Produce Quality and New Uses (NP 306)
2022 Annual Report

Introduction

The USDA-ARS National Program NP306: Product Quality and New Uses (including biorefining) in 2021 started its first year of its 5-year research plans for the various research projects. Scientists in NP306 continue to demonstrate impact in numerous and diverse areas of research that enhance marketability of agricultural products, increase the availability of healthful foods, develop value-added food and nonfood products, and enable commercially viable technologies for post-harvest processing and biorefining. National Program 306 Vison & Relevance can be found at: https://www.ars.usda.gov/nutrition-food-safetyquality/product-quality-and-new-uses/ and includes: the FY2020-2024 Action Plan for NP306.

The overarching goal of NP 306 is to conduct research that develops knowledge and enables commercially viable technologies to: (1) Measure and maintain/enhance post-harvest product quality, (2) Harvest and process agricultural materials, and (3) Create new value-added bio-based products.

By developing commercially viable technologies that maintain/enhance postharvest product quality and create new products, ARS Product Quality and New Uses research increases the demand for agricultural products and, therefore, benefits both agricultural producers and rural communities.

This National Program is organized into three problem areas:
(1) Foods – Problem Areas of research are: 1a. Define, measure, and preserve/enhance/reduce attributes that impact quality and marketability; 1b. New bioactive Ingredients and health-promoting foods; and 1c. New and improved food processing and packaging technologies.

(2) Non-Foods – Problem Areas of research are: 2a. Maintain/enhance fiber and hide quality; and 2b. Enable technologies to produce new and expand marketable nonfood biobased products derived from agricultural feedstocks.

(3) Biorefining – Problem Areas of research are: 3a. Viable technologies for producing advanced biofuels (including biodiesel, and sustainable aviation fuel), or other marketable biobased products; 3b. Technologies that reduce risks and increase profitability in existing industrial biorefineries; and 3c. Accurately estimate the economic value of biochemical, thermolysis conversion technologies.

During FY 2022, National Program 306 had 201 full-time scientists and 37.8 vacancies working at 21 locations across the U.S. actively engaged in 62 ARS-base funded projects. Number of graduate students and postdoctoral students 72. The quality and impact of NP 306 research was further evidenced in 2022 by the following:

- 289 refereed journal articles published
- 10 new patents
- 10 new patent applications
- 14 new invention disclosures submitted
- 37 current cooperative research and development agreements with stakeholders
- 37 new material transfer agreements with stakeholders.

In 2022, NP 306 scientists participated in research collaborations with scientists in 31 different countries:

ARGENTINA - 1
AUSTRALIA - 2
BELGIUM - 1
BRAZIL - 10
CANADA - 3
CHILE - 1
CHINA - 7
COSTA RICA - 1
DENMARK - 1
FRANCE - 4
GERMANY - 2
GREECE - 2
ISRAEL - 1
ITALY - 2
JAPAN - 3
MALAYSIA - 2
MEXICO - 2
MOZAMBIQUE - 1
NEW ZEALAND - 2
PAKISTAN - 2
PHILIPPINES - 1
SLOVAKIA - 1
SOUTH AFRICA - 1
SOUTH KOREA - 7
SPAIN - 4
SWEDEN - 1
SWITZERLAND - 1
THAILAND - 1
TURKEY - 4
UGANDA - 2
UNITED KINGDOM – 3

Significant Accomplishments for FY 2022 – NP306

This section summarizes significant and high impact research results that address specific components of the FY 2020-2024 action plan for NP 306. Each section summarizes accomplishments of individual research projects in NP 306. Many of the programs summarized for FY 2022 include significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA-ARS research by rapidly disseminating technology, which enhances the impact of ARS research programs.

Component # 1 FOODS

Developing and validating a universal measurement protocol for hemp THC concentrations. Total THC concentrations in commercial hemp materials cannot exceed 0.3 percent. Meeting this standard has been a challenge to U.S. hemp producers and requires clear and reproducible analytical methodology. ARS researchers in Peoria, Illinois, developed a rapid 10-minute measuring procedure to determine 20 different cannabinoids and validated a reproducible ethanol extraction method to be used worldwide to analyze for tetrahydrohydrocannabinoid, delta-9 tetrahydrohydrocannabinol, and tetrahydrohydrocannabinoic acid. In collaboration with NIST, researchers participated in an analysis of three uniform samples examined by

130 labs and found that postprocessing methods can generate variable results. Findings were presented in 2022 at the Phytochemical Society of North America Annual Meeting and the Cannabis Research Conference. (NP 306, C3, PSA, Project No. 5010-41000-183-000D)

Catfish bone powder increases the appeal of fried catfish strips. Catfish bones or frames are a waste product of the filleting process. ARS scientists in New Orleans, Louisiana, and Louisiana State University colleagues transformed catfish frames into a high calcium, safe-to-eat bone powder and incorporated it into breading mixes. Fried catfish strips coated with bone powder mixes generated positive feedback and favorable acceptance from consumers. Additionally, information about bone powder utilization increased consumer interest in product purchases. Using this catfish byproduct in prepared foods can reduce waste from the seafood sector, enhance value for producers, and increase calcium in foods without hindering sensory quality. (NP 306, C1, PSC, Project No. 6054-43440-051-000D)

Controlling apple peel disorders linked to climate change. Increasing temperatures and sun exposure contribute substantially to apple peel disorders and postharvest loss and waste. ARS scientists in Wenatchee, Washington, and Washington State University collaborators developed a fruit sorting protocol that determines the risk of apples developing climate-related postharvest disorders. This protocol predicted the development of sunscald, a sun-related disorder that affects the highly sensitive 'Granny Smith' variety and many other commercially important apple cultivars, with a 95 percent accuracy rate even before symptoms developed. Adapting this system to existing commercial apple fruit sorting lines or in-field sorting lines essentially eliminates sun-related postharvest disorders and crop loss from the apple industry cold chains. This research received financial support from the Washington Tree Fruit Research Commission. (NP 306, C1, PSA, Project No. 2094-43000-008-000D)

Annual baking quality assessment of hard winter wheat elite lines. ARS scientists in Manhattan, Kansas, completed the annual Hard Winter Wheat Crop Quality Survey, which included evaluating more than 600 individual and more than 100 composite hard winter wheat samples for milling and baking quality. The resulting data was posted in real time to a webpage managed by Plains Grain Inc. as the harvest progressed; the data was also used by U.S. Wheat Associates in their final annual report for domestic and international customers, which had an export value of $7.2B in 2021. (NP 306, C1, PSA, Project No. 3020-44000-027-000D)

Potato postharvest consumer quality evaluations and new potato cultivar releases. Acceptable processing quality after storage is an essential attribute of a successful commercial potato variety. The standardized evaluation procedures developed and used by scientists in East Grand Forks, Minnesota, are an important component of the overall evaluation process and release of new cultivars by federal and state cooperators nationwide. In the past year, in support of federal and non-federal public breeding/screening programs, 161 advanced breeding lines were analyzed for storage/processing quality at multiple storage temperatures and durations. Data from these analyses have contributed to the release of new commercial potato varieties. These improved varieties offer significant benefits to both producers and processors as they are adopted by the potato industry. (NP306, C1, PSA, Project No. 3060-21430-008-000D)

Pecan genome sequences advance creating new pecan cultivars. The United States no longer leads in global pecan production. Understanding the genes controlling beneficial characteristics, including climate, fungal and pest resistance; salinity and drought tolerance; and reduced allergen content, will allow U.S. pecan farmers to regain a competitive edge in the global market. Traditional breeding methods can take more than 10 years to identify pecan varieties with improved traits. ARS researchers in New Orleans, Louisiana, sequenced the genomes of four genetically important pecan cultivars from different locations

and identified several genetic markers associated with important plant characteristics. The genome sequences and genetic markers obtained by this research will enable more directed strategies and reduce the time needed to create new pecan cultivars with desirable traits. (NP 306, C1, PSC, Project No. 6054-43440-052-000D)

Hemp seed oil-based margarine for health-conscious consumers. Cold-pressed hemp seed oil (HSO) is known to have many bioactive phytochemicals that promote human health and is low in saturated fats. ARS researchers in Peoria, Illinois, used their oleogel technology—a process where semi-solid fat or oil replaces unhealthy solid fats and is combined with natural waxes to make margarine—to create a HSO-based oleogel. When compared with commercial grade margarine spreads for hardness, HSO oleogel was achieved with less than 3 percent wax, whereas hardness for commercial stick margarines required up to 7 percent wax. This information is important for food companies seeking a way to develop healthier spreads that incorporate oils with low levels of saturated fats and healthful bioactive components. Margarines based on HSO will be highly desirable for health-conscious Americans. MARS Inc. and ParagonPure have initiated interest in this technology (NP 306, C1, PSB, Project No. 5010-44000-054-000D)

Cat litter from soybean hull waste. Most commercial cat litters are made from bentonite, a clay that absorbs urine and causes the litter to clump when becoming wet. Bentonite is mined, and cat litter from this clay presents both a long-term disposal problem and a health issue for asthmatic cats. Current commercial biobased cat litters are biodegradable and do not trigger asthma, but they do not control odor. Biochar pellets made from soybean hulls, an industry waste product, are an excellent absorbent for both odor and liquids. ARS researchers in Peoria, Illinois, used soybean hull biochar combined with copper sulfate—an antimicrobial substance that reduces cat-urine compounds—and an amylose inclusion complex to make cat litter. The efficacy of the resulting biobased and environmentally friendly litter was tested using simulated cat urine, and the litter was found to significantly reduce the growth of pathogenic bacteria and odor. A patent application based on this development has been filed and is being evaluated by a commercial cat litter company. (NP 306, C1, PSB, Project No. 5010-41000-182-000D)

Evaluation of sorghum cookies as inclusions in ice cream. One of the most popular ice cream types is cookies-and-cream which includes the addition of traditional wheat-flour cookies into the product. The use of wheat-flour cookies, however, introduces gluten into the ice cream. As an option for a gluten-free product, researchers from ARS in Manhattan, Kansas, and Kansas State University formulated and investigated two types of sorghum-flour cookies (chocolate and non-chocolate) for use as inclusions in ice cream. The sorghum-flour cookies had similar width, spread and thickness as wheat-flour cookies. The sorghum-flour cookies also had similar hardness to wheat-flour cookies when frozen. Chocolate sorghum-flour cookies were found to produce similar properties as chocolate wheat-flour cookies when crumbled, an important aspect for consideration as ice cream inclusions. The results of this study demonstrated that chocolate sorghum-flour cookies could be used as a gluten-free alternative for ice cream inclusions and opens new markets for use of sorghum flour. (NP 306, C1, PSA, Project No. 3020-43440-002-000D)

Single seed near infrared instrument facilitates corn hybrid development. Single seed, near infrared (NIR) instruments developed by ARS researchers in Manhattan, Kansas, are being used by collaborators at two university maize breeding programs in Ames, Iowa, and Gainesville, Florida. They are being used to sort doubled haploid (DH) seeds from hybrid seeds which has been a major bottle neck in the use of DH technology. Sorting is based on detection of the small oil content differences naturally found between DH and hybrid seeds. DH seeds are valuable in creating inbred lines used for hybrid development. The instruments will enable a faster and more cost-effective development of inbred plants, which in turn are used to create commercial hybrids. Ultimately, the time to develop hybrids will be shortened, allowing breeders greater flexibility to address issues of plant disease resistance, climate adaptability, and improved

agronomic traits, which will also benefit farmers. (NP 306, C1, PSA, Project No. 3020-43440-010-000D)

Computer simulation modelling improves fumigation in grain storage bunkers. A computer model was developed by ARS researchers in Manhattan, Kansas, and used to determine causes of fumigation failures in sealed grain storage bunkers. Fumigation failures in grain storage facilities allow some of the targeted insects to survive, which leads to resistant stored grain insect populations. As a result, phosphine—currently the most widely used fumigant to control the insects in stored grain—is in danger of becoming ineffective for insect control. Modeling results showed that the movement of the covering tarpaulin is the driving force of phosphine behavior in bunkers, and that phosphine distribution is very sensitive to motions caused by weather conditions. Based on these results, fumigation techniques can be modified in several ways, such as by locating the fumigant in more effective locations within the bunkers and orienting bunkers so that prevailing winds are more effective at helping distribute the phosphine gas. (NP 306, C1, PSA, Project No. 3020-43440-010-000D)

Pulse ingredients for more nutritious breads. Pulse flours are commonly added to food products to improve their functional properties, nutritional profiles, product quality, and health benefits. For bread manufacturers, however, the partial replacement of whole wheat flour with whole pulse flours (yellow pea, green pea, red lentil, or chickpea) on dough properties and bread quality has been poorly understood. Breads were processed and analyzed with up to 25% of the wheat flour replaced with whole pulse flour. Increasing the substitution level of pulse flours decreased dough viscosity, stability, development time, and bread volume. Among all the tested pulse flours, the composite flour containing yellow pea flour or chickpea flour had overall better potential for bread making by providing good dough handling properties and product quality. This study will benefit the development of more nutritious food products by combining cereal and pulse ingredients. (NP 306, C1, PSA, Project No. 3060-43440-016-000D)

Improved use of cottonseed byproducts in food packaging. Cottonseed protein (CSP) and cotton gin trash are underutilized by-products generated from cotton production. ARS scientists at New Orleans, Louisiana, in collaboration with Rochester Institute of Technology, have investigated the possibility of using cottonseed protein and gin trash as paper coating for food packaging applications. Relevant data of the coating were obtained, including the density of the CSP and gin trash, adhesion to the paper, heat sealing strength, mechanical strength, and oxygen and water vapor barrier. The CSP-based coating exhibited noticeable adhesion to paper and proved viable as coating to paper. Gin trash is a valuable addition to CSP coating, especially in enhancing heat sealing strength and oxygen barrier. For a food packaging application that allows the food item in the package to “breathe”, CSP/gin trash coating on paper can be used with moderate performance as food packaging. This work has also pointed out possible future approaches that can further improve the performance of CSP-coated paper for food packaging. (NP 306, C1, PSA, Project No. 6054-41000-113-000D)

Improving the safety and quality of refrigerated pickles. Refrigerated pickles do not undergo thermal processing, which can leave them vulnerable to microbial contamination. Previous research has shown that pathogenic bacteria, such as Escherichia coli O157:H7 could survive for more than 25% of the shelf life of refrigerated pickles. ARS researchers in Raleigh, North Carolina showed that a brief blanching of whole, raw cucumbers for 90 seconds in a 176°F water bath significantly reduced the native microbiota and is predicted to deliver a 5-log reduction of pathogenic E. coli on or within 1 mm of the surface of the cucumber. The proposed process can be implemented while maintaining the fresh-like qualities of refrigerated pickles during the typical shelf life and has the added benefit of retaining a fresher appearance for an extended shelf-life. This study illustrates that adding a brief blanching step in refrigerated pickle processing can reduce indigenous microbiota and target pathogens without negatively impacting quality attributes. This blanching process could assist pickled vegetable manufacturers in providing additional

safeguards for consumers, while maintaining a high-quality product. As the Food and Drug Administration moves towards risk-based food safety initiatives, the data generated from our study may also be useful for a future risk assessment of refrigerated pickles. This research was disseminated in invited oral presentations at stakeholder conferences and a publication in the Journal of Food Science, resulting in several pickled vegetable manufacturers expressing interest in the study results. (NP 306, C1, PSC, Project No. 6070-41000-010-000D)

A combination of human physiology and microbial metabolism produces a pH gradient along the colon. It is a critical factor for the development of the gut microbial community, a known contributor to human health. Changes to pH within microenvironments of the colon are often associated with disease and disease progression, however, the effect of pH change on the gut microbiota was unclear. To determine the ecological impact of environmental pH on the gut microbiota, ARS scientists in Wyndmoor, Pennsylvania, applied an in vitro model designed to simulate the human colon. The results demonstrated that both lowering and raising pH elicited significant changes to community structure in a donor-independent manner. Additionally, a more alkaline pH stimulated short chain fatty acid production, while these metabolites were reduced in the acidic environment. These results demonstrate that environmental pH is a critical parameter that can modulate gut bacterial community structure and function, which play an important role in human health and disease prevention. (NP 306, C1, PSB, Project No. 8072-41000-108-000D)

Component # 2 NON-FOODS

Cotton textile-based sensor to detect and trap SARS-CoV-2 virus. Combating the virus that caused the COVID-19 pandemic has been challenging for healthcare professionals and the public at large. ARS researchers in New Orleans, Louisiana, investigated how cotton can be used to both detect and prevent virus infections. They enhanced natural cotton peptides to resemble human cell peptides and demonstrated that the shape of the peptides influences their ability to adhere to the virus; they also found that the cotton peptide increased in its ability to bind with the virus as the negative charge of the peptides increased. This finding, which helped in designing protective cotton textiles, may also help in tailoring textiles to detect, trap, and neutralize viruses and in designing personal protective equipment, and could influence how we approach the development of control measures for the current and future pandemics. (NP 306, C2, PSB, Project No. 6054-41430-009-000D)

High-capacity reclaimers for high-speed roller ginning. High speed roller-ginning technology, developed in 2005, was largely adopted by the U.S cotton industry for roller ginning both Pima and Upland cotton. Operation of high-speed roller-gin stands produces a much larger amount of carryover (a mixture of unginned seed cotton and ginned cottonseed that is expelled from the roller-gin stand during operation) than is normal for conventional roller-gin stands. Existing conventional seed-cotton reclaimers cannot adequately handle the increased carryover and either become a bottleneck for production or do not adequately separate the unginned seed cotton from the ginned seed, resulting in excessive lint and seed loss. ARS researchers in Las Cruces, New Mexico, conducted research to develop and test experimental high-capacity reclaimers for the growing high-speed roller-ginning industry. The experimental reclaimers minimized the amount of seed-cotton loss, but they had more seed loss than a conventional reclaimer. Estimates of the value of the losses revealed that a conventional reclaimer had the lowest combined seed and lint loss of $3.56 per cotton bale when processing Pima cotton, while an experimental reclaimer based on a current cotton gin machine had the lowest combined loss when processing Upland cotton, nearly $10 per cotton bale less than the conventional reclaimer. That could be a significant savings considering that approximately 40,000 bales of Upland are roller ginned each year. These data were used to model and

optimize the experimental reclaimer performance and led to further testing to validate their performance. Western cotton producers could realize significant economic benefits from the adoption of this technology. (NP 306, C2, PSA, Project No. 3050-41000-010-000D)

Visualization of cotton leaf grade measurements. The cotton industry has adopted instrument rating of bales for non-lint content, otherwise known as leaf grade. Originally a visual observation, leaf grade is now determined instrumentally. ARS researchers in New Orleans, Louisiana, have developed an in-house data visualization and look-up table that maps the relationship of the total number of particles and percentage of the sample that is not lint with one of eight industry-defined leaf grades. This information is integral for developing new automated leaf grade measurement systems and will be available to researchers through a Partnerships for Data Innovation dashboard. (NP 306, C2, PSA, Project No. 6054-44000-080-000D)

Co-palletization of cotton gin trash with complimentary bio-waste. Cotton gin trash (CGT) is the vegetable by-product of the cotton harvesting process. CGT comprises from 10% to 40% of the harvested material by weight per bale of cotton depending on the harvesting method. By volume it may constitute as much as 50%. CGT has little if any market value with minimal amounts used as a supplement for cattle farmers, the remainder left to compost or returned to fields as a minimal nutrient supplement. When stored or windrowed, run-off from CGT can lead to waterway issues from herbicides and pesticides, and on occasion CGT may take a heat due to high moisture content resulting in spontaneous combustion. ARS researchers in Stoneville, Mississippi, are studying the feasibility of utilizing CGT as a source or co-source for bioenergy and as a bio-nutrient. The feasibility study parallels research efforts on pelletization of CGT. The long-term impact of the study is to support the disposition of CGT using environmentally sustainable methods to generate additional revenue for stakeholders. (NP 306, C2, PSA, Project No. 6066-41440-009-000D)

Component # 3 Biorefining

USDA-certified biobased personal care ingredients from renewable vegetable oils. New, economically viable, agri-based materials must be developed to sustain a bioeconomy that includes natural, renewable products to replace petroleum-based products. For example, ultraviolet absorbents used in personal care products such as sunscreen are derived from petroleum-based products and are potentially associated with adverse environmental and health effects. ARS researchers in Peoria, Illinois, developed biobased methods to convert vegetable oils and compounds—which are found in all plants and are particularly abundant in corn and wheat bran—into products for the personal care market. The agri-based products recently earned the USDA Certified Biobased Product label and were shown to perform equally well, if not better, as their petroleum-based counterparts. These biobased commercial ultraviolet absorbents and antioxidants make up part of a $60-million market in the United States and European Union for personal care products made with natural ingredients, a market that is projected to grow 5 percent annually. This research created new and expanded market opportunities for agricultural commodities and combats climate change by reducing dependence on petroleum-based chemicals. (NP 306, C2, PSB, Project No. 5010-41000-184-000D)

Self-neutralizing antibiotics to treat bovine mastitis. Bovine mastitis is caused by an infection in the milk ducts of dairy cattle and results in significant losses to the industry, because even when cattle are successfully treated, their milk and meat cannot be marketed for consumption. Current treatments use a significant amount of antibiotics, along with high doses of iodine, copper sulfate, and formalin. ARS researchers in Albany, California, developed a novel ‘reversible antibiotic’, or biocide, derived from natural products that has demonstrated excellent efficacy against pathogens that cause mastitis. When

formulated in a mastitis balm, this reversible biocide dramatically reversed the onset of mastitis and was as effective as high doses of iodine, the industry standard. Further research showed that the diluted biocide reverted to benign, farm-safe ingredients, which minimizes the development of antibiotic resistance associated with a residual accumulation of unwanted chemicals. (NP 306, C1, PSC, Project No. 2030-41000-068-000D)

Improved fermentation of unrefined biomass sugars into biofuels. Unrefined sugars extracted from agricultural waste residues are difficult for industry to process into biofuels because they contain numerous other chemicals that inhibit fermentation. One of the most problematic of these is acetic acid (a component in vinegar), because it persists throughout fermentation and dramatically lowers production even at modest concentrations. It is also expensive to remove using current technologies. ARS researchers in Peoria, Illinois, developed a process to conveniently remove acetate and other chemical inhibitors. The process is advantageous because it does not require additional equipment compared to other detoxification methods. The heart of the process is the fungus Coniochaeta ligniaria, which is especially good at growing on acetate. The process was also successful for fermentation of sugars prepared from acid treated biomass such as rice hulls, which are notoriously difficult to ferment because of their high acetate content. Fermentation of biomass treated with this fungus resulted in high biofuel yields. While this new fermentation process is of interest to rice farmers looking for a new market for their hulls, it also directly benefits all agricultural processors interested in biofuel production. This research recently received NIFA funding with several universities to apply this research to regional biomass feedstocks. (NP 306, C3, PSA, Project No. 5010-41000-190-000D)

High purity biophenol from renewable biomass. Phenol is a chemical with a $19.4 billion global market. It is made from petroleum and used to make many everyday products, such as plastics, pharmaceutical drugs, and herbicides. U.S. companies produce more than 1 million tons of phenol per year (with increasing demand), and they are under pressure to make it in a way that is environmentally friendly and cost-effective. ARS scientists in Wyndmoor, Pennsylvania, successfully made phenol from non-food biomass. The scientists took switchgrass and used a high temperature process to convert it into bio-oil that is similar to petroleum but contains relatively high levels of phenol. Then they separated out the phenol from the other components using processes similar to processes used in oil refineries, but with novel hardware changes. The result is a method to make phenol without expensive additives and with less complicated processes. The remainder of the oil is used to produce biofuels, and production of phenol as a high value co-product can reduce the minimum selling price of that fuel. Advancing this technology will reduce the need for both fossil-based fuels and phenol and reduce fossil greenhouse gas emissions. GlaxoSmithKline has initiated discussions to adopt this technology. (NP 306, C3, PSA, Project No. 8072-41000-112-000D)

Developed an environmentally friendly process for pennycress protein isolation. Pennycress is a winter annual that is being established as a cover crop and as a cash crop for oil (biofuel) and protein. Not only will pennycress provide an additional revenue stream to farmers, but its use as a cover crop can also increase soil quality while reducing runoff. New and improved pennycress varieties have been developed as a novel source of plant-based protein; however, no research had been done to determine if these new varieties have improved protein extractability and if the protein had market-valued properties. In addition, alternatives to petroleum- based solvents for defatting are being sought to better align with consumer preferences for ‘clean’-labelled products. ARS researchers in Peoria, Illinois, developed an environmentally sustainable method for extracting protein from the new pennycress varieties. The newly developed method produced a high-purity, highly soluble protein isolate with excellent foaming (important in whipped dairy products or dairy beverage alternatives), emulsifying properties (useful in salad dressing or paints), and water-holding properties (improving the texture of food products), thus increasing the value

of recovered protein. These new protein products will increase value and acceptance of pennycress crops and subsequently benefit farmers, downstream processors, and consumers. (NP 306, C3, PSB, 5010-41000-180-000D)

Encapsulated bio-active food ingredients into protein nano capsules that can aid in reducing the risk of chronic diseases. The most abundant and biologically active form of vitamin E is alpha-tocopherol (TOC). It is a water-insoluble antioxidant and can reduce the risk of many chronic diseases associated with oxidative stress, such as cancer, cardiovascular disease, and neurological and endocrinological disorders. However, TOC is biologically unstable when exposed to environmental factors such as light, temperature, and air (oxygen). To improve the stability of this type of bioactive compound, ARS researchers in Peoria, Illinois, have developed a procedure to encapsulate TOC into zein (corn protein) nanocapsules (the diameter of these particles is ~1/10,000 of a millimeter). The developed encapsulation process uses edible ingredients, and its encapsulation efficiency is higher than 90%, thus markedly improving the stability of the active ingredient. This new process should be applicable to the encapsulation of many other bio-active food ingredients that are not miscible in water. This technology provides a viable route to provide unstable valued ingredients to the consumer in an inexpensive and robust fashion and to utilize zein as a valuable corn product, benefiting farmers, food producers, and the ultimate consumer. (NP 306, C3, PSA, Project No. 5010-44000-187-000D)

Developed new resource for biofuel production. It has long been known that the sugar laden juice collected from sweet sorghum can be used to make butanol by fermentation. However, this leaves behind the bagasse or pressed plant stalks. ARS researchers in Peoria, Illinois, developed a new process that also converts the bagasse to butanol. Notable aspects of the process are combining steps for converting the treated stalks to sugars, fermentation, and recovery of the butanol into a single tank. Using a single tank saves money, and continuous butanol recovery greatly accelerates butanol production. This work supports expanded U.S. production of sweet sorghum, a crop which requires low agricultural inputs and is highly drought tolerant. This will benefit the biofuels industry by increasing the yield that can be realized for butanol when growing sorghum on arid lands. (NP 306, C3, PSB, Project No. 5010-41000-189-000D)

New biodiesel catalysts and feedstocks were investigated. Biodiesel which can be easily refined to make jet fuel, is a renewable, environmentally friendly alternative to conventional petroleum diesel fuel, that is produced from vegetable oils and animal fats by a process called transesterification. However, conventional transesterification requires high quality oils to be successful. In addition, the most common catalysts are not recyclable and generate large quantities of wastewater during their removal from the biodiesel product. Thus, ARS researchers in Peoria, Illinois, in collaboration with external partners, converted lower-quality feedstocks, such as tallow, Jatropha oil, and others, to biodiesel using new catalyst technologies. The recoverable and recyclable catalysts included one made from calcium and iron oxides, and another that was from a common bacteria found in soil. In addition, their use also reduced the amount of wastewater generated during the process compared to older methods. With this new technology, a variety of low-quality oils were processed, and the fuel property results compared favorably to the fuels from more expensive sources, such as a green algal oil. The improved economic competitiveness of biodiesel with petroleum diesel may result in new possibilities for fuel from agricultural resources. These benefits, such as enhancing vegetable oil supply, reducing wastewater generation, and lowering catalyst costs, will help facilitate the societal transition away from petroleum to mitigate the impact of climate change. (NP 306, C3, PSA, Project No. 5010-41000-186-000D)

Developed value-added nano-cellulose from sorghum stover expanding its commercial uses. Sorghum stover is considered an agricultural waste that has little economic value. It contains several fibers such as hemicellulose, cellulose, and lignin. Cellulose, which has been used for many years in food and non-food

applications (as digestible fibers in food products and as the major constituent of paper, paperboard, and card stock), is the most abundant organic polymer on earth. However, one of the drawbacks slowing the rate of cellulose penetration into the water soluble/dispersible products markets is that cellulose particles are too large to process in water. If the particle size of cellulose is reduced to the nanometer scale (1 nm = 1/1,000,000 millimeter), these particles can be dispersed into water and form gel-like suspensions which have unique properties that significantly expand it's beyond those highlighted earlier. These applications would include automobile panels, paints, and 3D printing. Unfortunately, little research has been conducted in using agricultural waste sorghum stover for isolating cellulose and producing sorghum nano-cellulose. ARS researchers in Peoria, Illinois, have developed a relatively simple method to prepare cellulose from sorghum stover. After treating the sorghum cellulose in a fashion often seen in the paper industry, the material was subjected to high temperature (200 F) with extremely high mixing (high pressure homogenization). This resulted in the long sorghum cellulosic fibers to be reduced mechanically to provide nano-sized cellulose. The nano-sized cellulose will broaden the use of cellulose from sorghum, a climate resilient crop, and benefit consumers by providing a new route for delivering high value biobased products. (NP 306, C3, PSA, Project No. 5010-44000-187-000D)