phytonutrients after production of whole grain products.** ARS scientists in Pullman, Washington, and Beltsville, Maryland, determined that the most abundant phenolics in wheat grains largely survive dough proofing and baking processes. These phenolics – ferulic acid, lutein and  $\alpha$ -tocopherol (Vitamin E) – are probably stable because they are bound and insoluble – and all are associated with health benefits.

**Relating protein content to tortilla quality.** Tortillas are a high-growth market in the U.S. To help provide wheat breeders with biomarkers to facilitate development of superior varieties for the production of tortillas, ARS scientists at Manhattan, Kansas, in collaboration with Texas A&M and non-profit trade organizations, determined that low glutenin content is preferred for tortilla flour. In contrast, high glutenin content is needed to maximize bread loaf volume.

**Developing genetic markers for sorghum breeding.** Sorghum breeders lack genetic markers for important end-use quality traits such as physical grain traits, protein, starch, and phenolic content as well as anti-oxidant levels. ARS researchers at Manhattan, Kansas, screened and characterized large genetically diverse sorghum populations for these end-use quality traits, and Kansas State University collaborators are using the data to identify genetic markers associated with these traits.

**Accurate real-time measurement of moisture in grain elevators.** Although moisture is a critical parameter in grain storage, there has been no easy method for determining moisture levels inside grain elevators. But now, grain elevator operators are installing a system developed by ARS researchers at Manhattan, Kansas, to continuously monitor the moisture content inside elevators. The system is based on moisture-sensing wire/cables.

**Predicting cross-reactivity of allergens in different nuts.** Allergists assume that patients allergic to a particular nut are also sensitive to other nuts, but no laboratory-validated reference database of such cross-reactivities existed. ARS scientists in New Orleans, Louisiana, in collaboration with university partners validated the cross-reactivity of nut-based allergens using immune assays; the resulting data of cross-reactivities for nut allergens has been incorporated into the on-line Structural Database for Allergenic Proteins (SDAP).

**Effect of ripening temperatures on avocado quality.** California avocado producers use a variety of temperatures to ripen their fruit, but no scientific study has been done to assess the effect of ripening temperature on consumer-perceived quality. ARS scientists in Parlier, California, in collaboration with the University of California, that final quality of ‘Hass’ avocados, as measured by texture, richness, degree of grassy flavor, and taste, is relatively unaffected by the range of temperatures used in industry for ripening (15-25 °C).

**Aseptic sweet potato purees answer emergency food security needs.** ARS scientists in Raleigh, North Carolina, in collaboration with university partners, developed a continuous microwave sterilization process allowing for the high-volume production of aseptic packages of sweet potato purees, approved for USAID Emergency Food security needs. Other vegetables like golden potatoes and fleshy fruits like pumpkins and squash, equally abundant in nutrients like sweet potatoes, have been shown to be excellent candidates for this aseptic packaging

process. Patents for this aseptic microwave process have been filed in China, New Zealand, Australia, and an international patent has recently been filed in the U.S. The U.S. licensee has built a processing facility in North Carolina that produces 40,000 lbs (18,160 kilos) of aseptic puree packages per day.

**Reducing waste treatment-related costs in pickled cucumber production.** Current commercial practice employs acetic acid, sulfite and salt for preserving cucumbers in bulk before pickling; but these chemicals create a significant waste treatment burden for the industry and some consumers are sulfite-intolerant. ARS scientists in Raleigh, North Carolina, developed a sulfite-free acidification treatment for preserving cucumbers that significantly reduces wastewater treatment costs. An industrial partner is commercializing the technology.

**Reducing risk of spoilage in pickled products.** *E. coli* are the most acid-resistant pathogen in refrigerated pickle products. ARS researchers in Raleigh, North Carolina, modified commercial brine formulations to achieve significant reduction of pathogenic *E. coli* without affecting flavor or other quality attributes. The modified method also inhibits lactic acid bacteria in refrigerated storage, and should also inhibit other pathogens. These researchers are working with industry to adopt the technology. In addition, the same researchers determined that using phosphoric acid (rather than acetic acid) to adjust pH in pickling brine prevents spoilage (secondary fermentation) in pickles. An industrial collaborator is using the technology commercially.

**Identifying peanut production lots more or less prone to turning rancid.** Peanut varieties with high oleic to linoleic acid ratios (O/L) are favored in the marketplace due to their increased oxidative stability (less rancidity). ARS scientists in Raleigh, North Carolina, determined that seed maturity is the greatest determinant of seed O/L ratio. In the process of conducting this research, these scientists also developed a rapid and inexpensive method for determining oleic-to-linoleic (O/L) ratio in individual seeds and the peanut industry is adopting this new method to assess O/L variability in individual product lots.

**Minimizing post-harvest spoilage of tree fruits.** Pear growers worldwide use ethoxyquin, an antioxidant and food preservative, to control superficial scald, but the European Union may ban the use of ethoxyquin. ARS researchers in Wenatchee, Washington, determined that 1-MCP (an inhibitor of ethylene hormone) is an effective substitute for ethoxyquin for prevention of superficial scald during or after storage of 'Anjou' pears if they are treated within 7 days after harvest. In addition, they found that the use of 1-MCP also delays fruit ripening and may preclude the need for controlled-atmosphere storage after harvest. These same researchers also identified storage conditions that prevent/reduce stem-end browning in 'Gala' apples. In addition, they found that 'Honeycrisp' apples maintain their flavor during long-term storage if titratable acidity (TA) in the fruit is 0.5 percent or higher and that higher TA values are facilitated by application of 1-MCP after harvest and/or during storage under controlled atmosphere (low O<sub>2</sub>, high CO<sub>2</sub>). They also found that keeping 'Gala' apples dry and using a commercial coating to prevent sunburn (i.e., Epishield<sup>TM</sup>) before harvest lowers the risk of peel lenticel (pore) breakdown during storage. They also determined that 1-MCP treatment (at harvest) of 'Lady Alice' apples had no effect on lenticel breakdown during storage, and indeed that storing this cultivar under a controlled atmosphere (low O<sub>2</sub>, high CO<sub>2</sub>) made these apples more susceptible to lenticel breakdown than when they are simply stored in air.

## 2. Fibers

**New rapid, low-cost process for making nano-materials.** The promise of nanotechnology to add value to agricultural applications has been slowed by the inability to scale-up production of nano-materials and be cost-effective. ARS scientists at Albany, California, have developed a new ‘blow’-spinning process to produce nano-materials, which is much cheaper and rapidly scaled-up compared to the industry standard, electrospinning. The specific advantages of nano-scale ‘blow’-spinning are: a higher fiber production rate, an ability to scale-up production using inexpensive commercially-available components, an ability to ‘blow’ nano-materials onto surfaces without consideration of their electrical charge, its relative portability, and savings in that no high-voltage equipment is required. A patent has been filed. Currently ‘blow’-spinning, using biobased materials, is being tested by a large convenience-food company to reduce “noisy” packages.

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

**Improved lint cleaner.** Saw-type lint cleaners in cotton ginning operations tend to reduce fiber length and create neps (entangled fibers). Modeling the design of spike cylinders used in the textile industry, ARS researchers in Lubbock, Texas, developed a sawless lint cleaner to improve fiber quality. The device has successfully completed 2 years of a 3-year field test at a commercial cotton gin.

**Enabling market growth for non-woven cottons.** Non-woven cotton fabrics hold great promise for increasing cotton demand in the U.S. and world-wide. ARS researchers at New Orleans, Louisiana, developed a needle punch process to attach nonwoven cotton batting to other fabrics for applications in home craft markets (e.g., quilting, pillows). Products utilizing this technology are now being sold in Jo-Ann Fabric and Craft Stores and Walmart. These same researchers also showed that lower-quality, lower-cost, byproduct cotton fibers from ginning can be blended with full fiber to create nonwoven fabrics of acceptable quality. In addition, these researchers demonstrated that using hydroentanglement to produce cotton nonwoven fabrics results in products that exhibit (1) unexpected strength when wet and (2) retain more strength after laundering than expected. These findings indicate that cotton nonwovens are good candidates for applications in semi-durable products (e.g., geotextiles, automotive and garments) and in disposables such as wipes, diapers and personal care.

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

**New standard analytical method for moisture content in cotton fiber.** ARS scientists in New Orleans, Louisiana, developed a more accurate analytical method for measuring moisture content in cotton fiber. The method is recognized by ASTM International as the standard method (ASTM D7785-12).

**Increasing the value of seed cotton.** “Seed cotton” is the cotton fiber that’s still attached to the seed after ginning. Cotton ginners are blending more lint from seed cotton, but are unsure of the impact on product quality. ARS researchers in Stoneville, Mississippi, in collaboration with a commercial ginner, determined that up to 2 percent fiber from seed cotton cleaning can be blended with ginned cotton without significant loss in overall product quality. These same researchers also determined that cultivar type had the largest influence on fiber loss when cleaning seed cotton at high throughput rates (processing more material per unit width on the gin). These results are useful as commercial ginners are processing at high throughput rates, but are not sure of the impact on fiber loss or quality. Further, these scientists, in collaboration with ARS researchers in New Orleans, Louisiana, and a commercial mill, demonstrated that whereas seed cotton from saw ginning is not acceptable for fiber-spinning, seed cotton from roller-ginning can be used for spinning cotton fiber.

**Minimizing energy waste in cotton ginning.** Electrical power accounts for over 25 percent of the variable costs in cotton ginning, and the bulk of the electrical consumption is for powering the ginning equipment. ARS researchers in Stoneville, Mississippi and Las Cruces, New Mexico, determined that ginners can minimize energy costs by shutting down idle equipment whenever the time between processing bales exceeded 12 minutes.

**Screening cotton cultivars that are easier for ginning.** Cotton breeders would like to develop new varieties that can be ginned faster and with less energy, but the traditional method used to measure fiber-seed attachment force is very time consuming (individual seeds are tested with a pendulum and inclinometer and involve 2-4 pendulum swings per seed). ARS researchers in Stoneville, Mississippi, developed an accurate automated method to measure fiber-seed attachment force that simply involves measuring the power consumption in a lab-scale gin stand (where fiber is separated from the seed). Other ARS researchers at the same location are now using this new method to screen varieties and have begun using it to identify specific genes associated with ginning efficiency.

**Developing new biobased products from waste hide material.** Collagen fiber can be produced from untanned hide scraps and exhibits superior toughness and ductility, but there are few value-added applications for hide-derived collagen. ARS scientists in Wyndmoor, Pennsylvania, have developed technologies for using collagen in industrial products such as air filters and biobased polymer reinforcements. A tanner is validating these technologies at commercial scales. Other ARS scientists at the same location have developed a computerized molecular model for collagen microfibrils that biomaterials engineers can use to evaluate *in-silico* ideas for using or modifying collagen or for inserting active agents into collagen.

**Economical and environmentally-benign process for removing dried manure from hides.** “Adobe” manure (dry & matted manure and hair) is difficult to remove from hides and is a major problem in meat and hide processing operations. Utilizing low-cost and biodegradable materials (crude glycerol and enzymes), ARS researchers at Wyndmoor, Pennsylvania, developed an effective cleaning process to remove adobe manure. The process is being validated at commercial-scale by a meat packer.

**Value-added products from wool-based keratin.** ARS scientists in Wyndmoor, Pennsylvania, developed urethane-like derivatives of wool-based keratin. The derivatives are elastomeric, adhere well to hair, skin and nails (which are also keratin-based), and are effective substitutes for silicones in cosmetics. These same scientists also developed a new technology for sulfonating keratin into products that, unlike sulfonated keratin currently used in hair conditioners, actually strengthens hair. Patent applications have been filed for both technologies and an industrial partner plans to commercialize them.

### **3. Biobased Products**

**Novel nanoparticles improve glass window cleaners.** While nanoparticles have attractive industrial properties, when used in liquids, over time, they bind together and fall out of solution becoming ineffective. ARS scientists at Peoria, Illinois, developed a bio-degradable solution of protein nanoparticles when applied to solid surfaces like glass, spread out preventing the beading of water. Near-term application includes solar panels and side-windows on vehicles which have no wipers. This technology, applicable to the manufacturing of glass-window cleaners, is expected to show superiority over current, commercially available cleaners. An invention disclosure has been submitted and a patent application is in process. Additional research has shown nanoparticles can be prepared with proteins from various sources such as cereals whose proteins showed promising features: better functionality and lower production cost.

**A new family of bio-based lubricant additives using boron.** Current lubricant additives require the use of phosphorous, zinc, and sulfur in order to be effective, but can react with water, forming acids that corrode engine parts and bearings; and they are often incompatible with plant (bio-based) lubricants. ARS scientists at Peoria, Illinois, in collaboration with an industrial partner, have synthesized new organic additives, made primarily from boron compounds, in formulations utilizing gel-stabilized (hardened/epoxidized) bio-based oils. From this research, anti-wear and anti-oxidation, boron additives have been shown to be highly effective with soybean oil lubricants. This development helped in the creation of new bio-based lubricants

which can be used in a wide variety of industrial applications. A patent on ‘organoboron’ compounds has been filed.

**Rice-based encapsulates.** ARS scientists at New Orleans, Louisiana, have produced nano-scale encapsulation of Co-Enzyme Q-10 with rice starch and micro-scale encapsulation of blueberry phenolics with porous rice flour and starch. Encapsulation of bioactive components improves several characteristics important to food products; including the extension of shelf life, removal of bitter taste, and increased bioavailability. The characteristics of these two encapsulates will provide a unique delivery system of healthy bioactive compounds into baked foods and beverages, with improved taste characteristics and improved oral bioavailability. This research will provide healthier food products and will benefit consumers and also farmers by utilizing waste products (blueberry, pomace, etc).

**Prebiotic for livestock.** ARS researchers in Peoria, Illinois, developed a process converting waste products from the Texas yellow pine wood-paneling industry into a low-cost, nutrient additive for the livestock and pet food industries. This sugar-based compound enhances the growth of beneficial bacteria which promotes intestinal health, while suppressing enteric (food-borne illness) bacteria. This technology has been transferred to industry and is being used to produce Previda™, a commercial prebiotic.

**New platform for sugar-based chemicals.** ARS scientists in Peoria, Illinois, have developed and patented a chemistry which utilizes fruit and vegetable processing waste and converts it into glycoside-based (–C–) oligosaccharides, that are both water and fat soluble (in effect a detergent). By changing the choice of sugars, these detergents can be either strong for use in dishwashing, or exceptionally mild for use as baby shampoos. The process also avoids the use of environmentally-problematic organic solvents.

**Substitutes for gum Arabic.** Gum Arabic, commonly used in chewing gum and as an emulsifier in foods and beverages, is produced only in politically unstable sub-Saharan Africa. ARS researchers in Peoria, Illinois, developed and patented an enzymatic process for converting a microbially-produced polysaccharide (alternan) into a product with properties similar to gum Arabic. The process is completely GRAS-certifiable (Generally Recognized as Safe), so that the product can be used as a food ingredient. In addition, a different group of ARS scientists at Peoria, Illinois, developed a soy-based, biodegradable and digestible replacement for gum Arabic. This second technology is currently being tested by an industrial cooperator in preparation for commercial implementation.

**Applying genetic engineering to guayule, an industrial crop.** Most natural rubber is produced in Southeast Asia; but guayule, a woody plant, is now being cultivated in the U.S. for the production of natural rubber for medical applications and possibly for automotive tires. ARS scientists at Albany, California, and Maricopa, Arizona, in collaboration with university scientists, have sequenced the guayule genome. The same ARS researchers in Albany, California, also developed a new protocol for *in vitro* tissue culture of guayule; the new protocol has a 30 percent faster regeneration rate compared to prior protocols. These accomplishments are greatly accelerating the breeding of new guayule varieties with superior traits.

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

**Biochars to reduce heavy-metal contamination in water from military training ranges.**

Rainwater draining from soils at military firing ranges is typically contaminated with heavy metals such as lead, copper, nickel and cadmium. An estimated 12,000 military and non-military shooting ranges are scattered across the U.S., and heavy metal – especially lead – contamination is a regulatory concern. ARS researchers at New Orleans, Louisiana, in collaboration with the Army Research Laboratory and other DoD partners developed biochars specifically formulated to bind heavy metals in soils. The researchers determined that producing biochars produced via slow (lower-temperature) pyrolysis from materials containing higher levels of leachable phosphorous, and which were activated by a post-pyrolysis oxidation step, were the biochars that maximized the binding of heavy metals. Adding properly-produced biochars to contaminated soils decreased soluble Pb, Cu, Ni and Cd concentrations in leachate water from 300µM to below detection limits.

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

**Camelina meal for healthful livestock feed.** Camelina, an oilseed crop, is under development to produce and convert camelina oil into renewable jet fuel. However, value-added uses need to be developed for the seed meal byproduct (after deoiling). In response to this need, ARS scientists in Peoria, Illinois, developed the meal as a healthful ration in livestock feed. Specifically, they found that the meal contains cancer-inhibiting glucosinolates similar to the glucosinolates found in broccoli. Further, unlike glucosinolates in canola – another oilseed crop being developed for bioenergy production – camelina-derived glucosinolates are not goitrogens (causative agent for goiter disease). The research resulted in an FDA-approved feed additive for egg-laying chickens and the FDA is considering approval of its use in feeds for dairy cattle and pets. In addition, ARS scientists in Wyndmoor, Pennsylvania, developed a process to remove the slimy mucilage (a polysaccharide) that coats camelina seeds, thereby increasing the value of

camelina seed meal in aquaculture feeds. These same scientists are also evaluating the mucilage for use as a drilling fluid in oil and gas wells. *[research for this second technology was done under NP213]*

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