ACCOMPLISHMENTS REPORT
Western Regional Biomass Research Center (WRBRC)
October 2019 – September 2021
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Locations Reporting:
Albany, California (Western Regional Research Center)
Crop Improvement and Genetics Research Unit
Bioproduct Research Unit
Maricopa, Arizona (U.S. Arid Land Agricultural Research Center)
Plant Physiology and Genetics Research Unit
Water Management and Conservation Research
Riverside, California (Agricultural Water Efficiency and Salinity Research Unit)

Research Focus

(1) Feedstock Development:

1A. Accomplishments

Genome-wide association study analysis of camelina seedling germination under salt stress condition: Camelina is an important renewable oilseed crop for biofuel and feedstock that can relieve the reliance on petroleum-derived oils and reduce greenhouse gases and waste solids resulted from petroleum-derived oils consumption. Carmelina molecular mechanisms affected by salinity stress has yet unknown. ARS researchers at Maricopa, Arizona screened 211 camelina accessions that were germinated under 100mM NaCl concentration. Seedling germination traits, including germination rate at two stages (5- and 9-day seedling stages), germination index, dry and fresh weight, and dry/fresh ratio, were recorded. Significant correlations were found between germination rate at two stages as well as plant biomass traits. A total of 17 significant trait-associated molecular markers were identified to be related to germination rate at the two stages and dry weight. These markers are located on the putative candidate genes controlling plant root development and indirectly related to salt stress resistance. These identified markers could provide a foundation for future molecular breeding efforts aiming to improve salt tolerance in Carmelina.

Discovering candidate genes related to flowering time in the spring panel of camelina sativa: Camelina sativa is a promising oilseed and industrial crop that benefits sustainable food, feed and fuel industries. Early flowering is critical for local adaptation as well as maximizing yield in Camelina sativa. Even though the preliminary data indicated wide variation in flowering time in the spring camelina germplasm, the understanding of underlying genes and their roles in regulating flower development is still limited. In this study a research team consists of scientists from ARS lab, Maricopa, Arizona and Morris, Minnesota, University of Nebraska, University of Florida, and Danforth Plant Science Center combined genotypic data and flowering time from the spring panel, followed by genome-wide association study (GWAS) and whole-genome prediction to identify significant trait-associated markers and evaluate the predictive capability of the entire marker set. Using GWAS approach identified 20 putative molecular markers that are colocalized within/near a variety of transcription factors or protein families related to floral development in Camelina sativa. In addition, the predictive ability to use the current set of molecular markers for future genomic selection for early flowering was estimated. This study is the first step for future in-depth exploration and genetic improvements of flower development and timing in camelina for breeding, and thus improve early flowering varieties in camelina

Phenotypic examination of camelina accessions from the USDA National Genetics Resource Program: In comparison to other oilseed plants, Camelina (Camelina sativa) has a very short life cycle (85-100 days) and is economical to grow due to minimal requirements for nutritional inputs and with capacity for both summer and winter crop production. To help facilitate adoption of Camelina as an oil seed crop, researchers from ARS at Albany lab, California and University of California-Davis has examined the plant and seed characteristics of 38 genotypes housed in the USDA National Genetics Resource Program (NGRP). Important traits for farmers such as germination time, time to flower, and seed yield, as well as oil quantity and quality were evaluated. We further examined the amenability of some of the varieties to genetic modification techniques and found that they differed in efficiency. The findings comprise a compendium of knowledge for breeders and biotechnologists to utilize in improving camelina as an alternative to sunflower and rapeseed oilseed crops.

Environmentally responsive QTL controlling surface wax load in switchgrass: Switchgrass is a native species of the North American tallgrass prairie. This adaptable plant can be grown on marginal lands and is useful for soil and water conservation, biomass production, and as a forage. Two major switchgrass ecotypes, lowland and upland, differ in a range of desirable traits and the responsible underlying loci can be localized efficiently in a pseudotestcross design. A mapping population of 750 F2 lines was used to examine the genetic basis of differences in leaf surface wax load between two lowland and two upland tetraploid cultivars. Leaf surface wax load is associated with heat and drought tolerance, UV protection, and defense against pathogens. ARS researchers at Albany lab, California in collaboration with researchers from Hudson alpha Institute for Biotechnology and University of Texas identified wax compositional variation among the population founders and to map underlying loci responsible for surface wax variation across environments. Gas chromatography–mass spectrometry analyses of surface wax extracted reveal higher levels of wax in lowland genotypes and show quantitative differences of ß-diketones, primary alcohols, and other wax constituents. The full mapping population was sampled over two seasons from four field sites with latitudes ranging from 30 to 42 °N, and leaf surface wax was measured. Three high confidence QTL were identified, of which 2 displayed significant GxE effects. Over 60 candidate genes underlying the QTL regions showed similarity to genes in either Arabidopsis or barley known to function in wax synthesis, modification, regulation, and transport. Differences in chemical composition and surface micro-topology of the waxy layer were described for the population's founders that likely represent environmental adaptation to specific local environments.

Heterosis for biomass yield and other traits in alamo x kanlow switchgrass populations: Switchgrass is a native grass of the North American Tallgrass Prairie. It is being developed as a bioenergy crop because of its high yields, adaptability, stress tolerance, and low input requirements once established. Hybrid vigor has been demonstrated in crosses between lowland and upland switchgrass ecotypes. ARS researchers at Albany, California in collaboration with researchers from University of Tennessee described crosses that display hybrid vigor within the lowland switchgrass ecotype. Exploiting hybrid vigor among lowland individuals with can be a useful strategy for increasing biomass production in regions where extreme cold hardiness is not required. It was also demonstrated that visual ratings of shoot density and thickness were highly correlated with biomass yield at two different locations and two years. This may be a rapid and effective indirect selection technique in switchgrass breeding programs.

Temporal analysis of natural rubber transferases reveals intrinsic distinctions for in vitro synthesis in two rubber-producing species: Development of rubber-producing crops will benefit from improved natural rubber yield in plants such as guayule. Guayule is currently under development in the South West of USA as a source of natural rubber, resins, and biomass. Knowledge of the fundamental biology and biochemistry of natural rubber synthesis in plants will lead to practical approaches to improve yield. Investigators from ARS Albany, California, and The Ohio State University concluded that rubber particles were isolated from plants such that they could still make rubber on the bench (in vitro). Concentrations of the initiator molecules and the monomer molecules were varied, and rubber production measured over time. Some of the surprising discoveries were that guayule can synthesis long polymer chains very rapidly (under 15 minutes), and that the maximum rubber polymer size (molecular weight) can exceed 50 million grams/mole, even though the product usually found in nature is about 1 million grams/mole.

Transcriptomic and evolutionary analysis of the mechanisms by which *Parthenium argentatum*, a rubber producing perennial, responds to drought: For sustainable domestic natural rubber production in the United States, rubber-producing plants like guayule must continue to improve in yield and other characteristics. Since guayule is cultivated in the semi-arid southwestern United States, its response to and ability to survive heat and drought stress is paramount. Using genomics analyses tools, researcher at ARS Albany labs, California, University of Arizona and Cornell University provided the fundamental information regarding guayule's response to drought at the gene expression level. Guayule survives drought stress by increasing the expression of defensive genes related to plant growth. The knowledge gained may aid in developing new varieties with even higher tolerance to arid conditions in the U.S. southwest.

Guayule Genomics Website: Modern crop improvement, and molecular mechanisms research for the natural rubber-producing crop, guayule (*Parthenium argentatum*), require background information characterizing the plant DNA and RNA. Researchers at the United States Department of Agriculture, Agricultural Research Service, in courtesy of USDA Graingenes developers, lunched the ARS Guayule Genomics website (https://probes.pw.usda.gov/Guayule/index.html). The website was developed to provide a one stop shop for researchers in 11 countries worldwide that are interested in genomics of guayule, and studying molecular mechanisms of natural rubber production and plant molecular mechanisms in general.

RNASeq analysis of drought-stressed guayule reveals the role of gene transcription for modulating rubber, resin, and carbohydrate synthesis: Successful cultivation of guayule as an industrial crop relies on improved germplasm and agronomic practices. Researchers at ARS Albany lab, California and Cornell University studied guayule at the RNA level could deliver a new insight on how and when plants produce natural rubber, resin, and carbohydrate, all three of which are valuable carbon-based products. Guayule produces more rubber when it is under drought stress, but expression of genes (RNA) for the rubber pathway is mostly down-regulated. At the same time, an important gene related to conversion of carbohydrates to sugars, is up-regulated, suggesting the sugars provide the carbon for rubber production. This study helps to identify strategies for crop improvement, but in addition, informs field practices. Results suggests that field irrigation practices might be calibrated to enable tunable accumulation of rubber, resin and carbohydrate in guayule.

***Physaria fendleri* and *Ricinus communis* lecithin: cholesterol acyltransferase-like phospholipases selectively cleave hydroxy acyl chains from phosphatidylcholine:** Most oilseed crops produce oil containing different ratios of just five basic fatty acids. However, there are hundreds of structurally diverse fatty acids produced in nature, and many non-domesticated plant species accumulate high amounts of a single "unusual" fatty acid in their seed oil. Examples include the hydroxy fatty acids present in the seed oils of castor bean or *Physaria fendleri*, which have potential usage in formulations of varnishes, cosmetics, surfactants, and engine oil lubricants. Castor bean and *P. fendleri*, however, have poor agronomic traits, which limits their utilization for production of these valuable feedstocks. Metabolic engineering offers an attractive approach for resolving this problem by transferring genes for hydroxy fatty acid synthesis to other crops that have better agronomic traits. Experiments to date have shown however, that relatively low amounts of hydroxy fatty acids are produced in engineered crops due to inefficiencies in transfer of these fatty acids into the oil of developing seeds. In the current study, an international group of scientists from the University of Alberta, Agriculture and Agri-Food Canada, the National Research Council of Canada, CSIRO in Australia, the Swedish University of Agricultural Sciences, and the ARS

labs in Maricopa, Arizona, and Albany, California, identified genes in castor and *Physaria fendleri* that help increase the accumulation of hydroxy fatty acids in engineered plants. These results will be of greatest interest to other scientists interested in understanding the genes and enzymes required for production of high value oils in crop plants, as well as companies involved in the production and distribution of these oils for industrial partners and other end users.

SEIPIN isoforms interact with the membrane-tethering protein VAP27-1 for lipid droplet formation: seed oils of plants are important commodities used for food, feed, cooking, and industrial purposes. While much is known about the enzymes that synthesize oil in seeds, little is known about the mechanisms by which plants compartmentalize oil into organelles called "lipid droplets", which allows the oil to be stored as an emulsion in the aqueous interior of the cell. Recent studies have identified the SEIPIN protein as being critically important for this process. SEIPIN is located in the endoplasmic reticulum (ER) where it serves as a "vent" that allows newly synthesized oil to flow from the ER into an emerging lipid droplet. How SEIPIN performs this function is presently unknown. Collaborative research between scientists at the ARS lab in Maricopa, Arizona and the University of North Texas, University of Guelph, Canada, and University of Goettingen, Germany, has now revealed that the SEIPIN protein physically interacts with a protein called VAP27-1 to help form normal-sized lipid droplets. Loss of VAP27-1 resulted in production of aberrant, significantly enlarged lipid droplets in plant seeds. Studies in yeast confirmed that the VAP proteins were important for lipid droplet formation, particularly under conditions of elevated lipid storage. These studies provide fundamental insight to how eukaryotic organisms store oil in the aqueous environment of the cell, and are especially important to those scientists interested in understanding the factors that regulate the production of oil in plant seeds.

Genetic engineering of lesquerella with increased ricinoleic acid content in seed oil: The conventional source of hydroxy fatty acid (HFA) is from castor (*Ricinus communis*), which contains 90% ricinoleic acid (18:1OH) in its seed oil. The fatty acid 18:1OH and its derivatives are used as raw materials for numerous industrial products, such as lubricants, plastics and surfactants. The production of castor oil is hampered by the presence of the toxin ricin and hyper-allergenic 2S albumins in its seeds. Lesquerella seed oil contains a major HFA, lesquerolic acid at 55%–60%, therefore, efforts have been made through plant breeding to develop lesquerella as a new oilseed crop for a safe source of HFA. ARS researchers at Albany, California in collaboration with researchers from University of Nebraska demonstrated that significant high levels of 18:1OH can be achieved by blocking the desaturation and elongation steps in lesquerella. The results not only provide tools for engineering castor oil-producing lesquerella, but also enhance the understanding of the mechanisms of HFA synthesis.

Transcriptome analysis and identification of lipid genes in *Physaria lindheimeri*, a genetic resource for hydroxy fatty acids in seed oil: Hydroxy fatty acid (HFA) and its derivatives are used as raw materials for numerous industrial products, such as lubricants, plastics and surfactants. The conventional source of HFA is from castor which contains 90% ricinoleic acid (12-hydroxy 9-octadecenoic acid, 18:1OH) in its seed oil. The production of castor oil, however, is hampered by the presence of the toxin ricin and hyper-allergic 2S albumins in its seeds. The wild Brassicaceae species *Physaria lindheimeri* accumulates up to 85% HFA in its seed oil, therefore is a valuable genetic resource for engineering oilseed crops for HFA production. In collaborative work, researchers from ARS at Albany lab, California, Jeonju University, and University of Seoul, South Korea conducted experiment on *P. lindheimeri* transcriptomes constructed from leaf, flower bud, and developing seeds at various stages. Lipid genes involved in fatty acid and TAG

biosynthesis were identified by deep mining of the transcriptomes. Detailed spatial and temporal expression profiles of key genes were characterized by quantitative polymerase chain reaction (qPCR). *P. lindheimeri* sequences were further compared with orthologs from HFA-producing castor and lesquerella, as well as orthologs from non-HFA-producing species including Arabidopsis and Camelina. The findings provide essential information for future basic and applied research on HFA biosynthesis in oilseeds.

Variant castor lysophosphatidic acid acyltransferases acylate ricinoleic acid in seed oil: Castor seed oil (triacylglycerols, TAG) contains 90% ricinoleic acid (18:1OH), a hydroxy fatty acid (HFA) with numerous industrial applications. Castor lysophosphatidic acid acyltransferases (RcLPATs) are key enzymes contributing to the accumulation of 18:1OH in TAG. In efforts to identify isoforms of RcLPATs capable of acylating 18:1OH, researchers from ARS at Albany lab, California, Sejong University and Korean Rural Development Administration, South Korea, characterized the entire family of seven RcLPATs. We discover that all of the seven RcLPATs encode functional enzyme. We also reveal that RcLPATs are expressed variably among castor organs and during seed development. Based on spatial and temporal expression patterns, we suggest that RcLPATs play distinct and redundant roles in castor organs and developing seeds. Moreover, we found that three RcLPATs increased hydroxy fatty acids from 16.4% to 18.2–21.9% in Arabidopsis. These new RcLPAT genes are new targets for genetic engineering of oilseeds for hydroxy fatty acid production.

Regiobiochemical analysis reveals the role of castor LPAT2 in the accumulation of hydroxy fatty acids in transgenic lesquerella seeds: The conventional source of hydroxy fatty acids (HFA) is from castor (Ricinus communis), which contains 90% of ricinoleic acid in its seed oil (TAG). HFA are used as a raw material for manufacturing a range of products, such as lubricants, plasticizers and surfactants. The production of castor oil, however, is hampered by the presence of the toxin ricin and hyperallergic 2S albumins in seeds. Lesquerella (Physaria fendleri) does not have such biologically toxic compounds and also contains a major HFA, lesquerolic acid at 55-60% of seed oil. Therefore, lesquerella is being developed as an alternative industrial oilseed crop in the US. ARS researchers at Albany, California in collaborations with researchers from Montana State University and University of Hertfordshire, United Kingdom demonstrated that castor RcLPAT2 gene can be used to ricinoleis acid at the sn-2 position of TAG. Researchers further characterized the molecular species of TAG and their positional isomers (regioisomers) in those transgenic lesquerella oils using high-performance liquid chromatography and Electrospray Ionization Mass Spectrometry. These analyses, which can reveal regioisomeric structures of TAG with high resolution and accuracy, provide detailed information that are important to understand the mechanisms of HFA synthesis in seeds.

Contrasting responses of guar genotypes shed light on multiple component traits of salinity tolerance mechanisms: Guar is an important fodder crop that is rich in proteins. Besides, it is an important source of guar gum, which is used as a thickening agent in various food, as well as to increase the viscosity of water used to extract oil and natural gas from tight rock formations. Due to its ability to tolerate various abiotic stresses, guar can be successfully grown in water deficit conditions and/or with degraded waters, which are generally high in salt contents. ARS researchers at Riverside, California in collaboration with scientists from New Mexico State University conducted experiments to understand the importance of different component traits regulating salinity tolerance in guar. Field evaluations of four genotypes under non-saline conditions showed

comparable performance of these genotypes. Greenhouse experiments uncovered salt-tolerant and salt-sensitive genotypes. Salt-tolerant lines maintained low leaf sodium and chloride concentrations under salinity as compared to the salt-sensitive lines. The relative leaf potassium concentrations under salinity compared to control was significantly higher in salt-tolerant than salt-sensitive genotypes suggesting that it can be considered as an important parameter in screening guar genotypes for salinity tolerance. Expression analyses of genes involved in sodium and chloride transport showed that salt-tolerant lines differed in component traits of the salt tolerance mechanisms; hence, combining different component traits may lead to superior salt-tolerant genotypes. Outcomes of this study will be utilized by guar breeders and geneticists in developing salt-tolerant varieties suitable for areas with marginal soils and/or low-quality saline irrigation water.

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(2) Feedstock Production

2A. Accomplishments

Pyrolysis analysis of improved guayule genotypes: With the growing demand of energy and declining resources for fossil petroleum, discovery of new renewable energy strategies and feedstock is required. The byproducts from guayule shrubs are suitable for conversion to bio-oil and bio-char via pyrolysis, and thus have the potential to serve as a biofuel resource. In addition, because of Southern Texas and Northern Mexico origin, guayule is a good candidate for production in arid and semi-arid regions, which benefits the sustainability of U.S. agriculture systems. This study was conducted in collaboration between by ARS scientists in Maricopa, Arizona and Wyndmoor. Pennsylvania. The results indicated that pyrolysis byproducts production including non-condensable gases, condensable gases (bio-oil) and bio-char were significantly affected by guayule genotypes and irrigation levels. The observed significant phenotypic variations could lay a foundation for genetic improvement of guayule byproduct production. In order to maintain sustainable agricultural systems, reducing irrigation without impairing guayule productivity is required. This study indicates the significant association between irrigation schedules and guayule pyrolysis byproducts. To increase the genetic gain of guayule byproducts in future breeding programs, testing and selecting for targeted traits of interests in multiple environments or locations are required to detect and select superior breeding lines

Growth, water use, and crop coefficients of direct-seeded guayule with furrow and subsurface drip irrigation in Arizona: In recent years, US tire companies and others have increased efforts to develop and commercialize guayule in the arid US Southwest for domestic supplies of natural rubber. A critical matter in making guayule both profitable and sustainable in this region is ability to grow guayule by directly seeding it in the soil because costs of transplanting guayule are about ten times more than direct seeded. Since no information is currently available on irrigation management of direct-seeded guayule, irrigation research was conducted by ARS scientists in Maricopa, Arizona and University of Arizona. The research found that guayule rubber yield generally increased with higher irrigation water use in soils that are sandy but decreased with higher irrigation in clay soils. The studies provide recommended irrigation management practices for direct-seeded guayule for both sandy and clay soils. The research will also be of interest to the U.S. Rubber Industry, including Tire Manufacturers, irrigation consultants, water district water managers, and other research investigators of guayule.

Nitrous oxide emissions, N uptake, biomass, and rubber yield in N-fertilized, surface-irrigated guayule: Nitrous oxide (N2O) emissions from nitrogen (N) fertilizer applied to row crops makes up a large portion of the greenhouse gas loading from agriculture to the atmosphere. N2O emissions and N uptake have not been previously quantified in this multi-year cropping system of guayule. The ARS scientists in Maricopa, Arizona and University of Arizona conducted a 23-month study on transplanted and irrigated guayule to assess the agronomic and environmental responses to nitrogen (N) fertilizer application rate. Four N fertilizer rates ranging from 0 to 252 kg N ha-1 were applied as ammonium sulfate in three splits. Nitrous oxide emissions were measured with 1-L vented chambers 34 times from over 98 weeks from 17 April 2013 to 6 March 2015 with pauses during winter dormant seasons. Nitrogen rate significantly affected N2O emissions, which ranged from 2.0 to 5.5 kg N ha-1 for the 0 and 252 kg N ha-1 fertilizer rates. The percentage of added ammonium sulfate-N emitted as N2O ranged from 0. 7 to 1.4 %, which are in the range of those for other better-studied crops such as corn and cotton. Nitrogen uptake by guayule averaged 191 kg N ha-1 for biomass and rubber yields of 19 Mg ha-1 and 1070 kg ha-1,

respectively There was no effect of N rate on N uptake, biomass, or rubber yields because of high initial soil profile nitrate (NO3) levels. A N balance of inputs (initial soil NO3, N fertilizer, NO3-N added in irrigation) and outputs (N uptake, N2O, and N2 emissions) was constructed. Unaccounted for N was apparently lost as NO3 leaching below the root zone. The N uptake levels reported here can be used in updated, improved N fertilizer recommendations for guayule. Additional N fertilizer rate studies on guayule rubber yield are needed.

Humic substances to improve soil fertility under salt stress and drought conditions: The soils of semiarid regions are often poor in carbon and mineral nutrients, both necessary sources of energy for soil microorganisms and plants, respectively. Although the addition of amendments rich in organic matter may improve soil chemical characteristics, the effectiveness of different types and concentrations of organic matter in these amendments is poorly understood for semi-arid soils. ARS researchers at Riverside lab, California in collaboration with scientists at Paraiba University, Universidade Federal Da Paraiba and Federal Rural University of the Semi-Arid, Brazil evaluated the effect of two sources of organic carbon (Humistar® and diluted cow manure) on the chemical characteristics of a semi-arid soil cultivated with passion fruit and irrigated with saline water. The experiment took place in the Brazilian semiarid (northeast region) during the most severe drought in 30 years. The results with the soil used in this experiment contradict the general idea that organic matter can mitigate the harmful effects of salt in semiarid soils because the addition of both Humistar® and diluted bovine biofertilizer to the soil reduced soil fertility. Although this response may depend on the concentration of humic acids in the amendment, the results suggest that there is no economic return associated with the application of either amendment. This work benefits farmers and land managers who seek to improve soil fertility for farms in semi-arid regions. Organic farmers particularly may benefit as Humistar® is considered an organic amendment, but there are no economic studies to support its purported benefits.

Reclaiming tropical saline-sodic soils with gypsum and cow manure: Saline-sodic soils are a major impediment for agricultural production in semi-arid regions of the world. Salinity and sodicity drastically reduce agricultural crop yields, damage farm equipment, jeopardize food security, and render soils unusable for agriculture. ARS researchers at Riverside lab, California in collaboration with scientists at Universidade Federal Da Paraiba and Federal Rural University of the Semi-Arid, Brazil evaluated the use of gypsum and cow manure, separated and combined, on the reclamation of a semi-arid saline-sodic soil. The effectiveness of the sodic soil reclamation treatments was evaluated through soil hydraulic conductivity, chemical composition (cations and anions), electrical conductivity of the saturated soil-paste extract, pH, and the exchangeable sodium percentage. The results suggest that the combined use of gypsum with cow manure is better to reduce soil sodicity, improve soil chemical properties, and increase water infiltration than gypsum alone. These results are of interest to farmers, soil scientists, and agricultural extension personnel working on production agriculture in semi-arid regions and with saline-sodic soils worldwide

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(3) Conversion and Co-Product Utilization

3A. Accomplishments

Effect of size and amount of sugarcane fibers on the properties of baked foams based on plantain flour: There is an increasing interest in using natural fibers to reinforce polymers due to their positive effect on mechanical properties, significant processing advantages, low cost and low density. Several studies have shown that the use of natural fibers improves the physical and mechanical properties of starch-based biodegradable materials. The waste produced by the agricultural sector, such as sugarcane fiber, can be used as a reinforcing material in biodegradable composite materials. ARS scientists in collaboration with colleagues from Mexico demonstrated that sugarcane fiber size and concentration could beneficially modify the mechanical, physicochemical and structural properties of biodegradable baked foams. This technology could be used for applications in food packaging as a replacement for plastic containers.

Evaluation of biodegradation of polylactic acid mineral composites in composting conditions: Overproduction of plastics is an increasing public concern due to the large amounts of waste plastics amassing in marine environments and accumulating as litter. A large portion of the waste is from single-use items in the form of packaging. Plant-based poly-lactic acid (PLA) is finding its way into single-use items which is a benefit over the use of petrochemical-based plastics. However, PLA is difficult to biodegrade thus, even the plant-based plastics accumulate in the environment. The enhancement of the biodegradation rate of PLA filled with commercially available soil amendment product or a nanoclay was studied. The process could increase PLA degradation rate in industrial compost systems and thus decrease plastic accumulation in the environment. ARS researchers at Albany labs, California evaluate the enhancement of the biodegradation rate of polylactic acid (PLA) filled with commercially available soil amendment product (NTM) or a nanoclay (Cloisite 25A) Cloisite 25A and NTM were incorporated into PLA at 5, 10, 20 (w/w) through melt blending. Transmission electron micrographs revealed particles with a wide range of sizes that were formed by clumping of many smaller particles. The particles showed good dispersion in PLA by scanning electron microscopy. Under standard composting conditions using a standard technique for aerobic biodegradation of plastic materials, it was shown that the addition of NTM enhanced the biodegradation rate of PLA composites by 3- to 4-fold compared to neat PLA. Linear kinetics were used to obtain induction periods, half-lives, and rates of mineralization. Finally, mechanical and thermomechanical properties of these blends were compared with PLA.

Pretreatment affects activated carbon from piassava: Activated carbons are widely used in environmental remediation and purification processes because of their high adsorption capacities and specificity for pollutants. Biomass residues from agricultural and forestry industries can be converted into activated carbon thereby adding value to the residues and using the residues for environmental remediation. ARS researcher at Albany, California in collaboration with researchers from Federal University of Lavras, Brazil were successfully converted piassava (*Leopoldinia piassaba* and *Attalea funifera Martius*), a forestry byproduct in Brazil, to activated carbon and showed its efficacy for removing methylene blue and phenol from wastewater.

Pear peeling using infrared radiation heating technology: Bartlett pears are one of the major commodities in the fruit and vegetable processing industry and are generally peeled using lye. Lye processing involves the use of intensive energy and water consumption that also yields large quantities of wastewater that require neutralization prior to discharge. Neutralized lye water also

has high salinity and organic contamination. Concerns about the long-term water supply and wastewater management of the lye peeling technology need to be addressed to achieve the sustainability of the pear processing industry. Development of a sustainable pear peeling technology that reduces water consumption and disposal is a critical issue. One such technology is infrared heating that may be controlled to heat fruit to a limited, specific depth. ARS researchers from Albany, California and collaborators from University of California-Davis found that infrared peeling has potential for commercialization as an alternative to conventional lye peeling as it reduces water consumption and disposal. Infrared peeling can also increase fruit yield by controlling the depth of peel such that less peel is removed compared to lye processing. Specific operation parameters and conditions at the commercial scale need to be developed. Relevant issues to be addressed in a commercial system include operation and maintenance, peel depth control, pre-sorting based on size and firmness, and limiting juice leakage.

Effect of elevated temperature on sisal fibers degradation and its interface to cement based systems: Sustainable agriculture includes the use of biobased materials to replace petroleum-based fillers or reinforcing agents. Cement, used as a building material, generally contains fillers and/or additives to meet certain structural specifications. However, exposure to high temperatures can negatively impact the structural integrity of cement-based materials. The sisal plant, Agave sisalana, is easily cultivated and produces long, strong, flexible fibers. ARS researcher at Albany, California in collaboration with researchers from University of Brazil, Brazil and Technical University of Darmstadt, Germany studied the effects of temperature on natural fibers mechanical performance and to understand the modifications on structure, mechanical properties and adherence to cement. Developing an understanding of the behavior of new fillers in building material composites, such as sisal and cement, when exposed to adverse environmental conditions is critical for the design of safe building materials.

Changes on structural characteristics of cellulose pulp fiber incubated for different times in anaerobic digestate: Cellulose is an important biopolymer and plays a major role in achieving the goal of sustainable agriculture. Cellulose processability is commonly achieved by treatment with concentrated acids or alkalis. Such treatments generate large quantities of waste for disposable at a considerable cost and environmental impact. Treatment with microbial-derived enzymes is an attractive alternative as an environmentally sound process. Anaerobic bacteria that excrete enzymes into the surrounding environment serve as a continuously regenerating source of enzymes for cellulose treatment thereby improving processability. ARS researchers at Albany labs, California and researchers from Federal University of Lavras and Embrapa, Brazil concluded that treatment of wood pulp using the bacterial digestate partially removed the amorphous components of the pulp fiber resulting in a material with a high crystalline content. Such treatments show potential as mechanism for use in engineered fiber-based materials where the high crystallinity results in materials with improved strength and durability.

Torrefaction of almond and walnut byproducts: While the U.S. nut industry is growing, markets for nut byproducts, particularly nutshells and tree pruning, have not kept pace. Torrefaction is a thermochemical process used to improve physical and chemical properties of biomass for energy and other applications. ARS researchers at Albany, California in collaboration with researchers from Federal University of Lavras, Brazil characterized the effects of a range of torrefaction conditions on the properties of nut byproduct feedstock. The authors explored the usefulness of torrefied biomass to groups interested in producing bioenergy products, as well as other products and applications, from agricultural feedstocks.

Torrefied agro-industrial residue as filler in natural rubber compounds: Some of the biomass may be used as animal bedding, cattle feed or as roadside erosion control. However, the supply of biomass is outpacing the demand. Alternative, value-added uses of biomass is needed to supplement farmer income, lower disposal costs and reduce landfill space. Biomass may be used as fillers and as replacements for petroleum-derived products thereby reducing greenhouse gas emissions. ARS researchers at Albany, California heat-treated almond shells and rice hulls and compared the properties of the heat-treated biomass as replacements or partial replacement of petroleum-derived carbon black in rubber compounds. Results are promising and show that the heat-treated biomass products have comparable characteristics to carbon black as an additive.

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