Action Plan
National Program 306
Product Quality and New Uses
(including biorefining)
2025–2029

Vision
Research is focused on developing knowledge and enabling 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 products.

Mission
Enhance the marketability of agricultural products, increase the availability of healthful foods, develop value-added food and nonfood products, and enable commercially preferred technologies for post-harvest processing.

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 Fiscal Years 2022-2026:

- **Strategic Goal 1**: Combat climate change to support America's working lands, natural resources, and communities.
    - Objective 1.4 - Increase carbon sequestration, reduce greenhouse gas emissions, and create economic opportunities (and develop low-carbon energy solutions).
- **Strategic Goals 2**: Ensure America's agricultural system is equitable, resilient, and prosperous.
    - Objective 2.3 - Foster agricultural innovation
- **Strategic Goals 3**: Foster an equitable and competitive marketplace for all agricultural producers.
    - Objective 3.1 - Foster sustainable economic growth by promoting innovation, building resilience to climate change, and expanding renewable energy.
    - Objective 2.2 - Expand markets for emerging technologies, sustainable products, and novel products.

Relationship of This National Program to the USDA Science Blueprint A Roadmap for USDA Science From 2020 To 2025
This action plan outlines research that supports the following themes in the USDA Science Blueprint.

- **Theme 1** - Sustainable Ag Intensification. Discovering, fostering, and implementing advances in technology will allow agriculture to enhance sustainability.
    - Plant Production, Health, and Genetics objective
        - Enhance plant product quality by enhancing traits such as shelf life and taste/ favor, and optimize nutrition, health, and food safety components.
- **Theme 3** – Food and Nutrition Translation. To reduce the overall cost of foods through more efficient processing, packaging, and repurposing to minimize food waste.
    - Nutrition and Health Promotion objective

        - Promote food systems that reduce the prevalence and severity of food insecurity.
- **Theme 4** - Value-Added Innovations. New technologies and system designs are needed for producing higher value end products from agricultural products, emerging crops, and livestock, and forest feedstocks, which will enable new markets, establish new domestic supply chains, and create more jobs and economic opportunities.
    - Infrastructure, Innovation and Well-Being objectives:
        - Strengthen food, agricultural, and forest production, processing, manufacturing, utilization, and marketing through new technologies, innovation, and data analysis to create jobs and economic opportunities in rural areas.
        - Foster sustainable non-food, feed, and other high-value chemical and biophysical applications of plants (pharmaceutical, nutraceutical, industrial products, and feedstock ingredients).
        - Develop and evaluate methods to increase access to low-cost and nutritious food as well as sustain efficient agriculture and bioeconomy systems in rural communities.
        - Evaluate alternative systems that may improve the quality, resiliency, and sustainability of food, fiber, forest, and fuel supplies.
    - Bioeconomy objectives:
        - Promote the development of enabling technologies for the sustainable, efficient, and profitable production of biobased products from renewable agricultural and bioeconomic crops, including emerging supplemental and alternative crops.
        - Develop knowledge and tools to design and optimize biorefining and processing systems that leverage economies of scale to promote biobased product competition and market access.
        - Generate, gather, and synthesize relevant data and scientific information to quantify and inform the valuation of bioeconomic ecosystem as well as societal and environmental costs, benefits, and services.

Relationship of This National Program to the USDA Science and Research Strategy, 2023-2026: Cultivating Scientific Innovation This action plan outlines research that supports the following priorities in USDA Science and Research Strategy, 2023-2026: Cultivating Scientific Innovation. The USDA Science and Research Strategy, 2023-2026 outlines research that is centered on foundational principals ensuring that agricultural science and innovation successfully translate into real-world impact.

- Priority 1: Accelerating Innovative Technologies and Practices
    - Objective 1.3 Collaborative Intelligence Tools
        - Automate or eliminate repetitive tasks through collaborative intelligence (e.g., Artificial Intelligence assisted support systems) and transition workers to high-quality jobs of the future.
    - Objective 1.4 Bioengineered Traits and Customizable Management Practices
        - Improve sustainable production by developing novel selectable plant and animal traits, as well as advanced and customized agricultural and forestry management practices.
    - Objective 1.5 Diversified Future Systems
        - Create technologies suitable for use across diverse scales, systems, types, and locations of farms.
- Priority 2: Driving Climate-Smart Solutions
    - Objective 2.2 Climate Change Mitigation

        - Enhance research and technology development and improve the technical GHG mitigation potential of agriculture and forestry sectors to reduce GHG emissions, sequester carbon, and generate low-carbon sources of energy.
    - Objective 2.5 Bioeconomy
        - Conduct science that supports sustainable markets for agriculture and forest bioproducts and clean energy to identify potential for new revenue streams and drive sustainable economies and supply chains with reduced waste and GHG emissions.
- Priority 3: Bolstering Nutrition Security and Health
    - Objective 3.3 Predictive Analytics
        - Increase data and analytics for predicting, developing, and disseminating appropriate intervention or management strategies to reduce and eliminate contamination in food production and processing, reduce food loss and waste, improve the nutritional value of food in a changing climate context, including considerations to adapt to various cultures and contexts.
- Priority 4: Cultivating Resilient Ecosystems
    - Objective 4.2 Microbiome Research
        - Accelerate the deployment of technology and practices that improve crop and animal production, transform feed efficiency, and increase resilience to weed, disease, pest, and environmental threats by promoting and advancing microbiome research for soil, plant, and animal health.

Relationship of This National Program to the ARS Strategic Plan:
This action plan outlines research that supports the following strategic goals in the ARS Strategic Plan 2023–2026. Food, Non-food, and Biorefining outputs of NP 306 research support 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.

- **Strategic Goal 1**: Combat Climate Change to Support America's Working Lands, Natural Resources and Communities
    - Objective 1.4 - Increase Carbon Sequestration, Reduce Greenhouse Gas Emissions, and Create Economic Opportunities (and Develop Low-Carbon Energy Solutions).
- **Strategic Goal 2**: Ensure America's Agricultural System is Equitable, Resilient, and Prosperous
    - Objective 2.3 - Foster Agricultural Innovation
- **Strategic Goal 3**: Foster an Equitable and Competitive Marketplace for All Agricultural Producers
    - Objective 3.2 - Expand Markets for Emerging Technologies, Sustainable Products, and Novel Products

Introduction
ARS National Program 306 (NP 306), Product Quality and New Uses 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.

Reducing food waste will require advances in packaging that protects/preserves food without PFAS as PFAS chemicals bioaccumulate in humans with unknown health effects. ARS research involves advancing PFAS replacement/alternative products and developing other PFAS-free coatings. ARS is producing biochar with specific physical and chemical characteristics (from diverse biomass) that could absorb/remediate PFAS. Incorporating biochar into the bioeconomy also reduces agricultural waste (as well as food loss and waste) to valorize these and other organic waste streams into industrial applications that sequesters carbon, limits greenhouse gases (carbon dioxide and methane) and extends its application beyond soil enrichment.

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 bast fibers. Stakeholders who produce fibers 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 extract/separate desirable fibers, improve fiber quality, measure 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 biofuel producers. Furthermore, ARS has research experience and capabilities in pyrolysis, wet torrefaction, and torrefaction and these technologies 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 (2018–2022) action plan, and *2.*) research needs received from stakeholders via a web-based interactive poll conducted between October 2023 and January 2024. 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 products after harvest and bioconversion. ARS research in NP306 Product Quality and New Uses is capitalizing on robotics, artificial intelligence (AI), and machine learning (ML) for a wide range of research projects. Robotics research has the potential to address skilled harvest shortages and new harvesting solutions. AI and ML has the ability to transform and improve agricultural activities and associated duties. Artificial intelligence focuses on training computers (developing algorithms and systems) so that computers can do things that typically require human intelligence, such as visual perception or decision-making based on input data. An important tool for artificial intelligence is machine learning which is a specialization that involves training machines to learn from data without being clearly programmed. Machine learning processes detect patterns in data, make predictions and decisions, and build predictive models that are used to classify data, and recognize patterns.

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. Scientists conduct research on novel methods and processes for enhancing or reducing bioactive compounds that impact suitability of products for downstream processing by industry stakeholders and/or for end consumers. 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.

ARS will investigate impacts on food quality by evaluating i. genetics, production practices, pre- and postharvest environmental conditions, and mechanical handling; ii. potential for altered food quality in newly released crop varieties and animal breeds; and iii. baseline food composition information and associated 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.

ARS will investigate impacts on food quality by evaluating baseline food composition information and associated chemical, nutritional, physical, microbiological, and sensory attributes due to effects of storage and postharvest processing.

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.
- Capitalizing on robotics, artificial intelligence (AI), and machine learning (ML) for a wide range of research projects. Robotics research has the potential to address skilled harvest shortages and new harvesting solutions such as AI-based robotic technology to enable full and selective harvesting of tree fruits.
- 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, 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. Industry is transitioning towards sustainable pest management and requiring new plant-based 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 sustainable 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 sustainable 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 marketplace. 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; Hood River, OR; Raleigh, NC; Wenatchee, WA; Wooster, OH; and Wyndmoor, PA.

Component 2: Nonfood (fibers)
Research under Component 2 is focused on developing technologies addressing cotton, bast fibers, and nonfood, nonfuel biobased products that affect quality, environmental attributes, reduce energy needs of production, and enhance rural economies. Stakeholders who produce fibers 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 industries compete in a global bioeconomy market by minimizing the use of plastics.

The U.S. fiber industries are facing significant challenges from the production and market globalization of raw cotton, yarn, and yarn 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 quality
Most of the ARS research targeting this problem statement serves stakeholders in the cotton and bast fiber 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, 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, 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, bioplastics, cosmetics, pharmaceuticals, health foods, livestock feeds, biodiesel alternatives, biochar, and other advanced biofuels (sustainable aviation fuel). 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 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 (e.g. sustainable aviation fuel (SAF)). 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 sustainable aviation fuel (SAF). 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, bioplastics, or biobased materials.

- 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 (e.g. sustainable aviation fuel) 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

Biorefinery 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 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 biorefinery facilities; producing biofuels and other marketable products from food processing wastes; increasing the number of marketable products produced in existing biorefinery facilities; converting sustainable agricultural feedstocks into advanced biofuels, biobased chemicals, and bioplastics; and enhancing the value of existing byproduct streams. An economic incentive exists to develop new products such as biochar from underutilized feedstock (food wastes, renewable biomass, and agricultural co-products) to reduce waste, reduce environmental pollution, and increase economic benefits to agricultural and other industries.

Anticipated Products

- New ARS-enabled technologies used by existing biorefinery producers to reduce their business risks and increase profitability.
- New ARS-enabled technologies used by industrial buyers of co-products from existing biorefinery 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.