Action Plan
National Program 306
Product Quality and New Uses
(including biorefining)
2020–2024

Vision
To be recognized worldwide as a research leader in agricultural product quality enhancement/consistency, new uses, and biorefining that benefit the consumer, adds value for the producer, diversifies agricultural feedstock use, and promotes rural economies and environmental sustainability.

Mission
The mission of National Program (NP) 306, Product Quality and New Uses, is to conduct research that develops more healthful, value-added foods; results in enhanced biobased products including biofuels; and reduces loss and waste through commercially preferred technologies for postharvest processing, packaging, and storage.

Relationship of This National Program to the USDA Strategic Plan
This action plan outlines research that supports the following objective in the USDA Strategic Plan for FY 2018–2022:

- Goal 2 – Maximize the ability of American agricultural producers to prosper by feeding and clothing the world.
    - Objective 2.2 – Increase agricultural opportunities and support economic growth by creating new markets and supporting a competitive agricultural system.

Research outlined in this action plan also supports the following USDA Strategic Plan objectives:

- Goal 3 - Promote American agricultural products and exports.
    - Objective 3.1 - Expand international marketing opportunities.

Relationship of This National Program to the USDA Resource, Education, and Economics (REE) Action Plan
This action plan outlines research that supports Goal 2 – Responding to climate and energy needs, Subgoal 2B, Bioenergy/biofuels and biobased products in the 2014 REE Action Plan.

Relationship of This National Program to the ARS Strategic Plan:
Food and Non-food outputs of NP 306 research support the "Actionable Strategies" associated with the performance measures shown below from the 2012–2017 ARS Strategic Plan:

> **Strategic Goal 1.3:** 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 non-food technologies and products, except energy and fuels.

Performance Measure 1.1.3: Develop methods and technologies to better define, measure, preserve, or enhance quality and improve utilization of food crops, animals, and agricultural fibers, as well as nonfood, nonfuel biobased products and sustainable technologies/processes**.**

Target: 2024 – Cumulatively, 20 new technologies will be developed by ARS and adopted for uses that provide food crops and products with higher quality and extended shelf life; convenient and acceptable healthy foods; nonfood products with cost and performance features comparable or superior to nonagricultural-based products; and valuable co-products from agricultural residues and processing wastes.

Biorefining outputs of NP 306 research support the "Actionable Strategies" associated with the performance measures shown below from the 2012–2017 ARS Strategic Plan:

Strategic Goal 2.3: Develop technologies to enable sustainable commercial production of biorefining-based products.

Performance Measure 1.2.3: Develop technologies to enable sustainable commercial production of bioenergy feedstocks and other renewable fuels.

Target: By 2024 ARS will establish significant public-private partnerships for advancing feedstock variety improvement and incorporate new technologies and introduce new region-based systems that enable the production of biomass feedstocks to help achieve U.S. goals for meeting legislated mandates for blending biofuels. ARS will provide science-based practices/co-product technologies suitable with cost and performance features comparable or superior to petroleum-based products for commercialization.

Introduction

ARS National Program 306 (NP 306), Product Quality and New Uses, including biorefining, has the goal of enhancing economic viability and competitiveness of U.S. agriculture by improving quality and marketability of harvested foods and agricultural feedstocks to meet consumer needs, develop environmentally friendly and efficient processing concepts, and expand domestic and global market opportunities in biorefining in association with the bioeconomy.

In addition to food quality and product consistency that benefit food processors, millers, and manufactures, consumers have expressed concern over rising food prices, which can be attributed to multiple factors. A significant factor in the cost of food production can be attributed to food loss and waste among retailers, food service institutions, and consumers. Additional losses occur during food harvesting, storage, and distribution. The magnitude of the loss is even greater when resources spent on growing food such as fuel, water, fertilizer, chemicals, land-use, and labor are considered. ARS conducts research by developing value-added food/nonfood technologies and biobased products.

Interest in biobased products has increased as consumers and governments have sought more environmentally friendly products that provide alternatives to petroleum and do not contribute to greenhouse gases. There is some public concern that biobased products could contribute to the rising cost of food in the United States. ARS develops biobased products from agricultural feedstocks that do not compete with food. ARS also supports quality and processing research on crop fibers such as cotton and from animal hides such as leather and wool. Stakeholders who produce fibers and hides constitute an important segment of our rural economy. These industries are severely affected by energy and production costs and have lost market share to

foreign competition. To help the fiber industry compete on a global scale technologies are needed that improve fiber quality, reduce the energy consumption of processing equipment, and result in new products.

ARS also conducts biorefining research to develop viable technologies that improve profitability, reduce risks, increase the value of coproducts and biobased products, and expand the options available to existing biorefiners for generating revenue. Collaborations with existing biorefiners are critical to ensure that ARS conducts research that benefits industry. Given its limited resources for biorefining research, ARS must focus its research on a relatively limited number of promising technologies. ARS has been a long-time leader in research on biochemical conversion of agricultural feedstocks into biobased products. ARS also leads Federal government research efforts to benefit biodiesel producers, which make up the bulk of lipid-based biorefiners. Furthermore, ARS has significant research experience and capabilities in pyrolysis, a technology that can produce advanced biofuels compatible with the Nation's existing fuel-distribution infrastructure and that could be deployed at or near the farm.

This action plan was developed with consideration of both *1*) an assessment by an independent panel of the research accomplishments generated under the previous (2015–2019) action plan, and *2*) research needs received from stakeholders via a web-based interactive poll conducted between November 2018 and February 2019. Many of the research needs identified by stakeholders over the past several years continue to be relevant today and are addressed in the current, updated action plan. However, new research needs were also identified in response to issues and concerns of our changing society, economy, and environment.

NP 306 addresses postharvest quality and processing of foods and fiber, and biorefining technologies. The research described in this action plan is expected to increase our knowledge and develop viable technologies to better measure or enhance the quality of crop and animal food and fiber (including hides) products after harvest and bioconversion.

Component 1: Foods

Research under Component 1 is focused on developing technologies that improve food quality, extend product shelf life, reduce food waste, promote health, and reduce food costs. A significant factor in the cost of food can be attributed to food loss and waste. The USDA's Economic Research Service estimates that 30 percent of all foods and up to 43 percent of fresh fish, fruits, and vegetables produced in the United States is lost as waste. NP 306 research will develop technologies that improve quality, extend product shelf life, reduce waste, and decrease costs through innovative processing and packaging.

Problem Statement 1.A: Define, measure, and preserve/enhance/reduce factors that impact quality and marketability

For consumers, food is much more than an essential source of sustenance. People select food based on its taste, nutritional benefits, shelf life, price, convenience, and appearance—all attributes that contribute to food quality. Scientists conducting research to assess food quality or to determine or improve food quality standards or grades must identify, define, measure, and preserve food attributes contributing to appearance, flavor, and nutritional characteristics. These attributes can include color pigments, surface components, aroma, fundamental tastes (sweet, sour, bitter, astringent, and savory), textures, and bioactive compounds that affect human health. In addition, food processing and packaging can greatly influence food quality, safety, and nutrition, whereas new food processing techniques are needed to preserve and add value to foods, reduce waste, and reduce costs. Similarly, the marketability and value of commodities can be increased by ensuring that value-added food products (such as fresh-cut or minimally

processed whole produce) retain sensory qualities and nutritional values and are free from food safety hazards. The research in this component will also generate new information on health-promoting components of existing foods and new foods, and their effect on the human gut in collaboration with the ARS Human Nutrition National Program (NP 107) and other partners who assess food's effects on important human health, diseases and obesity.

Research Focus

ARS will investigate how genetics, production practices, pre- and postharvest environmental conditions, and mechanical handling influence quality, how new crop cultivars and animal breeds carry with them the potential for altered food quality; and how baseline food composition information can be accurately measured based on chemical, nutritional, physical, microbiological, and sensory attributes due to effects of storage and postharvest processing. Sampling strategies will accurately measure quality attributes, detect defects, predict overall quality, and effects on allergenicity.

Anticipated Products

- Systems to maintain product identity from the farm to the retail market.
- New information on health-promoting components of foods/new foods.
- New laboratory and pilot-scale food processing methods to better replicate commercial processes and improve evaluation of cultivars, harvest methods, storage, fermentation, and processing procedures.
- New efficient, high-throughput and nondestructive technology to better replicate commercial grading, sorting, and assigning value to food based on desired quality/marketability traits after harvest.
- New baseline composition of postharvest food influenced by preharvest variations in biotic, environmental, and management inputs (in cooperation with NP 305, Crop Production; NP101, Animal Production; and NP106, Aquaculture).
- Plant and animal genes/DNA markers for quality trait loci to better regulate color, flavor, texture, and other marketable attributes of food (in cooperation with NP 301, Plant Genetic Resources, Genomics, and Genetic Improvement; and NP106, Aquaculture).
- Sensor/analytical technologies to assess product quality and/or maturity prior to harvest for optimum harvest timing and/or at harvest.
- Technology to detect factors that diminish quality, or are defective, and to remove biochemical contaminants, and pre- and postharvest metabolites that cause quality deterioration, allergenicity, and cross-contamination of allergens after harvest.
- Tools to effectively manage postharvest processing and storage systems and their environments, including instrumentation, control systems, and decision support systems; and innovative storage systems and treatments that maintain/improve product quality and integrity and protect products from pathogens and insects.
- Technology for improvement of packaging, storage containers, and food coatings through management (e.g., humidity, temperature control, atmosphere regulation, and wavelength) to extend the shelf life of food and preserve flavor, texture, and color.
- Novel methodologies to enhance or predict the quality and utilization of agricultural products.

Potential Benefits

- Improved utilization of products through quality enhancement techniques.
- Linking preharvest environmental, biotic, and managerial impact with physical and chemical attributes, genetics, and harvest maturity to sensory and performance traits that produce rapid, inexpensive, product quality assessments throughout the supply chain.
- Faster delivery of improved crop cultivars through development and implementation of improved definitions of quality and methods to accurately assess cultivar quality.
- Improved sensors, quality definitions, and accurate measurements of quality attributes that improve food processing and production management decisions while minimizing product loss from spoilage, infestation, contamination, and poor quality.
- New technologies to detect and remove contaminants or defective products from food streams to minimize product loss and provide higher quality food to consumers.
- Innovative storage systems to maintain product quality and identity and reduce loss caused by inadequate postharvest storage and low-cost storage systems that can be used for temporary short-term storage at harvest and for emergency food shortages during domestic and international crises.
- Globally competitive, high-quality products with extended shelf life.

Problem Statement 1.B: New bioactive ingredients and health-promoting foods

Foods provide essential nutrients for sustaining life and they impart healthy physiological responses for both humans and animals. Health-promoting foods contain bioactive ingredients that influence health beyond basic nutritional value (i.e., calories and basic metabolic requirements). Health-promoting foods can be derived from plant, animal, or microbial sources and from bioactive ingredients such as naturally occurring or induced nutrients from plants, probiotic bacteria, and prebiotic oligosaccharides. The public health promise of the nascent health-promoting foods industry necessitates a multipronged research approach to identify biologically active compounds in agricultural materials and health-promoting foods, characterize their structures and physiological functions, and examine the interplay between biologically active constituents and nutritional components. Additionally, plant-based ingredients that promote human/animal health, or do not pose a health risk to humans and the environment, are bioactive pesticides. Identification of these natural constituents, in turn, facilitates agronomic practices and breeding of crop cultivars, livestock, or microbial strains with enhanced bioactive qualities.

Research Focus

ARS will focus on health-promoting foods with enhanced levels and activities of bioactive compounds (e.g., fiber, proteins, oils, phytonutrients) with established efficacy, bioavailability, and safety that represent cost-effective dietary interventions for reducing the risk of chronic disease and the human gut.

Anticipated Products

- New bioactive ingredients and methods to standardize minimum concentrations in foods such as proteomic, metabolomic, and nutrigenomic tools and improved biomarkers to predict success of full-scale human clinical trials and alleviate the need for animal testing.
- Innovative and improved delivery systems for functional food bioactive ingredients (i.e., novel encapsulation, nanoemulsion, controlled release, protein-based “natural”, probiotic bacteria, and synbiotics).

- New and improved crop varieties and animal and microbial strains that serve as sources of bioactive ingredients (in cooperation with other ARS national programs and partners).
- Processes to convert food waste (hulls, fruit peels, pulp, pomace, oil seed meal, and aquaculture byproducts) into value-added healthful bioactive ingredients.
- New health-promoting foods and new sources of novel bioactive ingredients identified, isolated, and characterized using innovative instrumental and bioassay techniques.
- Discovery of natural product-based pesticides and phytochemicals with properties that promote human/animal health.
- Alternative plant-based pesticides for specific needs, particularly compounds that will meet safety and environmental standards (or provide pesticides with new modes of action).

Potential Benefits

- Expansion of knowledge of probiotic bacteria and their role in promoting gut health, and prebiotic oligosaccharides that stimulate the growth of probiotic bacteria.
- New information on bioactive ingredients that relate metabolic pathways, regulatory genes, probes (e.g., simple colorimetric assays, high-throughput analytical techniques, gene specific molecular markers), and simulated human intestinal microbiome assays to predict which population subgroups will respond positively to the bioactive compounds.
- New food products that potentially stave off infectious or chronic diseases and health problems caused by aging, thus reducing healthcare costs in the United States.
- Enhanced competitiveness of the U.S. food industry in the global marketplace.
- Increased values of crops, livestock, or microbial strains used as health-promoting foods or raw materials for functional foods as a benefit to the U.S. rural economy.
- Improved understanding of mechanisms of action of bioactive food ingredients through the human gut and their role in human health and reducing risk of diseases.

Problem Statement 1.C: New and improved food processing and packaging technologies

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

Research Focus

ARS will study nonthermal preservation techniques to ensure product stability and safety, and enhanced retention and bioavailability of nutrients and food ingredients while retaining desirable sensory characteristics. ARS will develop new processes and technologies for protecting, stabilizing, or maintaining the activity of sensitive food components (vitamins, probiotics,

bioactive peptides, and fatty acids) throughout processing, storage, and component delivery. ARS will establish large-scale processes with minimal environmental impact to replace aging technologies associated with high energy demand, high water usage, and/or high wastewater load. ARS will also establish economical, small-scale technologies for value-added processing of locally produced commodities on or near the farm for local direct marketing of high-quality products.

Anticipated Products

- Food technologies yielding foods with enhanced nutritional benefits.
- Safer products and products with a longer shelf life from new processes that control growth of spoilage microorganisms and human pathogens (in cooperation with National Program 108, Food Safety, and other partners).
- New technologies for production of shelf-stable, frozen, and extended shelf-life food products, including cost-effective systems that preserve bioactive ingredients, enhance food security, or food tailored to meet nutritional requirements for the School Lunch Program, Food for Peace, “Ready to Eat,” and similar programs (in cooperation with National Program 107, Human Nutrition, and other partners).
- New food processes using protein-based food ingredients ranging from native to modified proteins, for fortification of foods and beverages.
- New packaging and coating technologies that protect or enhance the properties of foods, reduce or control the incidence of decay and enteric bacteria, and extend their useful life through shelf-stable packaging systems.
- New protective films and coatings for foods made from proteins, carbohydrates, lipids, and other food components to enhance the appearance, improve quality, and contribute to the function of shelf-based packaging system.

Potential Benefits

- Efficient (sustainable) food processing (including organically compliant) techniques that reduce energy use, water use, and waste generation per unit of food delivered to consumers.
- New processes (separation, concentration, extraction, and fractionation) to convert low-value commodities or byproducts into higher-value food ingredients or nonfood products.
- Continued availability of adequate, healthy, and affordable food supply for the U.S. population.
- Improved ability to optimize the nutritional, functional, textural, and sensory properties of foods.
- Increased ability for farmers and processors to deliver foods that have proven health benefits to people.
- Increased value to animal and plant foods with improved or new higher value-added co-products development from processing waste streams.
- Maintained or higher-quality produce to assist U.S. food processors to remain economically competitive in the global market place. Reduction of the environmental impact (e.g., petroleum-based energy use, water use, air pollution, and greenhouse gas emissions) required to safely produce and deliver food to consumers.

Component 1 Resources
Albany, CA; Athens, GA; Beltsville, MD; Dawson, GA; East Lansing, MI; Fargo, ND; Ft. Pierce, FL; Madison, WI; Manhattan, KS; New Orleans, LA; Oxford, MS; Parlier, CA; Peoria, IL; Pullman, WA; Raleigh, NC; Wenatchee, WA; Wooster, OH; and Wyndmoor, PA.

Component 2: Nonfood (fibers including hides)
Research under Component 2 is focused on developing technologies addressing cotton, wool, hides, and leather, and nonfood, nonfuel biobased products that affect quality, environmental attributes, reduce energy needs of production, and enhance rural economies. Stakeholders who produce fibers and hides constitute an important segment of our rural economy, and these industries have been severely affected by energy and production costs and have lost market share to foreign competition and synthetics. NP 306 research will aim to develop technologies that improve fiber quality, reduce the energy consumption of processing equipment, ensure contamination-free fibers, and develop new products/uses to help the fiber and leather industries compete in a global market.

The U.S. fiber and hide industries are facing significant challenges from the production and market globalization of raw cotton, wool, yarn and yarn products, raw animal hides, and finished leather products. These challenges include rising energy and labor costs, impediments from industry regulations, maintaining and improving product quality, developing new processes and products, and improving the management and use of waste and byproducts. As a low-cost agricultural producer, the United States has the necessary base of raw materials to support a healthy, domestic nonfood biobased-products industry. Furthermore, if U.S. non-food biobased products manufacturers can be the first to a global market and move down the learning curve for maximizing customer value and manufacturing productivity, U.S. manufacturing will enjoy an edge in the emerging worldwide bioeconomy. On the other hand, a loss of precompetitive research capacity could prevent U.S. manufacturers from developing new non-food biobased technologies and put U.S. leadership in the emerging global bioeconomy at risk to offshore competitors.

To ensure that ARS research targeting this component will benefit industry, collaborations with existing manufacturers and users are necessary. However, it is important that research addressing the problem statements within this component is precompetitive to the extent possible and enables commercially desirable technologies that the private sector cannot develop on its own within a time frame limited by existing market opportunities and threats. It is also important that intellectual property generated by this research be managed so that it is broadly available to U.S. stakeholders. Technologies enabled under this problem statement can either *1*) provide defensive protection to existing market share for U.S. stakeholders, *2*) help U.S. stakeholders increase market share in existing markets, or *3*) both.

Problem Statement 2.A: Maintain/enhance fiber and hide quality
Most of the ARS research targeting this problem statement serves stakeholders in the cotton, hides, and wool industries. These industries are in need of innovations to be competitive on a global scale and within their entire supply chains. Even if the production of finished nonfood biobased products occurs overseas, which is largely true for cotton textiles and leather goods, U.S. agricultural producers and processors need technologies to ensure that their products meet the quality and cost requirements of industrial customers in these competitive global markets.

Research Focus
ARS will focus on postharvest technologies/process efficiencies that reduce processing risk and develop criteria, methods, and instrumentation that allows industry to rapidly and accurately assess raw or in-process material quality, tools to predict processing efficiencies, and product quality/performance from raw materials. ARS will develop methods to enable industry to preserve raw or in-process material quality during handling, storage, or transportation; processes and equipment to increase labor, energy, and capital productivity, decrease contaminants and ecological/environmental footprints, and reduce water use; and increase product value.

Anticipated Products
- New criteria, methods, and instrumentation to assess raw or in-process material quality including contaminants.
- New tools to predict processing efficiencies and product quality/performance from raw material composition, contamination, and structure.
- New methods that preserve raw or in-process material quality during handling, storage, or transportation.
- New or improved processes or equipment to increase labor, energy, and capital productivity; decrease ecological footprints; and increase product value.

Potential Benefits
- Greater economic returns to U.S. agricultural producers, processors of nonfood products, and rural communities in the United States.
- Decreased contaminants, ecological/environmental footprints, and water use; and higher product values.

Problem Statement 2.B: Enable technologies to produce new and expand marketable nonfood, nonfuel biobased products derived from agricultural feedstocks
Research will affect existing markets and value-added chains (between harvest and product export or manufacturing) for nonfood products. The terms “agricultural feedstocks” and “biobased products” are broadly defined and include fibers and hides, plant feedstocks, crop residues, food-processing byproducts, and biorefinery co-products. Also, the term “nonfood biobased product” is broadly defined and includes animal feed.

Biobased products must be competitive in the marketplace, especially with conventional, petroleum-based products. Agricultural producers and processors increasingly need alternative market opportunities for existing and new products, especially those that increase the value of byproducts. ARS researchers address these issues by finding new uses for agricultural products, enhancing existing products or more environmentally friendly technologies for different applications to increase value, or develop completely new and innovative products that use agricultural products or byproducts for production.

Research Focus
ARS will identify agricultural products and processing byproducts that are wasted, underused, or used in low-value applications. Scientists will investigate agricultural feedstocks and processing byproducts for valuable properties that may be exploited in the design of new products and processing methods or methods that can be adapted from other industries. Scientists will identify inherent genetic properties, antimicrobial, production environment/practices, and harvesting practices of agricultural feedstocks that industry will use to maximize the composite returns to value-added chains for nonfood biobased products.

Anticipated Products

- New processing technologies for adding value to agricultural products and processing byproducts.
- New biobased products that can serve as competitive substitutes for conventional products.
- New biobased products with novel benefits or functions.
- Adaptation of existing biobased products to new application areas.
- New methods for evaluating the performance of new or existing biobased products.
- Newly adapted products and processing technologies to meet the needs of the producer industries and end users. New or modified processes and equipment to increase labor, energy, and capital productivity; decrease ecological/environmental footprints and water use; and increase product value
- Established economic viability of new biobased products.

Potential Benefits

- Greater economic returns to U.S. agricultural producers, processors of nonfood products, and rural communities in the United States.
- Increased competitiveness of U.S.-produced nonfood biobased products.
- Decreased ecological/environmental footprints and water use; increase product value.

Component 2 Resources

Albany, CA; Lubbock, TX; Mesilla Park, NM; New Orleans, LA; Oxford, MS; Peoria, IL; Stoneville, MS; and Wyndmoor, PA.

Component 3: Biorefining

Through research under Component 3, the U.S. biorefining industry has the potential to supply a significant portion of the national demand for fuels, chemicals, and other high-value U.S. consumable products such as proteins, sugar alcohols, biopolymers, cosmetics, pharmaceuticals, health foods, livestock feeds, biodiesel alternatives, and other advanced biofuels. The production of these bioproducts is not meant to completely replace their petroleum-based counterparts, but rather to supplement their use with a renewable resource base—plants and animal byproducts—to meet demand and to take advantage of low-value crops or byproducts of agricultural production that could increase farmers' profits. As an example, U.S. petroleum refineries are mainly set up to produce gasoline. When fluctuating demand for diesel begins to reduce supply, the price of diesel inches up. Biodiesel is normally blended with fossil-fuel diesel in various ratios to extend diesel supplies. Refining biodiesel from used vegetable oils or the nonfood crop switchgrass helps close that gap and ensures an adequate supply is available to maintain the strength of the U.S. economy.

The goal for biorefining research is to enable new, commercially viable technologies for the conversion of agricultural feedstocks into value-added products and biofuels (mainly biodiesel and biojet fuel). To achieve this goal ARS scientists will:

1. Maximize the long-term economic impact of ARS biorefining research;
2. Emphasize ARS' unique capabilities and avoid overlap with research at other institutions; and
3. Maximize returns to agricultural stakeholders from ARS investment of public funds.

By developing commercially viable technologies to produce biobased industrial products, ARS biorefining research increases the demand for agricultural products and therefore benefits agricultural producers and rural communities.

Under Component 3, ARS will conduct research of potential benefit to biorefiners that uses biochemical conversion technologies. Biorefining has narrow margins and lower profitability, mainly due to variability in feedstock costs and fuel market prices, particularly for conventional corn ethanol and soybean biodiesel. A sustainable and growing biorefining industry is dependent on having: cost-effective and efficient processes for converting biomass to biofuels and biobased chemical and products; and production and cost analysis tools.

Problem Statement 3.A: Viable technologies for producing advanced biofuels (including biodiesel), or other marketable biobased products
This problem statement focuses on research that can enable biorefineries converting sugar/starch-based feedstocks (such as noncorn grains, oil-seeds/energy crops, sweet sorghum, sugar cane, or sugar beets) or plant-derived fiber (such as grain fiber, stover, straw, or bagasse) into biofuel- or diesel-compatible fuel to supplement fossil-based fuels or other marketable biobased products. These agricultural feedstocks may include plant and animal processing wastes or agricultural residues.

A strong need exists for marketable biofuels that can supplement fossil-derived liquid transportation fuels such as biodiesel and biojet. Advanced biofuels and other products and co-products from the biorefineries that produce them will help maintain the economic viability of existing biorefineries and enable growth of the biorefining industry. Furthermore, to increase the likelihood that industry will adopt technologies enabled by ARS research in Component 3, close coordination is required between ARS researchers and product/co-product users. ARS research to develop products or co-products for animal feed applications will also likely require collaboration with ARS animal nutrition laboratories and may also benefit from collaboration with ARS feedstock development researchers.

Research Focus
ARS will focus on viable fractionating technologies of agricultural materials and food-process wastes into products for direct sale or for further processing into marketable products and processes for depolymerizing cellulose and hemicellulose to fermentable sugars. Viable routes will be established to develop new products and natural products with improved or novel antifungal/antibacterial activities using existing low-efficiency pretreatment and hydrolysis (enzyme) technologies, and other anticipated process efficiencies.

Anticipated Products
- A greater number of microorganisms that fully utilize all sugars/proteins for the fermentative conversion of agricultural materials into advanced biofuels and chemicals.
- Biocatalytic, chemical, or hybrid (biocatalytic and chemical) and thermolysis technologies that enable industry to produce advanced biofuels, biobased products, and co-products.
- Commercially viable hybrid (biocatalytic and/or chemical) processes that convert sugars, oligosaccharides, nonfood proteins, xylose, and lignin into advanced fuels or biobased materials.

- Technologies that significantly lower the crystallization temperature of biodiesel by reducing the levels of contaminants (e.g., sterol glucoside) and persistent intermediates (e.g., saturated monoglycerides).
- Provide recommendations to biorefiners, feedstock producers, and plant breeders regarding desirable feedstock traits and feedstock handling/preprocessing/blending practices that enhance biocoversion performance.
- Commercially viable processes that modify fatty acid alkyl ester structures in biodiesel to improve its low-temperature operability.
- Commercially viable process systems, feedstock or co-reactants, feedstock collection/storage practices, feedstock preprocessing methodologies (e.g., chopping, drying, densifying, torrefying, charring), or catalysts that enable commercially viable near- or on-farm conversion systems for the production of products to replace high-value petrochemical materials.

Potential Benefits

- Expanded markets for biofuels (including biodiesel) and biobased products;
- Increased demand for agricultural products;
- Technologies to enable “Green” manufacturing that have the potential to reduce greenhouse gas emissions.

Problem Statement 3.B: Technologies that reduce risks and increase profitability in existing industrial biorefineries

Biorefineries and biodiesel facilities are subject to large swings in profitability due to volatility in feedstock cost and selling price. Although modern facilities are efficient, improvements in operational robustness and efficiencies could have significant effects on economic viability. In addition, retooling bioconversion facilities to produce advanced biofuels, biodiesel, and other marketable co-products, or to increase the value of existing products from feedstocks, will decrease business risk and increase long-term profitability of these biorefineries.

Research Focus

ARS will focus on commercially viable sustainable chemical and biochemical technologies to increase process efficiencies or reduce the incidence of operating disruptions (e.g., antimicrobial) in existing biorefineries; enhancing feedstock-flexibility of existing biorefineries/biodiesel facilities; producing biofuels and other marketable products from food processing wastes; increasing the number of marketable products produced in existing biorefineries/biodiesel facilities; converting sustainable agricultural feedstocks into advanced biofuels or biobased chemicals; and enhancing the value of existing byproduct streams.

Anticipated Products

- New ARS-enabled technologies used by existing biorefiners/biodiesel producers to reduce their business risks and increase profitability.
- New ARS-enabled technologies used by industrial buyers of co-products from existing biorefiners/biodiesel facilities.
- Technologies deployed by industry that significantly improve cold-flow performance of biodiesel fuels.

Potential Benefits

- An economically healthy biorefining industry.
- Stable demand for agricultural products that supply feedstocks for the biofuel production industry.

Problem Statement 3.C: Accurately estimate the economic value of biochemical, thermolysis conversion technologies

The viability and sustainability of a commercial process is a function of its economic competiveness. In turn, the potential impact of a new biorefining technology is a function of its anticipated effect on the production economics for a commercial biorefinery. By knowing the major cost components for a process technology, ARS researchers can focus their efforts to yield the most impact. Therefore, technoeconomic analyses will be conducted to accurately estimate the expected economic effect of ARS biorefining research.

Research Focus

ARS will focus on establishing accurate estimates of the effect of new technologies on capital and operational costs in commercial biochemical conversion facilities.

Anticipated Products

- New capital and operating cost models for biocatalytic- and hybrid-based biorefining and thermolysis technologies.
- New technologies that maximizes the effect of public funding are identified for biochemical conversion and thermolysis.

Potential Benefits

- Increased commercial deployment of new biorefining/biodiesel technologies.

Component 3 Resources

Albany, CA; New Orleans, LA; Peoria, IL; and Wyndmoor, PA.