USDA United States Department of Agriculture
Agricultural Research Service

Produce Quality and New Uses (NP 306) 2024 Annual Report

Introduction

The USDA-ARS National Program NP306: Product Quality and New Uses (including biorefining) in 2020 started its first year of its current 5-year research plans for the various research projects. Additional information can be found in individual project annual reports located here.

Mission

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: Product Quality and New Uses (including biorefining), Vision and relevance can be found at: https://www.ars.usda.gov/nutrition-food-safetyquality/product-quality-and-new-uses/ and includes the FY2025-2029 Action Plan for NP306.

Vision

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 factors 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 quality; and 2b. Enable technologies to produce new and expand marketable nonfood, nonfuel biobased products derived from agricultural feedstocks.
3) **Biorefining**: Problem Areas of research are: 3a. Viable technologies for producing advanced biofuels (including biodiesel), or other marketable biobased products; 3b. Technologies that reduce risks and increase profitability in existing industrial biorefineries.

During 2024, National Program 306 had 200 full-time scientists and 39 vacancies working at 22 locations, actively engaged in 60 ARS-base funded projects. During fiscal year 2024, ARS base funding for NP306 research was approximately $115M, not including approximately $8M from incoming agreements. The quality and impact of NP 306 research was further evidenced in 2024 by the following accomplishments:

- 272 refereed journal articles published

- 22 Book chapters
- 1 Trade journal
- 6 New patents
- 7 New patent applications
- 13 New invention disclosures submitted
- 3 Licenses issued
- 35 Current cooperative research and development agreements with stakeholders
- 43 New material transfer agreements with stakeholders.

In 2024, NP306 scientists participated in research collaborations with scientists in 26 different countries including Australia (1), Belgium (2), Brazil (6), Canada (2), Chile (4), China (7), France (1), Germany (1), Greece (1), Israel (1), Italy (2), Japan (2), Malaysia (1), Mexico (3), Mozambique (1), New Zealand (1), Pakistan (1), Philippines (2), Portugal (1), Saudia Arabia (1), South Korea (7), Spain (4). Taiwan (1), Turkey (3), Uganda (2), United Kingdom (1). NP306 scientists were also active in serving on committees and as advisors/mentors for undergraduate and post-doctoral students and serving as adjunct/affiliate faculty members.

- 65 Students and Post-Docs (ARS and Non-ARS)
- 11 SYs Serving as Advisors
- 9 Mentorships
- 13 Adjunct or Other Appointments
- 36 "Student related outreach activities - # of activities (Presentations to schools, Science fair participation, Student tours/visits to ARS locations. Facilities & Equipment)"
- 8145 "Student related outreach activities - # of student participants (Presentations to schools, Science fair participation, Student tours/visits to ARS locations, Facilities & Equipment)"
- 28 Other Outreach Activities - # of activities
- 2903 Other Outreach Activities - # of student participants in other outreach activities
- 3375 Other Outreach Activities - # of non-student participants in other outreach activities

Significant Accomplishments for FY 2024 – NP306

This section summarizes significant and high impact research results that address specific components of the FY 2020-2024 action plan for NP306. Each section summarizes accomplishments of individual research projects in NP306. Many of the programs summarized for FY 2024 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

1) **Winemaking byproducts fortify flour formulations.** Food products often focus on promoting consumer health by incorporating functional components, such as those found in winemaking byproducts, into food formulations. This also helps to address environmental issues associated with the need to dispose of large amounts of grape byproducts generated by the wine industry. ARS researchers in Albany, California, used a mix of corn and lentil flour with natural flavoring agents to develop various grape byproduct formulations. They found the total phenol, total flavonoid, and anthocyanin content were higher in all formulations that included 20-percent fermented Cabernet Sauvignon skin/seed or unfermented Chardonnay seed flours, regardless of

the corn and lentil flour in the formulations. This indicates that winemaking byproducts have the potential to be used as functional and prebiotic ingredients that add nutritional value to new functional food products, promote diversified consumption of lentils, and add value to winemaking byproducts. (NP306, 1B, 2030-41000-069-000D)**.**

Cotacallapa-Sucapuca, M., Berrios, J., Pan, J., Arribas, C., Pedrosa, M., Morales, P., Camara, M. Winemaking byproducts fortification of flour formulations based on corn and lentil. Journal of Food Composition and Analysis (*IN PRESS*).

2) **Single microwave frequency determines moisture in peanut kernels.** Microwave sensing has many potential applications for rapidly and nondestructively measuring moisture content in a variety of agricultural commodities. However, the development of microwave-based sensors requires empirically measuring the effects of many input variables on dielectric properties and extensive spectra data modeling. ARS researchers in Athens, Georgia, developed machine learning and artificial intelligence (AI)-based software to accurately predict peanut kernel moisture content from their dielectric properties measured at a single microwave frequency. This software has the advantage of providing moisture content without making any assumptions concerning the electromagnetic wave used for sensing and material interaction and does not require previously established analytical models correlating the dielectric properties to moisture content. Another important feature of the software is that moisture content can be determined without knowing the bulk density of the material being measured. This software provides a critical tool for developing microwave moisture sensors for a variety of applications. (NP306, 1A, 6040-41440-003-000D).

   Lewis, M.A., Trabelsi, S., Bennett, R., Chamberlin, K.D. 2024. Utilization of a resonant cavity for characterization of single in-shell peanuts. Journal of Food Measurement and Characterization. https://doi.org/10.1007/s12161-024-02620-x

3) **New enhanced method for accurate, precise, and efficient detection of catfish off-flavor volatiles.** Studies estimate that in 2022, the $367 million catfish industry incurred economic losses of $74 million from off-flavor catfish. Accurate and precise detection of muddy earthy off-flavor volatiles such as geosmin and 2-methylisoborneol (MIB) is critical to studying and resolving this issue. Traditional detection methods are inconsistent, with variability ranging from 20-85 percent. ARS scientists in New Orleans, Louisiana, developed a solution to minimize this variability by using isotope dilution measurements of off-flavor catfish, an approach that enhances sample throughput. Unlike the traditional labor-intensive microwave distillation method, which processes only single samples, the new method can analyze up to 20 samples simultaneously, resulting in an approximately 160-fold increase in sample throughput. This increased efficiency also reduces labor and equipment needs, and time spent on preparation and cleanup. With this improved measurement ability, researchers can now assess off-flavor mitigation strategies. (NP306, 1C, 6054-43440-051-000D)

   Dupre, R.A., Smith, B., Lloyd, S.W., Trushenski, J. 2024. Improved quantification of geosmin and 2-methylisoborneol in farmed fish using stable isotope dilution GC-MS. Journal of Agricultural and Food Chemistry. https://doi.org/10.1021/acs.jafc.3c08130

4) **Peppers may help lower blood sugar levels.** Capsiate is a chemical found in many commonly consumed peppers, and its structure is like capsaicin, the more familiar compound that brings “heat” to chili peppers. In support of a process patented to produce pure capsiate from peppers, ARS researchers at Oxford, Mississippi, investigated how a Capsicum annuum extract of pure capsiate, which does not possess any undesirable pungency or spiciness, affects metabolic

disorder receptors. Results indicated that capsiate can enhance glucose uptake, prevent lipid accumulation, and inhibit the adverse effect of blood glucose-lowering drugs belonging to thiazolidinediones class without compromising their main effects. This is the first report to reveal the multiple properties of capsiate from C. annuum and assess its potential in preventing the undesirable side effects of antidiabetic drugs. (NP306, 1A, 6060-41000-015-000D)

Chae, H., Cantrell, C.L., Khan, I.A., Jarret, R.L., Khan, S.I. 2023. Capsiate-rich fraction of Capsicum annuum induces muscular glucose uptake, ameliorates rosiglitazone-induced adipogenesis, and exhibits activation of NRs regulating multiple signaling pathways. Journal of Agricultural and Food Chemistry. https://pubs.acs.org/doi/10.1021/acs.jafc.3c06148?ref=PDF

5) **First time growing peanut plants from partial peanut kernels.** The sustainable production of nutrient-rich peanuts faces a unique challenge: seed has long been the largest cost factor in peanut production, accounting for more than 20 percent of the total production cost. In a groundbreaking study, ARS researchers in Beltsville, Maryland, used only half the peanut kernel (one cotyledon containing the embryo) as the seed, and used the other half as food. They demonstrated for the first time that it is feasible to grow peanut plants from partial peanut kernels and identified opportunities to improve peanut kernel germination and plant growth by using ultrasound. This accomplishment could generate additional peanut food products without compromising seed supply, provide peanut farmers with an additional income stream, and improve food and nutrition security for consumers. (NP306, 1B, 8042-43440-006-000D)

6) **Potentially saving sharks from overfishing with perennial oilseed.** Silflower is a drought-tolerant perennial plant in the sunflower family native to the central United States and the composition of silflower oil is like the composition of oil in annual confectionary sunflower. Replacing annual food crops with perennial food crops has many agronomic and environmental benefits, but several agronomic silflower traits need improvement before its production is economically competitive with annual confectionary sunflower. ARS researchers in Peoria, Illinois, analyzed the yield, composition, and oxidative stability of silflower oil and found it contains unusually high (up to 4.8 percent) concentrations of squalene, which is used in nutraceutical, cosmetic, and pharmaceutical industries. Squalene is currently obtained from shark liver oil, and this sourcing is controversial due to international concerns with shark overfishing. While silflower oil stability was found to be compromised by high chlorophyll content, this could be mitigated by refining or breeding to reduce postharvest chlorophyll levels. These findings provide breeding strategies to optimize squalene in silflower oil and improve its oxidative stability, which can advance its potential use as a perennial climate-resilient oilseed crop and renewable squalene source. (NP306, 1A, 5010-44000-054-000D)

Hwang, H., Liu, S.X., Moser, J.K., Singh, M., Van Tassel, D.L. 2024. Composition and oxidative stability of silflower (Silphium integrifolium) seed oil and its potential as a new source of squalene. Journal of the American Oil Chemists' Society. https://doi.org/10.1002/aocs.12814

Component # 2 Non-Foods

1) **Turning old cash into nanocellulose for use in new engineered materials.** There are ~175 billion banknotes in circulation worldwide, and around 90 percent are made almost entirely from cotton. When these bills are pulled from circulation they must be destroyed, often via processes that create greenhouse gas emissions. ARS researchers in Albany, California, collaborated with a commercial partner to use banknotes for creating nanocellulose additives—cellulose nanocrystals (CNC), cellulose nanofibrils (CNF), and microfibrillated celluloses (MFC)—that can

be used to make stronger, more sustainable plastic composites. This “first-of-its-kind” demonstration shows how agriculturally derived components of banknotes (cotton and linen) can be part of a circular economy that results in high-value plastics and mitigates the need to incinerate the notes or add them to landfills, both of which would add to greenhouse gasses. (NP306, 2B, 2030-41000-068-000D)

US Patent Docket Number: 8823; Title: Synthesis of cellulose micro and nanoparticles from cotton banknotes; Description: ARS researchers in Albany, California files a provisional patent for a technology that uses a high-temperature and high-pressure autoclave to render end of life banknotes and other sensitive documents into a substrate that cannot be easily counterfeited.

2) **New tool for round cotton modules that reduces plastic contamination.** Plastic contamination in U.S. grown cotton has increased with the adoption of new harvesters that form cylindrical or “round” modules of seed cotton wrapped in multi-layer plastic film. The increase in plastic contamination is estimated to cost the U.S. cotton industry approximately $750 million annually. Research has shown that much of the plastic contamination originates from segments of the plastic wrap that inadvertently remain in the cotton after the wrap is manually cut and removed from the modules. ARS researchers in Lubbock, Texas, developed a new hydraulically actuated work tool for wheel loaders that rotates round cotton modules into a proper position for manual wrap cutting. In automatic positioning mode, the system controls the rotational position of round modules by sensing the location of radio frequency identification tags embedded in the plastic module wrap. This system reduced the incidence of plastic contamination at a cooperating commercial ginning facility by 50 percent and is now commercially available from a machine shop; four units are running in the Texas Panhandle this ginning season. (NP306, 2A, 3096-21410-009-000D)

   Wanjura, J., Hold, G., Pelletier, M. 2024. Loader attachment for managing round modules. 2024 Cotton Beltwide Cotton Conferences, Omni Hotel, Fort Worth, TX, January 3-5, 2024. https://www.cotton.org/beltwide/proceedings/2024/event-data/pdf/a108/fl142

3) **Eastern red cedar has versatile uses in capturing toxins, repelling red imported fire ants, and preventing termite and wood decay fungi.** The breakdown product of tire-derived 6PPD (tire rubber antioxidant), reacts with ozone in the air and forms 6PPD-quinone which is highly toxic to salmon and causes large fish kills in the northwestern United States. ARS researchers in Peoria, Illinois, found that biochar made from Eastern red cedar adsorbs 6PPD-quinone pollutants from contaminated water, which mitigates salmon die-offs and prevents associated economic losses. They also found that cedarwood oil, a safe natural material derived from Eastern red cedars, repels invasive red imported fire ants (RIFA) that girdle young trees and injure animals/people. RIFA are serious economically injurious pests around the world that annually cause U.S. losses of $6.7 billion. In addition, the researchers determined that an engineered starch/cedarwood oil dispersion prevents termite infestations and fungal wood decay and demonstrated that Eastern red cedar extracts could subsequently be used to treat otherwise susceptible wood and deter termites and wood decaying fungi from attacking wood. (NP306, 2B and 3B, 5010-41000-183-000D).

   Kirker, G.T., Hassan, B., Mankowski, M.E., Eller, F.J. 2024. Critical review on the use of extractives of naturally durable woods as natural wood protectants. Insects. https://doi.org/10.3390/insects15010069

Appell, M., Wegener, E.C., Sharma, B.K., Eller, F.J., Evans, K.O., Compton, D.L. 2023. In vitro evaluation of the adsorption efficacy of biochar materials on aflatoxin B1, ochratoxin A, and zearalenone. Animals. 13(21). Article 3311. https://doi.org/10.3390/ani13213311

Eller, F.J., Kirker, G., Mankowski, M., Selling, G. 2024. Butylated hydroxytoluene and ethylenediaminetetraacetic acid combined with cedarwood oil as wood treatments for protection from subterranean termites and wood-decaying fungi. BioResources. https://doi.org10.15376/biores.19.3.5847-5861

4) **New dual-arm apple harvesting robot.** Labor for harvesting is the single largest cost in the production of apples and other tree fruits, so harvest automation is urgently needed to control rising costs and mitigate growing labor shortages. Building on previously developed single-arm robotic harvesting technology, ARS researchers in East Lansing, Michigan, and Michigan State University collaborators developed a new dual-arm harvesting robot to enhance fruit harvest efficiency and cost effectiveness. Compared to the single-arm robot, the new robot improved harvesting efficiency up to 34 percent and shows significant potential for further performance enhancement. This new robot design provides a commercially viable solution to automated apple harvesting, which is critical to the long-term sustainability and global competitiveness of the U.S. apple industry. (NP306, 1A, 5050-43640-003-000D)

Chu, P., Li, Z., Zhang, K., Lammers, K., Lu, R. 2024. High-precision fruit localization using active laser-camera scanning: Robust laser line extraction for 2D-3D transformation. Smart Agricultural Technology. 2024(7). Article 100391. https://doi.org/10.1016/j.atech.2023.100391

Zhang, K., Chu, P., Lammers, K., Li, Z., Lu, R. 2023. Active laser-camera scanning for high-precision fruit localization in robotic harvesting: system design and calibration. Horticulturae. 10(1):40. https://doi.org/10.3390/horticulturae10010040

Zhang, K., Lammers, K., Chu, P., Li, Z., Lu, R. 2023. An automated apple harvesting robot—from system design to field evaluation. Journal of Field Robotics. 1-17. https://doi.org/10.1002/rob.22268

Chu, P., Li, Z., Zhang, K., Chen, D., Lammers, K., Lu, R. 2023. O2RNet: Occluder-occludee relational network for robust apple detection of clustered orchard environments. Smart Agricultural Technology. 5. Article 100284. https://doi.org/10.1016/j.atech.2023.100284

5) **Biodegradable biobased films for consumer products.** Information is increasing about the level and impact of plastic pollution in the environment and micro-plastics accumulation in water. Research and development are ongoing to replace plastics used in thin films for packaging and coatings, since these films are typically made from non-biodegradable, petroleum-based plastics. Biodegradable biobased thin films provide a viable alternative and had a market size of $1.3 billion in 2024, which is expected to rise to $1.9 billion by 2034. ARS researchers in Peoria, Illinois, converted a mixture of two natural, replenishable, agriculturally based polysaccharides into thin films that encapsulate and slowly release compounds of interest, such as antimicrobials and antioxidants, expanding market opportunities in the food, personal care, and cosmetic industries. Other collaborations between ARS scientists in Peoria and New Orleans, Louisiana, explored the valorization of cottonseed byproducts for bioplastic applications by blending a biodegradable polymer cellulose gum and washed cottonseed meal. Blending these two components produced single-layer films that are useful as water-soluble food packaging and coatings and as dissolvable bags and pouches for detergents and agrochemicals. (NP306, 2B,

5010-41000-184-000D; NP306, 1C, 6054-41000-113-000D and NP306, 3B, 5010-41000-188-000D)

Cheng, H.N., Biswas, A., Kuzniar, G., Kim, S., Liu, Z., He, Z. 2024. Blends of carboxymethyl cellulose and cottonseed protein as biodegradable films. Polymers. 16(11). Article 1554. https://doi.org/10.3390/polym16111554

6) **New treatment methods to help eliminate a $6 billion poultry disease.** Necrotic enteritis (NE) is a prevalent and often fatal gastrointestinal disease in poultry caused by the bacterium Clostridium perfringens. In addition to affecting chicken health and welfare, global losses from NE have been estimated to cost the poultry industry $6 billion annually. ARS scientists in Peoria, Illinois, and Beltsville, Maryland, and University of Maryland Eastern Shore collaborators developed a novel approach to control C. perfringens using the enzyme phage endolysin PlyCp41, which has the unique ability to selectively target and destroy the harmful bacterium. This enzyme was produced using modified yeast so that it could eventually be included in animal feed to control NE. This intervention eliminated up to 99.99 percent of the harmful bacteria in laboratory testing and experiments. These promising results suggests that incorporating this modified yeast into chicken feed could serve as an effective strategy to control this devastating disease and lower antibiotic use. (NP306, 2B, 5010-41000-191-000D)

   Barnas, M.R., Attuquayefio, W.D., Donovan, D.M., Skory, C.D., Hammond, R.W., Siragusa, G.R., Timmons, J.R. 2024. Yeast expressing a phage endolysin reduces endogenous Clostridium perfringens ex vivo in 21-day-old broiler chicken intestinal fluids. Avian Diseases. 68(2):129-133. https://doi.org/10.1637/aviandiseases-D-23-00088

7) **Biochar produced from the cash crop sugarcane pays further dividends by increasing other crop yields.** Biochar is a carbon rich substance made from biomass such as sugarcane bagasse, a byproduct from sugar mills. ARS researchers in New Orleans, Loiuisiana, found that amending soils with sugarcane bagasse biochar increased cotton lint yields up to 22 percent and increased cotton seed yields up to 13 percent. After the third year of successive biochar applications, corn yield increased 16 percent. These studies demonstrate that successive biochar applications can benefit crop production. (NP306, 2B and 3A, 6054-41000-114-000D)

   Pinnamaneni, S.R., Lima, I.M., Boone, S.A., Anapalli, S.S., Reddy, K.N. 2023. Effect of sugarcane biochar on rainfed cotton (Gossypium hirsutum L.) growth, lint yield and quality in the humid Mississippi Delta. Nature Scientific Reports. https://doi.org/10.1038/s41598-023-37820-8

8) **Faster, safer, cheaper field diagnostic kit for the invasive Lebbeck mealybug.** The invasive Lebbeck mealybug found in Florida feeds on and damages citrus and ornamental plants and there is concern it may spread to other states. To control populations and prevent mealybug spread, growers use field diagnostic kits that uses 10 percent potassium hydroxide for early detection. Researchers in Fort Pierce, Florida, and research partners found a faster, safer, and less expensive detection process that replaces the established method with 5 percent sodium hydroxide. This replacement is just as effective less hazardous, less expensive, readily available, five times faster, and takes less than one minute. (NP306, 1A, 6034-41000-018-000D)

   Ahmed, M.Z., Dorado, C., Ellenrieder, N.V., Quinn, N., Roda, A., Schoeller, E.N., Mckenzie, C.L., Osborne, L.S., Diepenbrock, L.M. 2023. Development of a species-level field diagnostic kit for Nipaecoccus viridis (Newstead) (Hemiptera: Pseudococcidae), an invasive and regulatory pest in the United States. Journal of Applied Entomology. 1-9. https://doi.org/10.1111/jen.13177

Component # 3 Biorefining

1) **New biodiesel from pennycress reduces greenhouse gases.** Biodiesel can reduce greenhouse gas emissions and improve air quality. The global biodiesel market size was estimated to be more than $35 billion in 2023 and is expected to maintain a 10 percent annual growth rate and reach more than $73 billion by 2030. Using winter cover crops such as field pennycress developed for U.S. Midwest production can produce high amounts of oil suitable to meet this increased demand. ARS researchers in Peoria, Illinois, and university collaborators developed new varieties of pennycress for industrial applications such as biodiesel. They investigated a new variety of high oleic pennycress (HOP) oil as a biofeedstock for producing biodiesel fuel and found HOP biodiesel exhibited exceptional fuel cold flow properties (winter acceptability) and good lubricity (reduced engine wear). Additionally, HOP biodiesel can be used as an additive to conventional diesel to improve the performance of petroleum diesel. Developing industrial applications for HOP could enhance sustainability and profitability for U.S. farmers. (NP306, 2B, Project No. 5010-41000-185-000D)

   Winfield, D.D., Dunn, R.O., Moser, J.K., Cermak, S.C., Marks, M.D. 2024. Characterization, physical properties, and potential industrial applications of high oleic pennycress oil. Industrial Crops and Products. https://doi.org/10.1016/j.indcrop.2024.118095

2) **Jojoba oil biodiesel benefits the environment.** Biodiesel is normally produced from commodity crops that are also used for other food-related applications and the cost of commodity oils can account for up to 80 percent of the cost to produce biodiesel. Because of these factors, non-food, low-cost feedstocks are needed to augment the supply of alternative fuels, which will make biodiesel more cost-competitive with conventional diesel fuel. ARS researchers in Peoria, Illinois, investigated inedible jojoba oil obtained from the seeds of the jojoba plant, which is native to parts of the United States, as a feedstock for biodiesel production. They compared fuel properties of jojoba oil-based biodiesel with important fuel standards and determined the biodiesel had excellent low temperature performance, which is advantageous in winter months and/or in cold climates. These findings highlight the enormous potential of jojoba oil as an alternative feedstock for biodiesel production because it offers favorable fuel properties that can contribute to sustainable and environmentally friendly energy solutions and does not compete with edible uses. These results will be beneficial to the renewable fuels industry, jojoba farmers, and the public as using alternative fuels facilitate the societal transition away from petroleum and its consequent environmental and climatic impacts. (NP306, 3A, 5010-41000-186-000D)

   Liu, Z., Shah, S.N., Vermillion, K., Cheng, H.N., Biswas, A. 2023. Lewis acid catalyzed cis (liquid) to trans (solid) isomerization of Jojoba oil in supercritical CO2. Biocatalysis and Agricultural Biotechnology. 54. Article 102902. https://doi.org/10.1016/j.bcab.2023.102902

3) **Improved brewer's yeast for advanced biofuels.** There is an unmet demand to catalytically upgrade second-generation cellulosic ethanol for producing sustainable aviation fuel (SAF). Finding yeast hardy enough to grow and ferment unrefined cellulosic sugars is a major barrier to processing cellulosic agricultural residues into ethanol and other bio-based products. ARS scientists in Peoria, Illinois, previously identified a distiller's yeast that performed well when challenged on unrefined cellulosic sugars. However, this yeast did not ferment the sugar xylose, which comprises 20-30 percent of the sugar in sugar syrups manufactured from agricultural residues. The yeast was also shown to stick to itself and to bioreactor walls, making it difficult to work with. The researchers developed a better yeast with improved growth characteristics that maintained the original yeast's hardiness. The new yeast was successfully engineered to ferment

xylose and produced 5-17 times more ethanol than other yeast strains when fermenting cellulosic sugars. The new yeast will advance efforts to produce second-generation ethanol because increased production directly increases plant revenue. Ethanol producers are keen to produce second-generation ethanol because the SAF market is targeted to expand from the first commercial 9-million-gallon production facility, which opened early in 2024, to 3 billion gallons by 2030. (NP306, 3A and 3B, 5010-41000-190-000D)

Hector, R.E., Mertens, J.A., Nichols, N.N. 2023. Metabolic engineering of a stable haploid strain derived from lignocellulosic inhibitor tolerant Saccharomyces cerevisiae natural isolate YB-2625. Biotechnology for Biofuels and Bioproducts. https://doi.org/10.1186/s13068-023-02442-9

4) **Oxygen-limited fermentation condition for 2,3-Butanediol production.** The bacteria strain Paenibacillius polymyxa naturally produces the platform chemical 2,3-butanediol (2,3-BDO), a starting material for producing several value-added products, including sustainable aviation fuel (SAF). However, high concentrations of 2,3-BDO must be achieved for economically feasible production. Limiting oxygen improves generating 2,3-butanediol from fermentable sugars in agricultural feedstocks that are subjected to sodium carbonate pretreatment. ARS scientists in Wyndmoor, Pennsylvania, showed that using fully aerobic fermentation conditions within the first 24 hours results in exponential biomass growth and substantial sugar consumption, and removing oxygen after 24 hours of fermentation stimulates the production of 2,3-BDO for the remainder of processing. Controlling the fermentation oxygen level via this process achieves much higher concentrations (nearly 40 g/L 2,3-BDO) than a control fermentation with constant oxygen levels. Research is continuing on incorporating fed-batch processing to produce concentrations of 2,3-BDO greater than 40 g/L, which will enable more efficient downstream product separation and recovery. (NP306, 3A, 8072-41000-111-000D)

Stoklosa, R.J., Garcia-Negron, V., Latona, R.J., Toht, M.J. 2023. Limiting acetoin generation during 2,3-butanediol fermentation with Paenibacillus polymyxa using lignocellulosic hydrolysates. Bioresource Technology. https://doi.org/10.1016/j.biortech.2023.130053