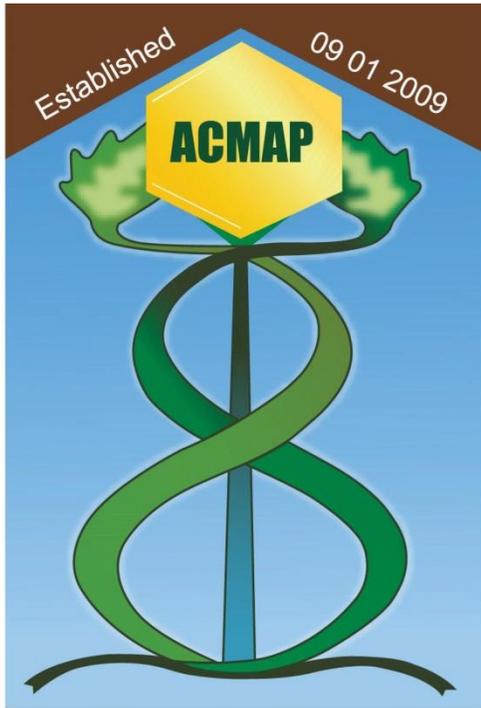


ACMAP - 8th Annual Conference, Clemson, SC

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8th Annual Conference



American Council for Medicinally Active Plants

June 20—June 23, 2017

Clemson University

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8th ACMAP CONFERENCE

Jeffery Adelberg
Chair
June 19 -22, 2017
Clemson, SC

American Council for Medicinally Active Plants

Dear Colleagues:

On behalf of the American Council for Medicinally Active Plants (ACMAP), I extend to each of you a Warm Welcome to the 8th Annual Conference of ACMAP being hosted by Clemson University, in Clemson, SC. Established in 2009, ACMAP has successfully organized highly appreciated annual conference each year, providing a platform for world-renowned scientists to present their research findings in sciences related to medicinal plants.

In keeping with its culture, the 8th Annual Conference of the ACMAP is designed to provide an academic forum to exchange current research and educational information on medicinal and bioactives by bringing together professionals, researchers, and scientists from academia, government, and private sector laboratories and other entities actively involved in medicinally active plants research, relevant to human and animal health, and general well-being. The Grower Panel is indeed a unique feature of this 8th Annual Conference as it serves as the 'ground-trothing' of high-tech scientific research findings generated in universities, and private and public laboratories!

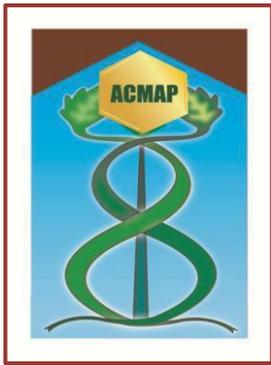
Much of the credit goes to the Program Chair, Dr. Jeffrey Adelberg and his Team who conceptualized many a creative idea and brought them to fruition with due diligence and extraordinary perseverance. Congratulations to the members of the ACMAP Board of Directors who encouraged and worked with Jeffrey for enabling yet another conference for the 8th consecutive year since the inception of ACMAP!

ACMAP remains deeply indebted to our generous sponsors, Clemson University, and all presenters and participants for making this conference a reality. I sincerely urge each of you to participate, share, and interact with one another as we strive to understand the science behind folkloric/anecdotal medicine and push the frontiers of the science of plant-based medicine further.

On behalf of the ACMAP Board of Directors, I hope that you'll find this conference, and this venue most productive and enjoyable. Please feel free to contact any of our organizers if we can help make your ACMAP participation more exciting and rewarding. Again, thank you all and welcome to the 8th Annual Conference of ACMAP.

Sincerely,

Srinivasa Rao Mentreddy
President, ACMAP Board of Directors



American Council for Medicinally Active Plants

Dear Participants of ACMAP-8:

We are lucky people!

To make my point, just look around at who has attended this ACMAP meeting. Look carefully at the people, we are pretty well nourished and generally in good health. We know the power of plants. Both as nutrients and biochemical agents that build our bodies and maintain its health.

Now, let's feed the mind. Peruse the titles and topics in the program and notice the diverse perspectives. Read the abstracts and you will find some excellent science. Our Scientific Program Committee, and the ACMAP board have called on many of the best researchers and practitioners in this broadly integrated field and they answered back, affirmatively. This dialog is not good enough without generous support from outside sponsors and my home institution, Clemson University. Their financial acknowledgement of this good work has enabled so many to attend. Yet this would be chaos without this program book, and the multiple layers of logistics that lie hidden between the lines. Gracious hosting has been provided by the Local Organizing Committee. I owe my gratitude to all these folks, for sharing the vision, and making this an event.

Filling our minds and bodies with facts and foods, would make the meeting seem successful. But, we are doing more. Medicinal plant research is not for the benefit of the researcher, but society as a whole. Sharing knowledge freely among peers is a hallmark of a great society. Bringing in the students, and the intergenerational transfer of knowledge, allows this knowledge to re-double over the years to come. The new American pharmacopeia belongs to them, but there is still so much hard work to be done.

We live in an age of specialists, and dwell in our narrowly defined bubbles. We claim expertise by mastering our specialties. It is far more courageous to reach out of the bubble and make connections with those far afield. So I welcome growers, processors, geneticists, chemists, clinicians and healers to stretch broadly. Look at who has chosen to come, and embrace what we have in common.

I applaud you for the unique perspectives you bring to the gathering. Our 8th Annual Meeting of the American Council for Medicinally Active Plants is a proud achievement.

So join us and see what comes up,

Jeff Adelberg
ACMAP-8 Program Chair

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8th ACMAP CONFERENCE

Jeffery Adelberg
Chair
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Clemson, SC



June 12, 2017

Dear American Council for Medicinally Active Plants Members,

Or should I say, Dear agronomist. . .environmentalist. . .nutritionist ... finance specialist... mechanic... investment analyst...engineer. . .soil scientist...business manager... meteorologist ...veterinarian ...marketer. . .accountant. . .conservationist. . .efficiency expert... technology practitioner, and so on?

This wide array of occupations came from a young woman with a degree in agriculture who went home to work on her family farm and help modernize production. After only three months on the job, she realized that the world of agriculture was rapidly changing and was far more complex than her wildest imagination. As she confronted more challenges, she began making a list of all the jobs that successful agricultural professionals needed to understand. And so it is for your profession, and for Clemson University's academic programs housed in the College of Agriculture, Forestry, and Life Sciences; College of Science; College of Business; College of Behavioral, Social and Health Sciences; and College of Engineering, Computing and Applied Sciences.

Robert H. Jones
Executive Vice President for
Academic Affairs and Provost

Office of the Provost
Clemson University
206 Sikes Hall
Clemson, SC
29634

P 864-656-3243
Asst. 864-656-3940
provost@clemson.edu

Thank you for choosing Clemson University for the 8th annual American Council for Medicinally Active Plants program. This is a great place to discuss medicinal plants! You will meet faculty, students, and staff who have a passion for the topic. Please take the opportunity to visit our special facilities, including our medicinal plant-rich South Carolina Botanical Gardens, our greenhouse facilities and biochemical laboratories, and our beautiful campus surrounded by thousands of acres of experimental forest. Clemson's research footprint covers all of the biophysical regions of the state, and many more across the nation and world.

Medicinal plant traditions run deep here. Our campus is home to the Cherokee, and their traditional medicines. The Calhoun and Clemson families and generations of slaves, sharecroppers, and family farmers practiced other types of agriculture and healing. Today, we study and use medicinal plants by combining the wisdom of science with the diverse ethnic traditions of our University community. We are the right place and time for nature, people, and science to meet.

I welcome the American Council for Medicinally Active Plants board members to Clemson and thank all of you for bringing your experience and expertise to this venue. It is wonderful to have an opportunity to collaborate. I also offer my gratitude to Dr. Jeffrey Adelberg and his colleagues for organizing this very special event.

;

Robert H. Jones
Executive Vice President for Academic Affairs and Provost

**American Council for Medicinally Active Plants
(ACMAP)
Clemson University, Clemson, SC**

Program

Tuesday - June 20, 2017		
1:00 pm - 4:00 pm	Southern Appalachian Herbal Medicine Preparation Hands-on Workshop (Additional Fee) Phyllis Light (Appalachian Center for Natural Health)	South Carolina Botanical Garden Hayden Center
2:00 pm – 5:00pm	Registration	Madren Center Connector (Madren Inn Side)
4:45 pm – 5:45 pm	Board of Directors Meeting	South Carolina Botanical Garden Discovery Center Upstairs Executive Conference Suite
6:00 pm - 7:00 pm	Registration and Reception Heavy hors d'oeuvres will be served	South Carolina Botanical Garden Discovery Center
7:00 pm	An Evening with Patrick McMillan, Ph.D. Director South Carolina Botanical Garden, Producer, host, writer, director and co-editor of the Emmy award-winning television program "Expeditions with Patrick McMillan" aired on PBS	South Carolina Botanical Garden Discovery Center
Wednesday – June 21 Madren Conference Center		
7:30 am – 10:30 am	Registration Exhibitors Table Set-Up (Room 132) Set Up Posters Professionals (Room 132) Graduate Students (North Lobby) Undergraduates (Auditorium Lobby)	Auditorium Lobby
8:30 am	Opening	Auditorium
9:00 am	Plenary: James Simon, Ph.D. (Rutgers University) Out of Africa	Auditorium
10:00 am	Break Graduate Student Poster Competition Erika Pambianchi (North Carolina State University) Niroshan Siva (Clemson University)	Room 132 Seminar Room II (Room 130)

Wednesday – June 21 Madren Conference Center	
10:30 am	<p>Session 1 – Joint Session Auditorium Chairs: Rao Mentreddy, Ph.D. (Alabama A & M) Jeanine Davis, Ph.D. (North Carolina State University)</p> <p style="padding-left: 40px;">10:30 Merle Zimmerman (American Herbal Products Association) State of the Industry: An overview of medicinal plants, their consumers, and the United States’ marketplace</p> <p style="padding-left: 40px;">11:15 Mark Blumenthal (Founder and Executive Director, American Botanical Council, Editor-in-Chief, <i>HerbalGram & HerbClip</i>) Adulteration of Botanicals and Their Extracts: A Status Report on the ABC-AHP-NCNPR Botanical Adulterants Program</p>
12:00 Noon	<p>Lunch Madren Ballroom Speaker: David Newman, D. Phil. (Former Director of Natural Products Section, National Cancer Institute) Endophytes as the “true source” of important medicinal plant products</p>
1:15 pm	<p>Session 2a – Growing the Crops Auditorium Chair: Jeanine Davis, Ph.D. (North Carolina State University)</p> <p style="padding-left: 40px;">1:15 Ronald Ross (Garnay Inc.) Garnay Inc. – Ginkgo biloba production in Sumter, SC.</p> <p style="padding-left: 40px;">1:35 Randy Beavers (OrganiPharm) Goldenseal: One Plant’s Journey from Endangered Species to Botanical Drug</p> <p style="padding-left: 40px;">1:55 Jim Hamilton, Ph.D. (North Carolina State Extension, NC State University) Spreading the ginseng gospel: case study in production and landowner education</p> <p style="padding-left: 40px;">2:15 Jeanine Davis, Ph.D. (North Carolina State University) Growing a Hop Industry in the Southeast</p>
1:15 pm	<p>Session 2b - Food Biotechnology Seminar Room II (Room 130) Chair: Kalidas Shetty, Ph.D. (North Dakota State University)</p> <p style="padding-left: 40px;">1:15 Kalidas Shetty, Ph.D. (North Dakota State University) Metabolic Innovations for Food Microbiome to Advance Global Food Security and Health</p> <p style="padding-left: 40px;">1:35 Fabricio Medina-Bolivar, Ph.D. (Arkansas State University) Biosynthesis and Enhanced Production of Functional Ingredients in Hairy Root Cultures of Peanut</p> <p style="padding-left: 40px;">1:55 Dipayan Sarkar, Ph.D. (North Dakota State University) Climate Resilient Metabolic Strategies for Improving Medicinally Active Food Plants</p> <p style="padding-left: 40px;">2:15 Xiaoyan Chen, Ph.D. (College of Pharmacy, Medical University of South Carolina) Drug Leads from the Human Microbiome and the Impact of Plant Secondary Metabolites their Production</p>
2:45 pm	<p>Break Room 132 Graduate and Undergraduate Student Poster Competition Seminar Room II (Room 130) Lindsay Caesar (University of North Carolina - Greensboro) Victoria Willis (Clemson University) Justin Stempin (University of North Carolina - Greensboro - Undergraduate)</p>

Wednesday – June 21 Madren Conference Center		
3:15 pm	Session 3a - Processing, Quality, Sourcing Chair: Jeanine Davis, Ph.D. (North Carolina State University)	Auditorium
	3:15 Ed Fletcher (Herbal Ingenuity, Director of Quality and Sustainability) Global Botanical Sourcing: Social, Quality and Regulatory Changes Through the Years... 3:45 Bill Chioffi (Gaia Herbs, Vice President of Global Sourcing) Vertical Integration of Raw Material Sourcing and Herbal Medicine Manufacturing 4:15 Kurt Young, PhD. (Nutra Manufacturing/GNC) Quality Testing/Assurance of Botanicals in Dietary Supplements: An Industry Perspective	
3:15 pm	Session 3b - Cosmeceutical, Wound Healing, Dermatologic Chair: Mary Ann Lila, Ph.D. (North Carolina State University)	Seminar Room II (Room 130)
	3:15 Stefano Manfredini, Ph.D. (University of Ferrara, Italy) Botanical photo-protection alternatives to synthetic UV filters 3:45 Charles Gray (EnDev Labs / EI Pharmaceuticals) Regulatory Considerations for Therapeutic Cosmetic Products 4:00 Alessandra Pecorelli, Ph.D. (North Carolina State University) Evaluation of protective effects of topical vitamin C compound mixtures against ozone-induced damage in different cutaneous models 4:15 Mary Ann Lila, Ph.D. (North Carolina State University) Skin repair/healing properties of arctic berries	
4:45 pm	Pictures and Break	Madren Courtyard Garden
5:15 pm	Tours: Poole, Life Sciences, Biotechnology Research Complex and Greenhouses (Load buses by the Auditorium Lobby)	
6:30 pm	Dinner: On your own - Downtown or Sole on the Green (Restaurant in the Madren Center)	
Thursday, June 22 Madren Conference Center		
8:00 am – 10:00 am	Registration	North Lobby
8:30 am	Session 4a – Functional Foods Chair: Bhimu Patil, Ph.D. (Texas A&M University)	Auditorium
	8:30 Bhimu Patil, Ph.D. (Texas A&M University) Healthy Functional Foods: Effects of Processing and Storage on Health-Promoting Molecules 9:10 Dilrukshi Thavarajah, Ph.D. (Clemson University) Pulses as Whole Food Solution to Global Health Challenges 9:35 Sun-Ok Lee, Ph.D. (University of Arkansas-Fayetteville) Health effects of grain sorghum	

Thursday, June 22 Madren Conference Center	
8:30 am	<p style="text-align: center;">Session 4b – Environments for High Value Plants and Fungi Seminar Room II (Room 130) Chair: Gary Stutte, Ph.D. (SyNRGE LLC)</p> <p>8:30 Gary Stutte, Ph.D. (SyNRGE LLC) Increasing Production of Phytochemicals in Controlled Environments</p> <p>9:00 Byoung Ryong Jeong, Ph.D. (Institute of Agriculture and Life Science, Gyeongsang National University, Korea) Evaluation and Elicitation of Secondary Metabolites by Light Quality in Micropropagated Clones of <i>Scrophularia kakudensis</i></p> <p>9:20 Tradd Cotter (Mushroom Mountain Research Facility) Environmental Influence on Medicinal Fungi: Research Focus at Mushroom Mountain LLC</p> <p>9:40 Rabia El-Hawaz, Ph.D. (Clemson University) In vitro mineral nutrition of turmeric rhizomes effects subsequent essential oil production in the greenhouse</p>
10:00 am	<p style="text-align: center;">Break Room 132 Undergraduate Student Poster Competition Seminar Room II (Room 130) Katlynn Murphy (Clemson University) Emily Wallace (University of North Carolina - Greensboro)</p>
10:30 am	<p style="text-align: center;">Session 5a - Transforming Traditional Botanical Medicine into Precision Medicines Auditorium Chair: Mark Hamann, Ph.D. (College of Pharmacy, Medical University of South Carolina)</p> <p>10:30 Mark Hamann, Ph.D. (College of Pharmacy, Medical University of South Carolina) Derived Natural Products in Precision Medicine for Cancer</p> <p>10:55 Yuewei Guo, Ph.D. (Professor at the Shanghai Institute of Materia Medica, Chinese Academy of Sciences) Exploring for bioactive natural products from Chinese mangroves</p> <p>11:20 Shan He, Ph.D. (Drug Development, Ningbo University, China) Discovery and Development of the Karlotoxin Class in Precision Oncology</p> <p>11:45 Ivett Pina, Ph.D. (College of Pharmacy, Medical University of South Carolina) Natural Products from the Endangered Plant <i>Microbiome Echinocactus grusonii</i></p>
10:30 am	<p style="text-align: center;">Session 5b – Anti-inflammatory, Anti-oxidant, Anti-cancer Seminar Room II (Room 130) Chairs: Feng Chen, Ph.D. (Clemson University) Kevin Zhou, Ph.D. (Wayne State University)</p> <p>10:30 Kevin Zhou, Ph.D. (Wayne State University) Development of grape skin components for diabetes management by targeting postprandial hyperglycemia</p> <p>11:00 Anait S. Levenson, M.D., Ph.D. (Long Island University) miRNA-mediated cancer chemoprevention and therapy by dietary stilbenes</p> <p>11:20 Mary H. Grace, Ph.D. (North Carolina State University) One-step isolation of carnosic acid and carnosol from rosemary by centrifugal partition chromatography</p> <p>11:40 Haihui Xie, Ph.D. (South China Botanical Garden, Chinese Academy of Sciences) Bioactive compounds from strawberry and star fruit</p>

Thursday, June 22 Madren Conference Center	
12:00 Noon 1:00 pm	Lunch Poster Session (Authors to be present with their posters) Madren Pavilion
2:00 pm	Session 6a – Breeding, Germplasm and Genomic Tools Chair: Jeff Adelberg, Ph.D. (Clemson University) <div style="margin-left: 40px;"> <p>2:00 Toni Kutchan, Ph.D. (Donald Danforth Center) Production of terpenes in <i>Camelina sativa</i> oilseed</p> <p>2:30 Massimo Iorizzo, Ph.D. (North Carolina State University) Genetic and genomic approaches to link anthocyanin genetics and nutrigenomics in specialty crops</p> <p>2:50 Joe-Ann McCoy, Ph.D. (North Carolina State Arboretum) Utilizing Germplasm Repositories for Collaborative Research</p> <p>3:10 James Simon, Ph.D. (Rutgers University) Breeding Basil</p> </div> Auditorium
2:00 pm	Session 6b – Antibiotic, Antimicrobials Chair: Anthony Pometto Ph.D. (Clemson University) <div style="margin-left: 40px;"> <p>2:00 Jeremy Tzeng, Ph.D. (Clemson University) Antimicrobial and Anti-Efflux Properties of Goldenseal (<i>Hydrastis canadensis</i>)</p> <p>2:30 Armitra Jackson-Davis, Ph.D. (Alabama A&M University) Use of Natural Antimicrobials in the Food Industry</p> <p>2:50 Anthony Pometto Ph.D. (Clemson University) Rapid Screening of Natural Plant Extracts with Calcium Diacetate for Differential Effects Against Foodborne Pathogens and a Probiotic Bacterium</p> <p>3:10 Oleg Maksimov, Ph.D. (American College of Healthcare Sciences) Essential Oils as Natural Preservatives – Future of Food Industry?</p> </div> Seminar Room II (Room 130)
3:30 pm	Break Graduate and Undergraduate Student Poster Competition Indika Mapa (Clemson University) Nolan Barrett (Medical University of South Carolina) Room 132
4:00 pm	Session 7a - Ethnobotanic Healers Chairs: Rao Mentreddy, Ph.D. (Alabama, A&M) Jeanine Davis, Ph.D. (North Carolina State University) Jeff Adelberg, Ph.D. (Clemson University) <div style="margin-left: 40px;"> <p>4:00 Nomi Gallo (Ayurvedic Center for Healing Life and Longevity) Ayurvedic Herbal Practice</p> <p>4:30 Phyllis Light (Appalachian Center for Natural Health) Southern and Appalachian Folk Medicine</p> <p>5:00 Hong Zhang (Greenville Health System) Traditional Chinese Medicine and Acupuncture</p> </div> Auditorium

	Thursday, June 22 Madren Conference Center	
4:00 pm	Session 7b - Validation of Activity of a Single Compound vs. Multi-compound in an Extract Chairs: Agnes Rimando, Ph.D. (USDA) Fabricio Medina-Bolivar, Ph.D. (Arkansas State University) 4:00: Chun-Tao Che, Ph.D. (University of Illinois at Chicago) Metabolite profiling: Applications in quality assessment and bioactivity evaluation of herbal extracts 4:30: Bill Gurley, Ph.D. (University of Arkansas for Medical Sciences) Emerging Technologies for Improving Phytochemical Bioavailability: Benefits and Risks 5:00: Joshua Kellogg, Ph.D. (University of North Carolina-Greensboro) Complex mixture, complimentary activities: Multi-target bacterial inhibition by the medicinal lichen <i>Usnea barbata</i>	Seminar Room II (Room 130)
5:30 pm	Break	Room 132
5:30 pm	Board Meeting Judges get together	Seminar Room II (Room 130)
7:00 pm	Business, Bluegrass, Banquet and Awards	Madren Pavilion
Friday – June 23		
8:00 am – 5:30 pm	Bus Tour: (Load buses by the Auditorium Lobby) (Additional Fee) 9:30 - 11:30 Gaia 12:00 - 2:30 Lunch and North Carolina Arboretum 4:00 - 5:15 Mushroom Mountain 5:30 - Arrive Back at Clemson *If requested there will be a drop at the Asheville airport at 3:00 pm or the Greenville – Spartanburg Airport at 4:00 pm.	

PLENARY SPEAKER
Wednesday, June 21, 2017 (9:00 am)
Auditorium, Madren Conference Center

Jim Simon, Distinguished Professor of Plant Biology
Director, New Use Agriculture and Natural Plant Products Program (NUANPP),
Co-Director, Center for Sensory Sciences and Innovation (CSSI)
PI, HortNutrition Project, of the UC-Davis led USAID funded Horticulture Innovation Lab, Rutgers University,
Department of Plant Biology-Foran Hall
59 Dudley Road New Brunswick, New Jersey 08901

Jim Simon serves as Director of the New Use Agriculture and Natural Plant Products Program (NUANPP), Rutgers University, which seeks to identify new crop opportunities, new applications of bioactive and nutritious plant compounds and new products from fruits, vegetables, herbs and most recently from marine organisms. Simon has co-led botanical cores of two NIH/NCCAM programs, (i) Purdue University and University of Alabama National Botanical Center on Age Related Diseases (2000- 2011); and (ii) NIH Center of Excellence for Research on Complementary and Alternative Medicine for Alzheimer's disease on the protective roles provided by grape derived polyphenolic compounds led by Mt. Sinai Medical School (2007-2012). Simon is currently the PI on the USDA/SCRI funded Strategies for Improving the U.S. Responses to Fusarium, Downy Mildew and Chilling Injury in Production of Sweet Basil (*Ocimum basilicum* L.); serves as co-PI on the USDA/SCRI funded Locally Grown Ethnic Greens and Herbs: Demand Assessments and Production Opportunities for East Coast Farmers on Ethnic Greens and Herbs for the East Coast, which also uses our market-first science driven models to explore new crop opportunities here in New Jersey and the East Coast, and leads and/or participants in several other national and international research initiatives (see our NUNAPP website).

Since 1994, Simon has also been conducting collaborative research in sub-Saharan Africa and in 2000 was a cofounder ASNAPP (Agri-Business in Sustainable Natural African Plant Products, www.asnapp.org) which continues to grow today with NGOs in Ghana, Senegal, South Africa and Zambia; and programs in Liberia, Malawi and Rwanda. Simon also served as PI for Partnerships in Food Industry Development for Natural Products (www.pfidnp.org), a US university-led USAID funded program which has facilitated the commercialization of natural products and horticultural crops for small African farmers in sub-Saharan Africa using a market-driven and scientific model of development for which ASNAPP serves as the coordinating and implementing partner in Africa. Simon was an original author for the WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants and has experience and programs in international research in sub-Saharan Africa (Cameroon, Ghana, Liberia, Kenya, Madagascar, Malawi, Namibia, Rwanda, Senegal, South Africa, Tanzania, and Zambia) and Israel. Simon is nationally and internationally recognized as one of the leading horticultural and medicinal and aromatic plant authorities with specialization in natural products and quality control.

Plenary Speaker Abstract
Jim Simon, Ph.D.
Out of Africa

Africa, and in particular Sub-Saharan Africa is a veritable treasure of plant species traditionally used in foods, beverages, flavors, fragrances and medicine. This presentation will focus on several models we have developed and use in concert with our African and US partners to explore, screen, and study biologically active indigenous and naturalized plant species to improve health and nutrition and for commercial development. Our core mission has been to use plants in a sustainable manner (environmentally, socially and economically) as the catalytic engine to generate income opportunities for local African communities, particularly women's groups. This presentation will include case studies from Liberia, Namibia, Kenya, Tanzania and Zambia to illustrate how science can inform, educate and be used to develop plant genetic resources for local and regional development. Tales from interweaving ethnobotany, germplasm collection and characterization to actual agricultural and agroforestry development and introduction to postharvest handling, processing and product development will be featured. One of our stories has been documented in the film, Women of Nsongwe, (<https://vimeo.com/110824453>), which illustrates how the introduction of just horticulture can transform the lives of rural African women.

ORAL PRESENTATIONS

Session 1 – Joint Session (Madren Center, Auditorium)

O1. State of the Industry: An overview of medicinal plants, their consumers, and the United States' marketplace

Merle Zimmermann¹, Michael McGuffin¹ and Maged Sharaf¹. ¹American Herbal Products Association.

Email: mzimmermann@ahpa.org

Medicinal plants are a major part of the natural products industry in the United States. With long histories of use to support health, these natural products are a sizable part of the over \$37 billion dollars of sales (as of calendar year 2015) in the US dietary supplement industry. In this presentation, we discuss the use of medicinal plants in the marketplace, the consumers they serve, and the frameworks, both self-regulatory and government-lead, which have established standards for operations in this area. For perspective, we will also examine a selection of the corresponding structures and product types used in the pharmaceutical drug industry and look at similarities and differences between the two arenas, as well as consider some of the resources and tools used in the industry to ensure a healthy marketplace that works to efficiently and sustainably provide high quality products to the public at affordable prices.

O2. Adulteration of Botanicals and Their Extracts: A Status Report on the ABC-AHP-NCNPR Botanical Adulterants Program

Mark Blumenthal, Founder & Executive Director, American Botanical Council, Editor-in-Chief, *HerbalGram* & HerbClip, Director, ABC-AHP-NCNPR Botanical Adulterants Program, Austin, TX, USA Email: mark@herbalgram.org

The chemically complex nature of herbs and botanically materials requires substantial quality control diligence for manufacturers and producers of herbal products. In the recent years, there have been numerous cases of accidental misidentification of botanical materials due to human error. There is also intentional adulteration – called economically motivated adulteration (EMA) – where raw materials are intentionally substituted or diluted with undisclosed lower-quality / lower-cost ingredients. Further, extracts may be “spiked” with various exogenous compounds to create a false sense of quality. Confirmation of adulteration of commercial botanical materials cases are currently being compiled in extensive peer-reviewed documents by an independent consortium of nonprofit organizations: the American Botanical Council (ABC), American Herbal Pharmacopoeia (AHP), National Center for Natural Product Research (NCNPR, at the University of Mississippi) Botanical Adulterants Program -- a multi-year international research and educational program supported by over 180 botanical industry companies, third-party analytical laboratories, nonprofit professional organizations (e.g., ASP & GA), trade associations, research centers, et al. To date (June 2017), the Program has published 31 papers on topics including the history of adulteration of herbs, spices, and botanical drugs over the past 2000 years; the adulteration of skullcap (*Scutellaria lateriflora*) with potentially hepatotoxic germander (*Teucrium* spp.); adulteration of so-called “grapefruit seed extract” with synthetic industrial disinfectants; adulteration of bilberry (*Vaccinium myrtillus*) fruit with synthetic dye and/or anthocyanins from other lower-cost plants; adulteration of North American black cohosh (*Actaea racemosa*) root/rhizome with lower cost and chemically different roots/rhizomes of Chinese *Actaea* spp.; adulteration of St. John's wort (*Hypericum perforatum*) herb extract with vegetal dyes; adulteration of arnica (*Arnica montana*) with *Heterotheca inuloides*, et al. These articles are available via open access on the Botanical Adulterants Program website: <http://cms.herbalgram.org/BAP/index.html>. The Program also produces Laboratory Guidance Documents in which analytical methods for adulterated botanicals are summarized and evaluated for their fitness for purpose to detect suspected adulteration.

Luncheon Speaker (Madren Center Ballroom)

O3. Endophytes as the “true source” of important medicinal plant products

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Over the last twenty or so years looking at the Marine environment, it has now become quite apparent that single-celled organisms, usually bacteria and fungi, are the actual source of the majority of the bioactive agents identified from the “host” marine invertebrate. In the terrestrial environment, there are now significant reports from investigators world-wide, linking the presence of what were considered to be “plant metabolites” to potential and actual production by endophytes, and in some cases, epiphytes. This talk will cover molecules where there are no doubts about the microbial source, through to others where although a “smoking gun” has not yet been identified, the circumstantial evidence is pointing to microbial involvement. There will also be examples demonstrating that if the correct methods are followed, microbes from plant sources that appeared to have lost the ability to produce after a few subcultures, in fact still will if the media components are suitably chosen. It should also be pointed out that in Traditional Chinese Medicine, the growth conditions of medicinal plants are very carefully described. Could it be that the ancient Chinese practitioner realized that there were other “unseen” components in their active mixtures?

**Session 2a – Growing the Crops
(Madren Center, Auditorium)**

04. Garnay Inc. – Ginkgo biloba production in Sumter, SC.
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Dr. Willmar Schwabe originated the idea of using an extract of Ginkgo biloba leaves for therapeutic purposes in the early 1960s. In 1965 the Schwabe Company introduced the first commercially available Ginkgo leaf extract under the trade name Tebonin®. In 1968, the Schwabe Company established a collaborative relationship with the Beaufour-IPSEN Group of France. The demand for EGb 761 continued to expand, and the decision was made to establish new plantations and drying facilities devoted exclusively to the production of dry Ginkgo leaves in France and the United States in the early 1980s.

All aspects of Ginkgo plantation management have evolved—and are still evolving—in response to the interaction of the following goals: maintaining the long-term health of the plants; producing high yields; producing high quality leaves; and mechanizing the cultivation process. The techniques developed in both plantations—the best management practices—represent an optimized balance of these competing factors and have produced the unique system of Ginkgo cultivation that is in use today. This “adaptive management” approach is characterized by ongoing experimentation and by year-round monitoring of all environmental factors affecting the production cycle, including soil fertility, leaf biochemistry, weather patterns, insect pests, and weed growth.

A tight feedback relationship exists between the development of harvesting and pruning equipment and the treatment of the plants in the field. With each passing year, the equipment has become more specialized and the manipulation of the plants in the field more sophisticated, resulting in a higher quality product and healthier plants. The cutback cycle, for example, has been standardized in order to keep the plants below two meters in height, a size that facilitates mechanical harvesting as well as other plantation operations such as fertilizing, cultivation, and weeding.

05. Goldenseal: One Plant’s Journey from Endangered Species to Botanical Drug
Randy Beavers (OrganiPharm) Email: info@sleepyhollowherbfarm.com

The ultimate goal of medicinal plant research is to bring high quality medicinal products to the marketplace. Historically, medicinal plant raw material has been procured from wild collected sources leading to significant issues regarding wild population viability, correct species identification, and potency variations. In addition, traditional processing methods and even modern chemical marker standardization do not necessarily prove to be reliable in predicting end product potency. In the United States, most medicinal plant products are regulated as dietary supplements with marketing claims limited to structure/function effect. Full medicinal claims can only be made by achieving Food and Drug Administration approval as a botanical drug which demands sustainable production, reliable potency, and uncompromising purity. Resolving these issues is a complicated process requiring a multi-disciplinary approach that must include growers, academic researchers, industry, and regulatory agencies. This presentation will outline a pathway for botanical drug development using the Convention on International Trade in Endangered Species Appendix List II plant *Hydrastis canadensis* L. (goldenseal) as a model.

06. Spreading the ginseng gospel: case study in production and landowner education
Jim Hamilton, Watauga County Cooperative Extension, Boone, NC 28607. E-mail: jim_hamilton@ncsu.edu

Over the last 4 years, Cooperative Extension has been providing on-farm demonstrations and workshops with forest landowners and intensive ginseng growers in northwestern North Carolina. Wild-simulated ginseng is a viable forest crop option for underutilized woodlands in prime ginseng growing habitat in northwestern NC (and many parts of the Appalachians). Interest in the county’s “ginseng program” and programmatic efforts have yielded participation by over 100 landowners who have sown close to 3,000 pounds of seed in the last 4 years. In 2014, Watauga County was home to the first felony conviction of ginseng theft on private property in North Carolina due in part to a coordinated and proactive educational approach directed towards law enforcement and the district attorney’s office. Successful elements of Extension’s wild-simulated ginseng production program will be presented to highlight how other organizations can garner interest from landowners in establishing ginseng on underutilized forest land.

07. Growing a Hop Industry in the Southeast

Jeanine Davis, Dept. of Horticultural Science, North Carolina State University, Mountain Horticultural Crops Research and Extension Center, 455 Research Drive, Mills River, NC 28759. Email: Jeanine_Davis@ncsu.edu.

The rapid growth of the craft beer industry has resulted in widespread interest in growing the ingredients used to make beer, including hops (*Humulus lupulus*). In response to production issues that new hop growers in North Carolina and Virginia were experiencing, in 2009 we initiated a hops extension program followed by a research program in 2010. Hop is a photoperiod sensitive plant that enters the flowering stage as the days shorten in the summer. The major hop production area in North America is in Washington, Oregon, and Idaho where spring days are long (the longest day in Yakima, WA is 15 h 50 s). The commercial varieties grown there were bred for those conditions. When grown in the South where the day length is shorter (the longest day in Asheville, NC is 14 h 34 s), these varieties often set flowers too soon before there is adequate foliage and side-arm development. As a result yields are low; often one-quarter to one-fifth of what they would be in more northern latitudes. Our studies have focused on looking for varieties that will perform better in the south and cultural practices that might influence flowering. We have also studied disease and insect control, weed control methods, crowning, trellis methods, and a portable mechanical harvester. We collaborate with local brewers to learn if our hops produce good beer. We recently initiated a hop breeding program with the main objectives being to develop varieties that perform better in our Southern environment, to reduce plant size, and increase disease resistance.

Session 2b - Food Biotechnology (Madren Center, Seminar Room II, Room 130)

08. Metabolic Innovations for Food Microbiome to Advance Global Food Security and Health

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Global food security challenges need to address challenges from both undernourishment and also emerging challenges of non-communicable chronic diseases (NCD) induced from calorie dense food from hyper processed and refined high carbohydrate sources. In building new opportunities for value added food systems to counter above nutrition and health challenges metabolic innovations focused on building diversity of plant foods systems in diverse localized ecologies globally is essential. In this strategic model metabolic innovation through control of pentose phosphate pathway is used as a gateway pathway to enhance health relevant bioactives in plant foods that can partition some of the primary metabolites towards plant secondary bioactive compounds which can be targeted to modulate key NCD pathways such as type 2 diabetes and its complications. Such bioactive enriched foods from diversity of plant foods can also be substrate matrix for beneficial microbiome based biotransformation to further enhance NCD countering bioactives while also enriching for probiotic type beneficial microbiomes. In this presentation several specific strategies of above metabolic innovations will be presented.

09. Biosynthesis and Enhanced Production of Functional Ingredients in Hairy Root Cultures of Peanut

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Peanut is currently grown worldwide as an economically important oil and food crop. This species produces prenylated stilbenoids to protect itself against various pathogens. In addition to their role in plant defense, these compounds have potential applications as functional ingredients due their diverse biological activities. However, despite their importance to plant and human health, the availability of prenylated stilbenoid is limited and their biosynthetic pathway remains to be elucidated. In this study, hairy root cultures of peanut were induced to produce peanut stilbenoids upon treatment with various elicitors. Co-treatment with methyl jasmonate and methyl- β -cyclodextrin led to sustained high levels of prenylated stilbenoids in the culture medium when compared to other elicitor treatments. This elicitor-controlled hairy root bioproduction system was further used to study the biosynthetic pathway of prenylated stilbenoids. Using metabolic inhibitors, we demonstrated that the prenyl moiety on the prenylated stilbenoids derives from a plastidic pathway. Furthermore, the characterization, for the first time, of a membrane-bound stilbenoid-specific prenyltransferase activity from the microsomal fraction of peanut hairy roots was achieved. The characteristics of this enzyme provided important information for subsequent cloning and comprehensive characterization of the first stilbenoid prenyltransferase gene from any plant species.

O10. Climate Resilient Metabolic Strategies for Improving Medicinally Active Food Plants

Dipayan Sarkar¹, Avani Manduri¹, Ashish Cristopher¹, Ramnarain Ramakrishna¹, Kalidas Shetty¹ ¹Department of Plant Sciences, North Dakota State University, Fargo, North Dakota-58108, USA. Email: dipayan.sarkar@ndsu.edu

Plant-based foods overall are an excellent source of phenolic antioxidants with diverse human health relevant medicinal properties. Therefore enhancing phenolic antioxidants in medicinally active food plants is an exciting strategy for improving the management of diet-linked non-communicable chronic diseases (NCDs), including type 2 diabetes. Novel climate resilient metabolic strategies have been developed to improve the biosynthesis of phenolic bioactives in different food plants (both pre- and post-harvest stages) by modifying the regulation of plant endogenous defense responses using mild induction of abiotic stresses such as ozone, instantaneous heat-shock, and chemical elicitor treatments. Different medicinally active food plants like grape, tomato, apple, crab apple, dry bean, and barley were exposed to mild abiotic stresses or chemical elicitor treatments at pre-harvest stages and their phenolic bioactive profile and associated functionalities targeting early stages type 2 diabetes were evaluated after harvest using rapid *in vitro* assay models. These elicitor treatments significantly improved phenolic-linked bioactive profiles and related human health relevant functionalities in above medicinally active food plants and in red wine derived from instantaneous heat-shock treated grapes. These findings suggest that climate resilient metabolic strategies involving mild stress induction at pre-harvest stages can be an effective and simple agronomic tool for improving and designing health-targeted bioactive enriched functional foods from medicinally active food plants. The foundations of these strategies are also relevant for developing plant systems for climate resilience.

O11. Lemon Yellow '118 A New Natural Food Colorant from the Peel of *Citrus limon*

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The last few years have witnessed a movement by food companies to replace artificial dyes and preservatives with natural products. This movement has been in response to consumer demands for natural and safer plant-based food ingredients. In addition to increased safety, natural colorants may possess desirable health benefits. As part of our continued investigation into replacement natural product food dyes and preservatives from current and emerging agricultural streams, a new yellow pigment from the ethanol extract of the zest of *Citrus limon* was purified. A new flavone which we have named lemon yellow #8, together with a mixture of hesperidin and aurantiamarin, were isolated from the zest of *Citrus limon*. The structure of lemon yellow #8 was elucidated on the basis of spectroscopic data, including 1D and 20 NMR spectroscopy, and its absolute configuration was assigned by comparison of experimental CD with calculated electronic circular dichroism (ECO) spectral data. CIELAB values and Delta CIELAB were measured and displayed this new water-soluble pigment has better UV stability relative to other natural products used as food dyes.

Session 3a - Processing, Quality, Sourcing (Madren Center, Auditorium)

O12. Global Botanical Sourcing: Social, Quality and Regulatory Changes Through the Years

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The natural products industry has gone through many changes in its history with more changes coming. We will look back at how buying herbs used to be done and what it takes to sell your natural products in today's market. Each aspect including social, cleanliness, quality and regulatory will be reflected on and projected on as to how it has altered the buying strategies for botanical raw materials around the world. The fact that many natural product companies are edging closer to producing and selling pharmaceutical grade products has impacted the buying strategies all the way back to the field and forests which I will show. We will have samples of botanical raw materials for apple to apple comparison to see the difference in quality, packaging and marketing of today's products compared to pre DSHEA material. This presentation will help sellers, buyers and consumers of natural products understand why they can trust that what's on the shelves in today's marketplace is safer and more efficacious than ever before.

O13. Vertical integration of raw material sourcing and herbal medicine manufacturing

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The use of modern qualitative and quantitative analysis of botanical raw materials allows herbal extract manufacturers to monitor peak activity and harvest times for medicinal plants. Having a dedicated source of crude herb material that is able to be adjusted and monitored for peak activity can lead to higher yields of medicinal compounds and overall higher quality. This talk will use examples of the integration of Raw Material growing and Herbal Extract manufacturing, specifically focusing on the increase in bio active compounds found in Hawthorne Leaf and FlowerBud.

O14. Quality Testing/Assurance of Botanicals in Dietary Supplements: An Industry Perspective

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In the U.S. many materials of botanical origin that have traditional medicinal applications are marketed in various product forms as dietary supplements. Manufacturing of these products falls under the regulatory guidance of FDA Current Good Manufacturing Practices (cGMP's) as outlined under 21CFR-111. Quality assurance throughout the manufacturing process involves the implementation of various analytical techniques to assure product quality and safety through identity, contaminant, label claim and other testing. Testing of botanical raw materials and solid-dosage forms at Nutra Manufacturing/GNC, involves physical, spectroscopic, chromatographic analysis, as well as microbiological and biochemical testing. Examples of identity, presence of adulteration, and marker compound/label claim testing using HPTLC and other chromatographic analysis will be presented and discussed.

Session 3b - Cosmeceutical, Wound Healing, Dermatologic (Madren Center, Seminar Room II, Room 130)

O15. Botanical photo-protection alternatives to synthetic UV filters

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Besides the unquestionable positive effects of solar exposure for human health, UV rays have been widely investigated for toxicology aspects related to excessive UVB and UVA doses, which involve sunburns, skin aging, DNA skin damage and tumorigenesis. In the last 10 years, in the United States, the incidence of melanoma has doubled. The highest rates of incidence are found in Australia, New Zealand, and Northern Europe where it increased up to 30%. At present, synthetic and mineral sunscreens are used to protect against UV damages, but several natural molecules can provide protection, including also synergic effect (i.e. antioxidant) or enhanced photo stability to synthetic filters. Although a large number of herbal extracts and plant origin molecules can deserve potential applications, most of the study reported utilizes different method and different strategies of investigation, making thus difficult to understand the real versus claimed potential. This is possibly one of the reasons why, beside the large body of literature, there are no officially approved (FDA/EMA/PCC) natural commercial sun-filters; notwithstanding that a consistent number of solar products (suntan) on the market contain herbal derivatives. In this context we have developed, in recent years, a discovery strategy based on characterization of photo-protective molecules from plant extracts and their structure-activity investigation in light of the most recent approaches. Structural modifications have also been applied in order to understand mechanistic aspects. Some interesting results will be reported and discussed.

O16. Regulatory Considerations for Therapeutic Cosmetic Products

Charles Gray, El Pharmaceuticals & EnDev Labs

Plant extracts have increasingly become integral components of skin care products largely due to their ability to impart a therapeutic effect on skin health and wellness. Ingredient suppliers have indeed done a great job of identifying these extracts and communicating their benefits to an increasingly educated consumer base. While the majority of products containing these ingredients conform to regulatory guidelines, some marketed products test the boundary between cosmetic and drug which has led to increased regulatory monitoring and action. Therefore, it is important in product development to fully understand regulatory considerations that ultimately lead to the commercialization of compliant therapeutic skincare products. Perspectives on the regulatory considerations will be provided.

O17. Evaluation of protective effects of topical vitamin C compound mixtures against ozone-induced damage in different cutaneous models

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Cutaneous tissues are directly exposed to pollutants including ozone (O₃), the most dominant oxidant present in photochemical smog. Several studies have demonstrated the noxious effects that O₃ can have on skin using *in vitro* (2D and 3D) and animal models. To date, there are no human studies that have clearly confirmed the propensity of O₃ to induce skin damage. In the present study, we investigated whether O₃ exposure, at the level that has been observed in polluted cities (0.2 - 0.8 ppm), can induce a response in human keratinocytes and human skin, and whether vitamin C compound mixtures could prevent O₃-induced damage. O₃ increased epidermal levels of 4-hydroxynonenal, isoprostanes, cyclooxygenase-2, metalloproteinase-9, and induced NF-κB activation. After O₃ exposure, there was a decrease in both type I and III collagen. Pre-treatment with the MIXs was able to prevent the aforementioned O₃ effects. In addition, a significant activation of Nrf2 in keratinocytes treated with the mixtures was also observed. To our knowledge, the current study with biopsy analysis is the first conducted in humans showing that O₃ exposure can broadly affect cutaneous tissue. Pre-treatment with the vitamin C compounds appears capable of preventing the oxidative damage induced by O₃ and this protective effect was correlated to the abolishment of NF-κB nuclear translocation, as well as activation of Nrf2 nuclear translocation, activating the downstream defense enzymes involved in cellular detoxification process.

O18. Skin repair/healing properties of arctic berries

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Polyphenol-intense berry fruits and their waste products (pomaces) are rich resources for phytoactive compounds that are relevant to skin care and skin repair. Flavonoids from berryfruits are best recognized for their anti-diabetic and cardioprotective properties, however, their natural anti-microbial benefits, skin-repair/wound healing mechanisms and UV radiation protective properties make them particularly relevant to topical applications, where the aura of 'made in nature' is also a boon to skin care industry marketing efforts. Berry fruit skins and seeds (components of pomace) have demonstrated capacity to stimulate the speed of migration of dermal cells across an inflicted wound in our *in vitro* models of the wound-healing process. The phytoactive constituents (complex flavonoid structures including proanthocyanidin oligomers [PAC]) accumulated in wild berry germplasm (tundra berries from the Alaskan coastal areas) have demonstrated some of the most potent efficacy, purportedly due to the intense accumulation of protective phytochemicals in response to environmental stressors. While natural fruit compounds are in demand for topical products, fruit-derived polyphenols are ephemeral (easily degraded at ambient conditions), accumulate at low concentrations and typically co-occur with other components (pectins, sugars) that are undesirable for skin formulations. Consequently, we developed a technique for solvent-free concentration and stabilization of fruit phytoactives by complexation with small amounts of benign protein carriers for cosmetic applications. Highest concentrations of ellagic acids, gallic acid and PAC oligomers were extracted from Noble muscadine grape on hemp protein isolate, hemp flour, and soy protein isolate carriers, whereas anthocyanins were most highly concentrated (8.39 mg g⁻¹) into hemp flour-blackcurrant matrices. The enriched matrices effectively inhibited tyrosinase enzyme (57.3% for hemp protein-black currant matrices) and curtailed *Staphylococcus aureus* proliferation at 20-30 mg mL⁻¹ total polyphenols. The strategy effectively concentrated and stabilized skin-protective polyphenolics in reliable ingredients for topical applications.

Session 4a – Functional Foods (Madren Center, Auditorium)

O19. Healthy Functional Foods: Effects of Processing and Storage on Health-Promoting Molecules

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Anthocyanins act as antioxidants, in addition to producing the variety of colors observed in most flowers, fruits, leaves, and stems. Commercial anthocyanins mostly derived from fruits and vegetables like red grape, elderberry, blackcurrant, blackberry, raspberry, black chokeberry, red cabbage, purple carrot, purple corn, red radish, acai berries, and purple sweet potatoes. Awareness of the health benefits of dietary anthocyanins has increased in recent years. Thus, consumer demand and the market for anthocyanin-rich foods are expected to reach \$387 million by 2021. Vegetable Fruit Improvement Center has developed anthocyanins rich Maroon carrots with 40% higher carotenoids than regular carrots. Mass spectral analysis demonstrated the presence of five cyanidin derivatives and exhibited inhibition of prostate cancer cell (LNCaP) proliferation activity. More recently, demand for foods that improve overall health, intestinal function, and digestion has also increased. It is well known that, prebiotics selectively nourish beneficial intestinal flora, stimulate their development, and reinforce their action. Due to dietary restrictions for dairy products, combination of good prebiotic foods such as legumes and probiotic bacteria aids in development of non-dairy based functional fermented foods. Germination of horse gram, a legume remarkably increased the levels of free amino acids, also showed higher α-amylase and α-glucosidase activity. *Lactobacillus plantarum* mediated fermentation facilitates release of the bioavailable phenolic compounds along with de novo synthesis of essential amino acids and imperative volatile compounds. Leafy greens, root vegetables and certain fruits are good sources of dietary nitrate and

other bioactive compounds. Currently, fruit juices are positioned as a top healthy food product and consumed frequently by a large percentage of global consumers. However, improper processing or storage of fruit and vegetable juice may alter the levels of key health-promoting phytochemicals; for example storage under non-ideal conditions can lead to the conversion of nitrate to nitrite, which could have negative effects. The results of storage stability in beetroot and arugula suggest that the nitrate levels were higher in initial day and degradation initiated within 24h at room temperature, while at 4°C degradation began after 4 days. Therefore, obtaining high levels of health-promoting compounds by common household processing techniques and changes during storage will be discussed.

O20. Pulses as Whole Food Solution to Global Health Challenges

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Millions of global populations are suffering from food caused health issues. Approximately 40% of the world's population is facing with hidden hunger due to lack of essential micronutrients in commonly eaten staple foods. In addition, chronic, non-communicable diseases associated with obesity result in 36 million deaths globally in each year, more than all other causes combined. Today, double burdens of malnutrition, both micronutrient deficiency and excess calorie intake, has resulted in severe global health challenges. In addition, increasing human population of more than 90 million people to feed each year, global food demands are expected to double by 2050. With limited arable lands, decreasing soil fertility, climate change, and declining water resources, the present food systems are already challenged in providing sufficient nutrients rich foods. Therefore, to combat global micronutrient and calorie malnutrition, novel ways to produce nutritious foods are required. To this end, traditional food crops including pulses (lentil, field pea, and chickpea) have potentials to provide nutritious food solutions to human health challenges.

O21. Health effects of grain sorghum

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Grain sorghum is one of the world's important crops, topped only by wheat, maize, rice, and barley. In the United States, only 3% makes its way to the food industry, with most being used for animal food and ethanol production. However, American consumers continue to request for functional foods and healthy products, grain sorghum is becoming more visible and desirable for its health benefits. Grain sorghum's functional starch content may help in preventing chronic diseases, particularly diabetes and obesity. Human studies were conducted to investigate the effects of grain sorghum on blood glucose and insulin levels. In a randomized-crossover design, 10 healthy and 12 prediabetic men consumed grain sorghum and wheat (control) muffins. Functional starch fractions, slowly digestible starch (SDS) and resistant starch (RS), were 9-10% higher in sorghum muffins compared to control. With the grain sorghum muffin treatment, the mean incremental area under the curve (iAUC) of glucose in healthy and prediabetic subjects were reduced by 26% and 35%, respectively. Incremental insulin concentrations also lowered about 55% (healthy) and 37% (prediabetic subjects). Results suggest that grain sorghum is a good functional ingredient in controlling blood glucose and insulin levels.

Session 4b – Environments for High Value Plants and Fungi (Madren Center, Seminar Room II, Room 130)

O22. Increasing Production of Phytochemicals in Controlled Environments.

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Controlled environment technology enables production of plants under conditions that optimize environment for growth, development yield and phytochemical production. The geographical limitations to crop production are removed by enabling environmental (temperature, relative humidity, CO₂ concentration), cultural (rooting matrix, nutrients, irrigation), and lighting (intensity, duration, quality) to be managed and replicated anywhere in the world. By optimizing cultural conditions, and enriching the CO₂ concentration, significant increases in yield, and reduction in time to harvest are often realized. Advances in technology, especially solid state lighting systems, are providing opportunities increase the production of phytochemicals in controlled environments. The reports of spectral quality effects on production of bioactive phytochemicals are increasing, and demonstrate that production of crops of super- or nutraceutical and phytopharmaceutical value can be achieved in controlled environments. Production in controlled environments, especially fully controlled structures, enables use of vertical, as well as horizontal space. The emerging industry of indoor farming, coupled with precise environmental control, is enabling yields per area that far exceed field yields. Controlled environment production of medicinal crops results in a consistent supply, relieving harvest pressure on native populations, improve the consistency of the product, and minimize microbial contamination. The diversity, high value, and unique properties of medicinally active plants make them promising candidates for controlled environment production.

O23. Evaluation and Elicitation of Secondary Metabolites by Light Quality in Micropropagated Clones of *Scrophularia kakudensis*

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Scrophularia kakudensis is a potential medicinal plant with multiple pharmaceutical benefits. Due to the narrow environmental adaptation and seed dormancy issues the conventional propagation of *S. kakudensis* has been hindered. In addition, the lack of information on the secondary metabolite contents resulted in the constricted utilization of this plant and its products. Micropropagation of *S. kakudensis* was achieved via adventitious organogenesis and somatic embryogenesis starting from a single seedling. Organogenesis was achieved from nodal explant on the Murashige and Skoog (MS) medium fortified with 2.0 mg·L⁻¹ 6-BA and 0.5 mg·L⁻¹ IAA. Somatic embryogenesis was accomplished from the leaf explants on the MS medium supplemented with 1.5 mg·L⁻¹ 2,4-D, and embryo development occurred on the MS medium containing 0.5 mg·L⁻¹ GA₃. The clonal fidelity of the micropropagated plants was authenticated using RAPD fingerprinting and inter simple sequence repeats (ISSR) molecular markers. Overall the aerial part of the plant contains highest amounts of phytochemicals with greatest antioxidant properties. The blue or red LED light enhanced growth and phytochemical contents (total phenol and flavonoid) as compared with the cool white fluorescent light. The red LED treatment significantly elicited the accumulation of acacetin in comparison with the white fluorescence light. The LED treatments resulted in the maximum production of endogenous hydrogen peroxide and significantly increased the activities of antioxidant enzymes. Moreover, the proteomic insights revealed the enhancement in the abundance level of proteins involved in transcription and translation, carbohydrate mechanism, post-translational modification, and stress response. Taken together, the incorporation of blue or red LED light sources during micropropagation can be beneficial to increase the medicinal values of *S. kakudensis*. Abinaya Manivannan and Prabhakaran Soundararajan were supported by a scholarship from the BK21 Plus Program, Ministry of Education, Republic of Korea.

O24. Environmental Influence on Medicinal Fungi: Research Focus at Mushroom Mountain LLC

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Light, gas exchange, and interkingdom interactions influence the biochemistry of fungi as they are growing naturally or cultivated in artificial environments. Several methods have been developed to limit or enhance the production of specific characteristics or desired compounds of interest. Employing classic interactive microbiology with industrial models for production, Mushroom Mountain bioprospects for fungi using several techniques to screen for antimicrobial activity based on manipulating growing conditions to produce metabolites that employ a target specific focus on specific pathogen groups to reduce drug resistance in hosts.

O25. *In vitro* mineral nutrition of turmeric rhizomes effects on subsequent essential oil production upon transfer to the greenhouse

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Turmeric (*Curcuma longa* L.) is a rich source of bioactive compounds useful in both medicine and cuisine. This work examined the effect of mineral concentrations (PO₄³⁻, Ca²⁺, Mg²⁺, and KNO₃) during *in vitro* rhizome development on the content of essential oils

in rhizomes after 6-months in the greenhouse. A response surface method (D-optimal selection criteria) was repeated in both high and low-input fertilizer treatments. Control plants were grown on liquid MS (Murashige and Skoog 1962) medium acclimatized in the greenhouse and grown for 6 months in the field. The essential oil constituents were detected in dry rhizomes by GC-MS. The total content of essential oils was higher in the high-input fertilizer (49.7±9 mg/g) with 4 mM Ca²⁺ and 60 mM KNO₃ than the low-input fertilizer (26.6±9 mg/g), and greater than the control (7.6±0.7 mg/g) MS medium with 3 mM Ca²⁺, 20 mM K⁺, and 39 mM NO₃. Major sesquiterpenes were highly correlated with each other (r=0.9) and with plant growth in the greenhouse (r=0.7). The interaction of Ca²⁺ with KNO₃ affected curcumenol isomer I and II, germacrene, isocurcumenol, and β-elemenone contents. Phosphorous increased neocurdione and methenolone at 6.25 mM and curcumenone at 1.25 mM. Methenolone was only well correlated with curcumenone (r=0.6). Germacrene A, B, and D compounds were detected only in the high-input fertilizer, highly correlated (r= 0.9) to other sesquiterpenes, except curcumenone (r=0.5), and well correlated with the plant growth (r=0.6). The essential oil compounds correlated poorly (r=0.1) with curcumin (El-Hawaz et al., 2016). These results concluded that minerals from the *in vitro* bio-reactor affected biosynthesis of turmeric essential oil components even after transfer to the greenhouse. High mineral concentration media were developed to increase the turmeric essential oil components without diminishing curcumin production. The multi-dimensional design identified the interactive effects among varied minerals on essential oil contents.

**Session 5a - Transforming Traditional Botanical Medicine into Precision Medicines
(Madren Center, Auditorium)**

O26. New Microtubule Stabilizers with Anticancer Potential from Higher Plants

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The plant-derived microtubule stabilizer paclitaxel (Taxol®) is one of the most effective drugs used to treat a wide variety of adult cancers, however innate and acquired drug resistance limits its utility for some patients. In the search for new microtubule stabilizing agents we identified the taccalonolides from plants of the genus *Tacca*, as new microtubule stabilizers. The taccalonolides are highly acetylated hexacyclic steroid lactones and differ chemically from other microtubule stabilizers. They have advantages over paclitaxel in that they can overcome multiple clinically relevant mechanisms of drug resistance. The taccalonolides bind covalently to β -tubulin and initiate a unique pattern of microtubule stabilization. One of our goals is to study the SAR among the natural and semi-synthetic taccalonolides to identify the constituents responsible for optimal microtubule stabilizing actions, *in vitro* potency and *in vivo* antitumor efficacy. Our studies have shown that taccalonolides with an epoxide bridging C22-C23 have markedly improved potency, for example AF, the C22-C23 epoxide analog of the major plant metabolite taccalonolide A, is 200-fold more potent than the parental compound. AF has excellent antitumor effects in murine models of cancer, but it has a short half-life. The closely related compound, taccalonolide AJ, that differs from AJ at the C15 position, with an acetoxy group in AF and a hydroxyl group in AJ, has excellent potency, yet is devoid of antitumor effects but did cause toxicity. Semi-synthetic reactions were used to incorporate moieties of different sizes at C-15 and multiple new taccalonolides resulted. These new compounds had a wide range of potencies, from 2.4 nM to greater than 20 μ M. These results demonstrate that potent taccalonolides can be semi-synthesized from the predominant plant precursors.

O27. Exploring for bioactive natural products from Chinese mangroves

Yuewei Guo, Ph.D. (Professor at the Shanghai Institute of Materia Medica, Chinese Academy of Sciences)

O28. Discovery and Development of the Karlotoxin Class in Precision Oncology

Shan He, Ph.D. (Drug Development, Ningbo University, China)

O29. Natural Products from the Endangered Plant *Microbiome Echinocactus grusonii*

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Microbiomes associated with endangered plants remains an unexploited source of natural products with potential medical use. As part of our search for therapeutic natural products we have studied the secondary metabolites produced by strains from the cactus *Echinocactus grusonii*, known as golden barrel cactus, from the family of Cactaceae. This endangered cactus has been used by Native American in the Southwest as a source of food in the summer months. In this study, small fragments of a healthy cactus were inoculated in Actinomycete media and bacteria colonies were isolated and purified. A pure strain of one Bacillus bacteria was scaled-up to a 12L fermentation culture. HP20 resin was added to the cell mass and filtered from the fermentation broth and subsequently extracted with ethanol. The resulting extract was dried-up and re-dissolved in water and extracted with hexane, dichloromethane (DCM) and n-butanol. The DCM and butanolic extracts were evaluated using LC-MS/MS and molecular networking analysis. This approach revealed the metabolite production profile of the cactus-specific Bacillus. The butanolic extract yielded a larger number of compounds and it was further fractionated using RP-HPLC (H₂O/CH₃CN, 0.1% formic Acid, 10 mL/min flow rate using a linear gradient 5% CH₃CN to 60% CH₃CN over 30 min, UV detection at 210 nm) and yielded several cyclic peptides. The structure elucidations of these metabolites were performed through NMR spectroscopic (2D-NMR – COSY, HSQC, HMBC), high-resolution electrospray mass spectrometry (HR-ESI-MS) and MS/MS.

**Session 5b – Anti-inflammatory, Anti-oxidant, Anti-cancer
(Madren Center, Seminar Room II, Room 130)**

O30. Development of grape skin components for diabetes management by targeting postprandial hyperglycemia

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Postprandial hyperglycemia occurs during the early stage of diabetes, characterized by hyperglycemic spikes that induce endothelial dysfunction, inflammatory reactions and oxidative stress, which cause a rapid progression of impaired glucose tolerance (IGT) to symptomatic diabetes. Grape skin extract (GSE) is a commonly consumed dietary supplement that contains a variety of bioactive components, notably polyphenol antioxidants and resveratrol. We have recently found that GSE also exerts a novel inhibitory activity on postprandial hyperglycemia. The dietary intake of a specific GSE significantly ameliorated postprandial hyperglycemia (by 31%) in diabetic mice and the hypoglycemic effect of GSE is independent of its antioxidant activity. Moreover, GSE intake also significantly reduced postprandial glucose in humans. Dietary supplementation of GSE significantly ameliorated hyperglycemia in high fat-induced obese mice. By week 12, 67% (8/12) of mice in the HF group (treated with high fat diet only), compared to only 8% (1/12) of mice in the HFGSE group (treated with high fat diet plus GSE), had fasting blood glucose (FBG) levels above 140 mg/dL. Overall, the three-month dietary GSE intake reduced FBG levels in DIO mice by 21%. The anti-postprandial hyperglycemia activity of GSE is related to its novel inhibitory activity on intestinal α -glucosidases, key enzymes controlling postprandial blood glucose.

O31. miRNA-mediated cancer chemoprevention and therapy by dietary stilbenes

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Growing evidence indicate that deregulation of the epigenetic machinery including microRNA (miRNA) network has a critical impact in cancer progression. In our previous studies, we identified resveratrol-regulated miRNA profiles in prostate cancer cells. Among others, resveratrol downregulated PTEN-targeting members of oncogenic miR-17~92, miR-106a~363 and miR-106b~25 clusters that are overexpressed in prostate cancer. We further demonstrated that both resveratrol and its potent analog pterostilbene are able to rescue tumor suppressor activity of PTEN through downregulation of endogenous as well as exogenous expression of miR-17 family members. Moreover, pterostilbene via downregulation of miR-17-5p and miR-106a-5p expression in tumors and systemic circulation, rescued PTEN mRNA and protein levels leading to reduced tumor growth in prostate cancer xenografts. In addition, we identified that metastasis-associated protein 1 (MTA1)-induced overexpression of miR-22 in prostate cancer cells promotes cell invasiveness and migration through direct targeting of E-cadherin-mediated epithelial-to-mesenchymal transition (EMT), which can be reversed by stilbene treatment. Taken together, our findings implicate the use of resveratrol/pterostilbene as attractive miRNA-mediated chemopreventive and therapeutic strategy in prostate cancer, and circulating miRNAs as potential predictive biomarkers for clinical development.

O32. One-step isolation of carnosic acid and carnosol from rosemary by centrifugal partition chromatography

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Rosemary (*Rosmarinus o-cinalis* L.) is known to have one of the highest antioxidant activities among herbs, is widely commercialized as a preserving agent in the food and cosmetic industries and has been identified as a source for nutritional supplements. The most potent antioxidant is the diterpene carnosic acid. Other less effective diterpenes are degradation products of carnosic acid. Carnosic acid is mostly converted to carnosol, followed by decomposition to form phenolic diterpenes with δ - and γ -lactone functions. The oxidation of carnosic acid to phenolic diterpene artifacts occurs in polar and nonpolar solvents and under thermal stress with oxygen availability. Due to the instability of carnosic acid, conventional methods of separation utilizing a solid support are not viable options. Centrifugal partition chromatography (CPC) is an all-liquid technique that is based on the partitioning of a phytochemical between two immiscible liquids. CPC does not use solid support as a stationary phase, therefore provides many advantages over conventional chromatography: (1) no irreversible adsorption onto column material (excellent recovery), (2) minimal risk of sample degradation (3) permits direct introduction of crude samples to the column without extra preparation, (4) considerable potential for scale-up, and (5) it is the method of choice for polar compounds like phenolics. Separation of carnosic acid and carnosol was successfully achieved by one-step CPC without any degradation. A two-phase solvent system, hexane/ethyl acetate/methanol/water (3:2:3:2 v/v) was run on a preparative scale. A 900 mg quantity of the crude extract containing 39.7% carnosic acid and 12.3% carnosol was loaded onto a 500 mL column, rotating at 1800 rpm. Carnosic acid and carnosol were obtained at purities of 96.1 \pm 1% and 94.4 \pm 0.9%, with recoveries of 94.3 \pm 4.4% and 94.8 \pm 2.3%, respectively. These levels of purity are suitable for industrial incorporation of the compounds into cosmetic or supplement applications.

O33. Bioactive compounds from strawberry and star fruit

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Studies on the chemical constituents present in the fresh fruits of strawberry cv. Falandi led to the isolation of twenty two phenolic and eleven non-phenolic compounds which have not been previously reported from the fruit. Their structures were determined by spectroscopic methods including mass spectrometry, nuclear magnetic resonance and electronic circular dichroism (ECD) calculation. These compounds were evaluated for antioxidant activity by three in vitro assays, and most of them showed potent ABTS radical cation scavenging capacity. In addition, their in vitro alpha-glucosidase inhibitory and cytotoxic activities were evaluated. On the other hand, sixteen flavonoid C-glycosides, fourteen non-flavonoid phenolic compounds and two alkaloids were isolated from star fruit for the first time, and their structures were identified. Moreover, their antioxidant, porcine pancreatic lipase and alpha-glucosidase inhibitory activities were evaluated. In conclusion, our research results revealed the structures of more than sixty compounds which were not previously reported from strawberry and star fruit and their in vitro biological activities.

Session 6a – Breeding, Germplasm and Genomic Tools (Madren Center, Auditorium)

O34. Production of terpenes in *Camelina sativa* oilseed

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Plants provide mankind with a vast array of phytochemicals that have a wide-ranging industrial and pharmacological application. Large-scale availability of phytochemicals can limit their use. Microbial production systems such as *Escherichia coli* and *Saccharomyces cerevisiae* are well established biotechnological platforms that can often be successfully bioengineered to serve as alternative sources for natural compounds. In addition to microbes, plant cell cultures have been exploited as potential biotechnological production platforms for phytochemicals. Despite the advantages of such cell-based production systems over the native producer, a common drawback is the requirement for specialized fermentation facilities, energy input and a continuous supply of macro- and micronutrients. Bioengineering of low-input crop plants to synthesize high value compounds would allow production of phytochemicals on farmland. However, whereas production of pharmacological proteins in plants has recently significantly advanced, suitable plant feedstocks for the production of small molecules remain under-explored. Many plant-derived compounds of high value for industrial or pharmaceutical applications originate from plant species that are not amenable to cultivation. Biotechnological production in low-input organisms is, therefore, an attractive alternative. Here we explore whether *Camelina sativa*, an emerging low-input non-foodstuff Brassicaceae oilseed crop grown on marginal lands or as a rotation crop on fallow land, can successfully be refactored to produce and store novel compounds in seed.

O35. Genetic and genomic approaches to link anthocyanin genetics and nutrigenomics in specialty crops

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Anthocyanins (ANC) are important health-promoting pigments. Nutrigenomic studies indicated that concentration, type and chemical structure of the ANC from fruits and vegetables affect their bioactivity and bioavailability. This study investigates the genetic basis and the variation of ANC in carrot and blueberry. The health-beneficial effects associated with these metabolites and the opportunity to use ANC from these two crops as source of natural colorant or bioactive ingredient, are contributing to increase carrot and blueberry production. Despite their importance in blueberry and carrot, little is known about the genetic mechanism controlling ANC accumulation in these two crops. In carrot, fine mapping, gene annotation and RNAseq analysis were used to identify candidate genes controlling ANC accumulation and the acylated forms of cyanidin, that has a negative effect on ANC bioavailability. Using this approach, candidate genes regulating the ANC pathway and the ANC acylation were identified. In blueberry, establishment of a new method to overcome fruit size bias for quantitative genetic analysis of ANC content is underway. Preliminary data from different germplasms indicated a great variation in terms of type of ANC and total ANC content. These results open new opportunities to further perform QTL mapping and candidate gene analysis for ANC accumulation in blueberry. In the long term, the outcome of this project will fill the gaps between plant breeding and nutritional genomics and support the development of new blueberry and carrot cultivars with improved health properties.

O36. Utilizing Germplasm Repositories for Collaborative Research

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The NC Arboretum Germplasm Repository (TNCAGR) is a collaborative effort by public and private organizations to advance the conservation, authentication, and economic development of plant based natural products by collection, development of chemical extracts, and long-term storage of germplasm. Germplasm includes but is not limited to seed, endophytes, and entire plants when applicable. In addition voucher specimens, DNA, and representative extracts for chemical analysis are collected and stored. Located at the NC Arboretum in Asheville, in situ collection efforts commenced in spring 2008. The NC Arboretum is located adjacent to one million acres of national forest land, which provides ideal conditions for the development of in situ preservation, maintenance, and collection sites. This presentation will summarize how researchers can collaborate to utilize TNCAGR. The collections are suitable for a wide variety of research ranging from chemical analysis of metabolites of interest to endophyte isolation, phylogenetic studies, and cultivar breeding. Examples of current research projects will be discussed. Illustrations of field collection methods, seed and control-pollinated cage propagation, and facilities utilized for seed cleaning, testing and storage will be included.

O37. Breeding Basil

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Basil is one of the most popular culinary herbs and a model system for the study of secondary metabolite biosynthesis in both the mevalonic and shikimic pathways. Yet, basil also faces several production and shipping constraints due to the devastating damage from downy mildew, as well as continued challenges from fusarium wilt and chilling sensitivity. There are no commercial sweet basil resistant or highly tolerant to downy mildew and chemical and management controls are limited in effectiveness and expensive, with few options for organic growers. This presentation will provide an overview of our basil breeding program, which has been working to develop downy mildew resistance, fusarium wilt resistance and tolerance to chilling temperatures. Our breeding program integrates the aroma and taste of basil as these characters are critical in ensuring quality of improved cultivars and to meet market acceptability. The terpenoid and phenylpropanoid volatile compounds impart the flavor and aroma that is essential to market acceptability, and we have been focusing on the mechanism of inheritance of basil volatiles. This presentation will present our discoveries and challenges in developing disease and chilling resistance basil and in examining the genetic inheritance of aroma compounds in basil.

Session 6b – Antibiotic, Antimicrobials (Madren Center, Seminar Room II, Room 130)

O38. Use of Natural Antimicrobials in the Food Industry

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In an *effort* to control the growth and survival of undesirable microorganisms in food systems and to extend the shelf-life of food products, antimicrobials are added as ingredients. These antimicrobials have traditionally been added in the form of synthetic antimicrobials. Because consumers are more health conscious and more aware of ingredients in foods, the use of synthetic antimicrobials is not as desirable. In addition, consumers are now concerned about the long-term effects and interactions of synthetic chemicals in the body. Further, consumers are now more concerned with their quality of life versus how long they will ultimately live. Due to consumer concerns regarding the use of chemicals in the production of food, the use of natural antimicrobials has increased. To meet this demand, research that focuses on the use of antimicrobials derived from natural sources has also increased. In addition, the food industry has responded to this demand by creating "clean labels" on food products. Although the ultimate goal is to use natural antimicrobials that offer protection similar to its synthetic counterpart, there are benefits and challenges associated with their use.

O39. Antimicrobial and Anti-Efflux Properties of Goldenseal (*Hydrastis canadensis*)

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Multi-Drug Resistance (MDR) efflux pumps have been increasingly reported in Gram negative and Gram positive bacteria. These efflux mechanisms pump out a wide variety of structurally unrelated antimicrobials thus leading to a low susceptibility due to lowered intracellular concentrations. The activity of such antimicrobials can be restored by the inhibition of the multi drug efflux pumps. Several MDR pump inhibitors that inhibit the efflux mechanisms in bacteria have been identified such as Reserpine and verapamil. However, the concentrations required to achieve these effects are too high to be clinically relevant. For example, reserpine has adverse effects such as neurotoxicity. The identification and development of safe and effective inhibitors of bacterial efflux pumps is needed. Goldenseal (*Hydrastis canadensis*) extracts provided by the Sleepy Hollow Farm, GA were evaluated for their antimicrobial and efflux pump inhibitory properties. First, minimum inhibitory concentration (MIC) of all different forms of goldenseal i.e., powders, liquid extracts, and retention solids, in five different ratios of root/leaf combinations was determined against MDR bacterial strains of *Staphylococcus aureus* and *Campylobacter jejuni*. The antimicrobial activity of goldenseal against human intestinal beneficial bacteria, *Lactobacillus acidophilus* was also determined. Goldenseal liquid extracts were found to have the highest activity against the MDR bacteria while showing minimum impacts on the *L. acidophilus*. Second, goldenseal leaf extract was assayed for its MDR efflux pump inhibitory activity against MDR pumps belonging to different pump superfamilies in both *S. aureus* and *C. jejuni*. Goldenseal increased the potency of different antimicrobials against the MDR bacteria when combined in sub lethal doses ($\leq 0.5\text{MIC}$) by at least 2-folds decrease in MICs of antimicrobials against *S. aureus* strains and 16-fold in *C. jejuni* strain. Quantitative real time RT-PCR and ethidium bromide uptake/efflux studies indicated that goldenseal leaf extract represses the genes encoding these MDR pumps in both the bacteria.

O40. Rapid Screening of Natural Plant Extracts with Calcium Diacetate for Differential Effects Against Foodborne Pathogens and a Probiotic Bacterium

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Many plant-based food materials contain natural bioactive compounds. In this study, a rapid turbidimetric bioassay was used to screen the antimicrobial potential of various natural extracts and to identify differential activities of these extracts against pathogenic and probiotic bacteria. Extracts from cranberry (NC) and oregano (OX) blended with calcium diacetate (DAX) a GRAS food stabilizer, were evaluated against *Escherichia coli* O157:H7, *Salmonella* spp., *Listeria monocytogenes* and *Staphylococcus aureus* using cocktails (~10⁸ CFU/mL) containing strains isolated from human food outbreaks. Extract blends at 1.5 and 3% (w/v) were prepared in sterile water or ethanol (20, 30, or 40% [v/v]) which corresponded to 0.26 and 0.51% (w/v) extract in each well, respectively. Of all extracts tested, 0.51% (w/v) DAX in ethanol was the most effective against all four pathogens. However, 0.26% extract blends from ethanol extractions consisting of DAX and OX (3:1), outperformed or were equal to 0.51% DAX alone. Biochemical analysis indicated that oregano extracts had the highest phenolic content, followed by cranberry extract. Subculture of wells in which no growth occurred after one week indicated that all water and ethanol extracts were bacteriostatic against the pathogens tested. The extracts had no effect on the probiotic organism *Lactobacillus plantarum*.

O41. Essential Oils as Natural Preservatives – Future of Food Industry?

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There is a significant interest in the natural antimicrobial and antioxidant agents that can be used to extend the shelf life of the food products. Essential oils are particularly promising as the source of these agents as they often anti-oxidant properties, antibacterial and antifungal properties. In addition, essential oil-rich spices, aromatic herbs, and hydrosols have been traditionally used in the Middle-Eastern, Indian, and Amharic cuisine to enhance food taste and stimulate digestion. A number of studies have demonstrated that essential oils when added in small amount (>> 1% v/w) to the meat and dairy products can slow-down rancidification, suppress bacterial growth, and improve taste properties. Synergistic interaction between essential oils was also demonstrated with the specific combinations being effective against a broad range of bacteria and fungi. In this presentation I will summarize recent findings focusing on the phenol and monoterpene-rich essential oils. I will identify active constituents responsible for the antimicrobial and antioxidant action and use this information to suggest other essential oils that have potential in the food industry. I will discuss synergistic essential between essential oil and constituents and explain how they can be combined to achieve desired effect. Finally, I will stress safety and regulations that apply to the use of essential oils in food industry.

Session 7b - Validation of Activity of a Single Compound vs. Multi-compound in an Extract (Madren Center, Seminar Room II, Room 130)

O42. Metabolite profiling: Applications in quality assessment and bioactivity evaluation of herbal extracts

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Medicinal herbs serve as a rich source of pharmacologically active substances. How can we best tap the wealth of past empirical experience to enhance future therapeutic advancement? Better understanding of the chemistry of medicinal herbs would enhance the exploration of new therapeutic benefits and product development.

Metabolite profiling (metabolomics) is a rapidly developing research field which provides sophisticated and advanced analytical methodologies to obtain precise information on the chemical composition of complex herbal extracts. Significant advances in chromatographic (e.g. LC-MS and LC-NMR) and spectroscopic methods (e.g. NMR and MS), coupled with bioassay profiling and chemometrics, serve an important role for the purposes of assessing the quality of herbal preparations and discovery of bioactive natural products. This presentation provides an overview of innovative research for quality assurance, identification of active components, and molecular mechanisms of multi-component herbal medicines.

O43. Emerging Technologies for Improving Phytochemical Bioavailability: Benefits and Risks

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Over the past two decades, the usage of botanical dietary supplements has steadily increased worldwide. This growing popularity has been especially notable among people in Western countries where almost 30% of consumers report regular usage of such supplements. Despite their popularity, demonstrable efficacy has remained elusive for many of these agents. To improve dietary supplement efficacy, researchers and manufacturers have begun adopting novel drug formulation technologies to enhance phytochemical bioavailability. Such methodologies include liposomes/proliposomes, phytosomes, nanoparticles, self-emulsifying microemulsions, and inclusion of natural inhibitors of human drug metabolizing enzymes (e.g., piperine). Most of these innovative technologies can dramatically improve phytochemical oral bioavailability. Improved absorption of pharmacologically active phytochemicals may augment efficacy; however, the risk of adverse events and herb-drug interactions may also be enhanced. Several examples of these methodologies will be presented along with their advantages and potential disadvantages.

O44. Complex mixture, complimentary activities: Multi-target bacterial inhibition by the medicinal lichen *Usnea barbata*
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A fundamental tenet of botanical medicine is the concept that the metabolite complexity of natural products results in heightened efficacy due to combination effects that affect single or multiple mechanisms. Conventional drug discovery has traditionally followed a reductionist approach, investigating single, specific compounds targeting a defined biological function or target. While initial efforts towards treating infectious diseases represented successful examples for this “one target-one drug” concept, the majority of diseases are multi-factorial, and targeting a single cause of a disease by a single drug may not deliver satisfactory treatment results, or may exert evolutionary pressure and drive resistance development. Thus, there has been a shift towards employing combinations of therapeutics to deliver optimum activity against disease targets. Natural products are complex mixtures of multiple components, and their therapeutic efficacy is often based on the combined action multiple constituents.

The lichen *Usnea barbata* (old man’s beard moss) has been widely employed by native peoples across North America, and has documented medical use in Europe as early as the 18th century. One of the well-established antimicrobial compounds from *U. barbata* is usnic acid. However, our initial investigations of the inhibitory activity of *U. barbata* against methicillin-resistant *Staphylococcus aureus* (MRSA) demonstrated higher inhibition for crude extracts of *U. barbata* than pure usnic acid. The crude extract was more than twice as effective in inhibition of MRSA growth. Subsequent biochemometric analysis of *U. barbata* crude extract and fractions revealed known antimicrobial compounds, including usnic acid, as well as potentially new bioactive metabolites which inhibited MRSA growth at low $\mu\text{g}/\text{mL}$ levels. In addition, three subfractions were potent inhibitors of the MRSA quorum sensing system, but not antibacterial. Unknown bioactive metabolites are currently being subjected to structure elucidation and biological evaluation, with the goal of determining how these complex mixtures from *U. barbata* target bacterial infections.

O45. Exploring for Bioactive Secondary Metabolites from the Chinese Medicinal Mangroves

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Mangroves comprise a large number of various salt-tolerant plants growing in tropical and subtropical intertidal estuarine zones. Historically, many mangrove plants were used to treat various diseases in traditional Chinese medicine. Currently, the secondary metabolites found in Mangroves represent an extremely rich source of novel chemical diversity for academic drug discovery and chemical biology programs. It is particularly true that the mangroves from Southern Coast of China are very prolific producers of bioactive natural products.

Our group at SIMM has long been engaged in the searching for novel secondary metabolites with pharmacological potential from Chinese mangrove medicinal plants. In collaboration with biologists and pharmacologists at SIMM, many mangroves used as folk medicine were chemically investigated and numerous novel isolates obtained were pharmacologically screened for activity in a variety of cell-based and pure enzyme assays designed to identify promising lead compounds for the development of drugs in the therapy of human diseases. This presentation will discuss examples of bioactive metabolites (structures and activities) from our recent discovery.

POSTER ABSTRACTS

PROFESSIONALS

(Madren Center, Room 132)

Session 2a – Growing the Crops

P1. The accumulation of phenolic compounds and flavor in genetically selected *Amaranthus hybridus* leaves is influenced by bio-transformed natural growth regulator

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Amaranth (*Amaranthus spp.* L) (Amaranthaceae), an endemic plant in South America, grows worldwide being cultivated in many temperate and tropical countries as a source of food, high quality forage and silage crops, medicinal and ornamental applications, accumulates high concentrations of valuable bioactive compounds. Although several species of amaranth are often considered weeds, the plant is recognized as an effective food and medical source, contributing macro- and micro- nutrients, and healthful bioactive compounds in foods in Africa, where the plant is widely cultivated, promoted, and increasingly consumed as leafy vegetable, and traditional medicine. All parts of the plant are used as medicine to heal a number of human and animal diseases in most African communities. Unfavorable climatic and ecological factors, however, reduce the growth, yield, and quality of active botanicals despite the use of the latest achievements of genetic improvement and modern plant growing technologies. The role of bio-transformed natural plant growth hormones on yield and accumulation of phenolic compounds in the leaves of amaranth selection *A. hybridus* var. *cruentus* is poorly understood. The current study assessed the effects of pre-sowing seed treatments with two different doses (0.2 % and 0.4 %) of bio-transformed microbial growth regulator (RIBAV) on germination, leaf yield, phenolic content, and flavor in *A. hybridus* selections under organic field cultivation. The collected data on the growth and yield of the plant material were subjected to analysis of variance (ANOVA). Pre-sowing seed treatment with RIBAV significantly influenced fresh leaf yield by 24% ($p < 0.05$), and the accumulation of bioflavonoids (apigenin, quercetin, and rutin, among others) from 12- 19% when compared with the control, producing higher mean values for all the measured variables. The use of bio-transformed microbial growth regulator appears very effective in increasing *A. hybridus* var. *cruentus* yield, chemical content, and improved flavor.

Session 2b - Food Biotechnology

P2. Lemon Yellow '118 A New Natural Food Colorant from the Peel of *Citrus limon*

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The last few years have witnessed a movement by food companies to replace artificial dyes and preservatives with natural products. This movement has been in response to consumer demands for natural and safer plant-based food ingredients. In addition to increased safety, natural colorants may possess desirable health benefits. As part of our continued investigation into replacement natural product food dyes and preservatives from current and emerging agricultural streams, a new yellow pigment from the ethanol extract of the zest of *Citrus limon* was purified. A new flavone which we have named lemon yellow #8, together with a mixture of hesperidin and aurantiamarin, were isolated from the zest of *Citrus limon*. The structure of lemon yellow #8 was elucidated on the basis of spectroscopic data, including 1D and 2D NMR spectroscopy and its absolute configuration was assigned by comparison of experimental CD with calculated electronic circular dichroism (ECO) spectral data. CIELAB values and Delta CIELAB were measured and displayed this new water-soluble pigment has better UV stability relative to other natural products used as food dyes.

Session 3a - Processing, Quality, Sourcing

P3. Chemical composition of the pods and seeds of *Xylopi*a *aethi*o*pica*

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Country spice or Ethiopian pepper (*Xylopi*a *aethi*o*pica*) is an aromatic evergreen tree native to tropical West Africa. It is mainly used for anti-inflammatory and anti-microbial purposes as well as for cosmetic and culinary purposes. Previous work has shown that the essential oil chemical composition of this Liberian spice varies between the different anatomical structures which include the seeds, capsules, and entire fruit overall. The objective of this work was to assess the chemistry of the seeds, capsule and the whole fruit (pods) of *Xylopi*a to establish trade standards. This work seeks to find new uses and applications for this West African spice from Liberia and Ghana. Seeds and pods were subjected to analysis of total phenols, total proteins, total minerals, crude fat and essential oil composition. The pods from Ghana were composed by 35% of seeds while from Liberia 25%. Total proteins were higher in the seeds from Ghana (3.8%) and lower in Liberia (3.1%). The seeds from Liberia showed 14.5% of total fats while Ghana seeds 13.9%. Total phenols were lower in the seeds (0.9%, 1.5% for Ghana and Liberian samples, respectively); while the capsules showed higher levels (5.4% and 5.5%, respectively). Total mineral content of the seeds for both samples were similar for the sam- ples of Ghana and Liberia (3.1% and 3.4%, respectively). Seed volatile oils were characterized by lower levels of α -pinene and higher levels of 1,8 cineole as compared with the capsules and whole fruits, suggesting a better sensory profiles for the seeds. This study demonstrates the potential new uses for the seeds of *Xylopi*a *aethi*o*pica* that can be developed as new spice products.

P4. Cooking reduces the levels of anthocyanins and other phenolic compounds in purple rice

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Blanca Isabel is a rice variety with purple grains derived from the cross Cypress/Hitan Kitan (C98-992). Analysis of anthocyanins in the lightly milled, heavy milled and brown grains of Blanca Isabel revealed the presence of cyanidin galactoside, cyanidin glucoside, but not the free anthocyanidin, as the main anthocyanin. Trace amounts of peonidin galactoside and peonidin glucoside, but the not the free anthocyanidin, were also found. The brown grains had the highest content of the anthocyanins, and the heavy milled grains had the lowest anthocyanin content indicating that these anthocyanins are removed by milling. Analysis of anthocyanins was also performed with the cooked grains. Our results showed that cooking reduced the levels of the anthocyanins. Resveratrol and pinostilbene were also found in the grains. Similarly, the levels of these phenolic compounds were decreased by cooking.

Session 4b – Environments for High Value Plants and Fungi

P5. Day and Night Temperature Regime Affect Growth and Physiology of Plug Seedling of Medicinal Plants *Adenophora triphylla* and *Astragalus membranaceus*

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Adenophora triphylla is an important medicinal plant used against cancers and obesity, and *Astragalus membranaceus* is an important medicinal plant widely used as a tonic to improve the immunity. However, there is not many studies on the propagation of these difficult to propagate species available, especially on the growth of seedlings as affected by day and night temperature re- gime. Germinated seedlings with two cotyledons were planted in plug trays and cultivated in growth chambers for six (*Adenophora triphylla*) or four (*Astragalus membranaceus*) weeks under one of the day and night temperature regimes of either 20C/20C, 25C/15C or 20C/15C with 70% relative humidity and 16 h a day photoperiod under 150 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF provided by white LEDs. Growth parameters such as stem diameter, number of shoots, biomass, and contents of total flavonoid, total phenol and sol- ible sugar of both species were significantly higher in the 25C/15C than in the other temperature regimes. Seedlings of both spe- cies showed significantly different activities of antioxidant enzymes, such as superoxide dismutase (SOD), catalase (CAT), ascor- bate peroxidase (APX) and *guaiacol peroxidase* (GPX), and content of hydrogen peroxide. The results suggested that 25C/15C was better day/night temperatures for the growth and physiological development of both *A. triphylla* and *A. membranaceus* seed- lings.

This study was carried out with a support from the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries (Project No. 116057-03). Ya Liu and Xiuxia Ren were supported by a scholarship from the BK21 Plus Program, Ministry of Education, Republic of Korea.

Session 5b – Anti-inflammatory, Anti-oxidant, Anti-cancer

P6. Phenolic antioxidant-linked Anti-diabetic Properties of Selected *Ocimum* Spp.

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Basil (*Ocimum spp*) in the family *Lamiaceae* have diverse medicinal properties and widely used in traditional medicines for centuries. Many of these medicinal properties of *Ocimum* spp. have been attributed to their rich phenolic acid profiles with high antioxidant capacities typical of species in the *Lamiaceae* family. Therefore, the aim of this study was to screen selections of *Ocimum* spp to determine phenolic antioxidant-linked anti-diabetic properties using rapid *in vitro* assay models. These can be targeted for use in ethnic foods of Asian community in the United States and globally. These 8 different basil selection from Asian origin (*Ocimum* spp.) were compared to high phenolic mint species (*Mentha arvensis*) and screened for total soluble phenolic content, phenolic acid profiles, total antioxidant activity, α -amylase and α -glucosidase inhibitory activities using *in vitro* assay models targeting their use for health diet design in the context of type 2 diabetes. Highest total soluble phenolic content and high antioxidant activity was observed in Indian basil (Tulsi) but was less than mint that was used for comparison. Further high α -glucosidase inhibitory activity was also found in mint and Indian basil. Overall, high α -glucosidase and low α -amylase inhibitory activity was observed in all Basil selections evaluated in this study. Further positive and high correlations between total soluble phenolic content, antioxidant activity (based on DPPH free radical scavenging assay), and α -glucosidase inhibitory activity was observed, which indicated potential phenolic antioxidant-linked anti-hyperglycemic function in these selections. The major phenolic acids found in these selections were gallic acid, catechin, benzoic acid, rosmarinic acid, protocatechuic acid, ellagic acid, and p-coumaric acid. This *in vitro* study provides the biochemical rationale and scientific foundation to further target these Basil selections of Asia for potential dietary and therapeutic uses in ethnic communities targeting improvement of food systems for early stages of type 2 diabetes and its associated complications.

P7. Biochemometrics to identify drug metabolizing enzyme inhibitors from green tea (*Camelia sinensis*)

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Green tea (*Camelia sinensis*) is an evergreen shrub tree from the Theaceae family. There is increasing attention to its widespread consumption due to its biological activities believed to improve health conditions. Botanical supplements have been shown to interact with conventional medications, although the mechanism of action in many instances remains unknown. We used a biochemometrics approach to identify green tea metabolites that interfere with glucuronidation enzymes, the UDP-glucuronosyltransferases (UGTs). Five of 38 commercial green tea samples were selected for extraction in 100% methanol, and metabolomic profiles of each extract were obtained using ultraperformance liquid chromatography coupled to high resolving power mass spectrometry. A biochemometric analysis workflow, which integrates partial least-squares statistical modeling with metabolomics data, was used. Inhibition of intestinal glucuronidation of the fluorescent UGT probe substrate, 4-methylumbelliferone (4-MU), by the green tea extracts at three concentrations (180, 60, or 20 μ g extract/ml) was evaluated using human intestinal microsomes. The selectivity ratio was used to determine which ion markers best predicted inhibition of 4-MU glucuronidation. Analysis identified (-)-epicatechin gallate (ECG) as the principal inhibitory metabolite. The inhibitory effects of ECG were confirmed using the clinically relevant intestinal UGT substrate, raloxifene. A representative green tea extract inhibited formation of raloxifene 4'- and 6-glucuronide in human intestinal microsomes, with K_i values of 2.6 and 2.8 μ g/mL, respectively.

Session 7a - Ethnobotanic Healers

P8. Biological Activity of dandelion (*Taraxacum officinale*) and avocado (*Persea americana*)

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Dandelion (*Taraxacum officinale*) has been used in traditional Brazilian medicine to treat various medical conditions for many years. The fresh or dried leaves and roots of dandelion are used to prepare teas, tonics, and extracts to treat urinary tract infections, poor digestion, liver disorders, as well as high blood pressure and diabetes. Fresh leaves are commonly consumed fresh in salads. Leaves of the avocado tree (*Persea americana*) is plant that is most widely used in holistic medicine. Traditional healers use avocado leaves to treat oxidative stress related problems such as infertility, tumors, diabetes and much more. Antioxidants are beneficial for our body because they help to reduce the effects of oxidative stress. Oxidative stress is a result of accumulation of free radicals in the body. Many beneficial properties of natural plant products are associated with their total phenolic content. The objective of this research is to study total phenolic and flavonoid content and the antioxidant activity of commercial samples of dandelion and avocado.

Total phenolics were quantified using the Folin-Ciocalteu method, and antioxidant activity was quantified using the ABTS radical scavenging assay. For total flavonoid plant extracts were combined with 0.5M sodium nitrite (NaNO₂), 0.3M aluminum chloride (AlCl₃), water (6H₂O) and 1M of sodium hydroxide (NaOH) and measured at 506nm. This study indicates that the two plants have a high total phenolic content and also a high antioxidant activity. This research is part of educational experiences in an urban community college setting, enabling students to acquire the critical thinking and research skills necessary to pursue a baccalaureate degree in a science-related discipline.

P9. The potential protective activity against oxidative stress of commercial samples of Neem (*Azadirachta indica*) extracts

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Neem tree (*Azadirachta indica* - Meliaceae), is a native plant from Southeast Asia, and now is gaining worldwide interest. It has been used for thousands of years as traditional medicine to alleviate different medical conditions, including malaria, bacterial and viral infections, and various skin problems. These diverse medicinal properties of neem are associated with the unique chemical composition of its different organs. The objective of this work is to investigate total phenolic composition, antioxidant capacity, and antiviral activities of different commercial samples of neem tree.

Total phenolics were quantified using the Folin-Ciocalteu method, and antioxidant activity was quantified using the ABTS radical scavenging assay. The effect of neem extracts on oxidative stress was assessed by Western blot in human fibroblasts exposed to hydrogen peroxide. The potential anti-HIV-1 activity was tested using the XTT and TZM-bl assays for cytotoxicity and antiviral activity, respectively. The assays allow to estimate the median cytotoxicity concentration (CC₅₀) and the half-maximal effective concentration values (EC₅₀). The therapeutic index (TI) was calculated using the CC₅₀/EC₅₀ ratio.

Leaves and bark extracts that exhibited high total phenolic and flavonoids content were associated with high antioxidant capacity and played a potential role in cellular response systems against oxidative stress. None of the plant extract tested showed selective antiviral activity against HIV-1. This research is part of educational experiences in an urban community college setting, enabling students to acquire the critical thinking and research skills necessary to pursue a baccalaureate degree in a science-related discipline.

GRADUATE STUDENT RESEARCH (Madren Center, North Lobby)

Session 2a – Growing the Crops

P10. Turmeric: A potential high-value medicinal crop in Alabama

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The US herbal products manufacturers are seeking domestically grown raw materials due to the inconsistencies associated with quality and production methods of imported raw materials. Turmeric (*Curcuma longa*), which is known for its anti-cancer, anti-inflammatory and anti-Alzheimer's disease is one such crop among many others. The medicinal properties of turmeric are attributed to the curcumin content of its rhizomes. Turmeric is gaining importance as a high-value medicinal crop in the southeastern US. However, a lack of robust varieties that combine high rhizome yield with high levels of curcumin, and adapted to the southeastern US is limiting its commercial production. To address this limitation, fifteen turmeric genotypes were assessed for their yield and curcumin content in replicated field trials using organic production system at the Alabama A&M University. Two to three plants from middle row were harvested from each plot to determine fresh and dry rhizome yields, and their curcumin content. The rhizomes were washed, weighed and dried in a forced-air drier at 50°C. The dry rhizome samples were extracted with 70% ethanol and analyzed for curcumin content using HPLC. The crops planted in early June matured by November end. The rhizome fresh and dry yields varied from 8,921 and 1,126 Kg/ha for CL9 to 27,802 and 4,003 Kg/ha for CL7. The average fresh and dry yield across genotypes were 17,177 and 2,337 Kg/ha. The curcumin content varied between 0.01-0.03% for *C. zadoaria* genotypes and 0.3- 2.3% for the *C. longa* lines. *C. longa* genotypes had consistently higher percentage curcumin than *C. zadoaria* lines. The results of this study combined with our three-year trials showed that turmeric has the potential for commercial production in Alabama and perhaps the southeastern US. There is a wide variation for both, rhizome yield and curcumin content among the genotypes which indicates potential for variety improvement.

P11. Teaching nutrition and food hygiene with microgreens in agriscience classrooms

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Teaching science, technology, engineering, and math (STEM) content in high schools requires enhanced application of laboratory and curricula in plants and nutrition for experiential learning. Microgreens are a new trend in culinary arts. These young seedlings are a nutritionally dense, edible food product, which can be grown quickly in a small space, which makes them ideal for classroom teaching. Six varieties of microgreen vegetables were aseptically prepared and grown under different light regimes and compared for their mineral nutrition. Plants grown under less intense fluorescent light were larger, however, dry matter varied with species and light treatment. *Raphanus sativus* (Daikon Radish) had more dry matter under light emitting diode (LED), while *Brassica juncea* (Mustard) and *Brassica campestris* (Chinese Cabbage) had more dry matter under fluorescents. Mustard was slightly better under LED than fluorescents. *Brassica oleracea* (Broccoli) was more nutrient dense under LED light, whereas the other vegetables had mixed results. The experiment was repeated in aseptic and classroom conditions to see if food products from the classroom had acceptable shelf life. Two weeks following harvest all treatments were in excellent condition and the ultimate shelf life will be reported. These type of laboratory exercises assist in implementing prepared lesson plans, classroom presentations, and demonstrations. The entire experiment was pilot tested with 12 agricultural education instructors from across the state of South Carolina. Participants indicated a willingness to incorporate this experiment within the classroom setting. Our cohort demonstrated competencies in biological and plant principles through teaching the propagation of microgreens.

P12. Hydroponic Nutrient Optimization for *Eucalyptus deglupta* and *Artemisia absinthium*

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A hydroponic nutrient formula is being developed for *E. deglupta* and *A. absinthium*. Expedited growth rate and rooting quality of stem cuttings were the primary responses in addition to plant quality (health, color, branching, overall appearance). A NFT (Nutrient Film Technique) hydroponic system was designed and constructed from gutter channels covered with insulation board to block all incoming light from contact with the nutrient solution. Twelve separate zones were constructed with four gutter channels per zone. Each zone had ≥ 13 *E. deglupta* seedlings and ≥ 4 *A. absinthium* seedlings. Initial average height and weight was taken from each seedling before transplanting into the NFT hydroponic system, (9.86cm)(20.02g(Wet Weight)). Each zone was constructed as a closed loop system independent from one another. Hoagland's nutrient formula was used at different concentrations in conjunction with different concentrations of Ammonium Sulphate. Solutions included 1/3x, 1x, and 3x Hoagland's solution; and 0x, 1/3x, and 1x Ammonium Sulphate. A full factorial was constructed of the three different concentrations of Hoagland and Ammonium Sulphate, making nine different nutrient solutions. Three zones were designated as controls consisting of 1x Hoagland, 1x Ammonium Sulphate. The three control zones were placed in opposite corners and center of the greenhouse to observe if zone location effects growth parameters. All other nutrient solutions were randomized within the greenhouse. After branching initiates, cuttings will be taken to quantify rootability of material from seedlings in different nutrient concentrations. Electrical Conductivity (EC) and pH is collected in addition to water samples at select time points throughout the experiment. Stage 2(Rooting) will conclude one month after cuttings are stuck. Cuttings will be rooted in Oasis media with 0ppm, 1000ppm, and 3000ppm kIBA and reporting will be completed in June.

Session 2b - Food Biotechnology

P13. Effect of Moisture Stress on Nutritional Quality of Kale (*Brassica oleracea* L. var. *acephala*)

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Kale (*Brassica oleracea* L. var. *acephala*) is rich with essential minerals and a range of low molecular weight carbohydrates (LMWC), which contribute to a balanced diet to prevent micronutrient malnutrition. Moisture stress resulted due to terminal drought can affect the presence of these nutrients. The objective of this study is to determine the response of kale genotypes commonly grown in southern US regions to moisture stress in terms of mineral concentrations, LMWC concentrations, and biomass loss. Kale transplants were grown in a greenhouse under normal growing conditions for 4 weeks, followed by 2 weeks of moisture stress (drought: 40% moisture; control: 80% moisture), and 2 weeks of recovery. Moisture stress significantly reduced kale biomass (by 19-35%) compared to controls. For minerals, Ca, Mg, and Zn concentrations in the leaf did not change but concentrations of K, P, Fe, Mn, and Cu significantly decreased as a result of moisture stress. Sorbitol, sucrose, and verbascose + kestose concentrations increased with moisture stress. Kale genotypes 'Black Magic', 'Darkibor', and 'Vates' had the least relative biomass reduction response to moisture stress compared to the other genotypes. Further, 'Beira', 'Black Magic', 'Darkibor', and 'Lacinato' did not change individual mineral content in response to moisture stress, and visual symptoms of water stress were not evident. These data confirm that moisture stress has a significant effect on kale biomass production and nutritional quality. Drought tolerance and nutritional quality of kale could be further enhanced by genetic sourcing. Overall, inter-varietal variation of kale nutritional quality under conditions of moisture stress may also allow Brassica vegetable breeders to incorporate these traits towards "field biofortification" to benefit North American consumers.

Session 3a - Processing, Quality, Sourcing

P14. Towards Enhanced Dynamic Range in Natural Product Mixture Analysis: A Test Case Using Goldenseal (*Hydrastis canadensis*)

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One of the most widely-used identification techniques for plant metabolomics studies is electrospray ionization-mass spectrometry. In the identification of metabolites in complex mixtures, such as botanical extracts, studies have shown that the response of one analyte can be influenced by the presence of others in the sample matrix. Botanical extracts contain hundreds to thousands of compounds in varying concentrations. In such complex mixtures, the analyst often encounters linear dynamic range limitations, in which metabolites present at low levels are masked by other more highly abundant metabolites. Our model extract is that of the medicinal plant goldenseal (*Hydrastis canadensis*). The crude extract and subsequent fractions are analyzed using Acquity Ultra Performance Liquid Chromatograph® (Waters Corporation, USA) coupled to a Q-Exactive™ Plus Hybrid Quadrupole-Orbitrap™ Mass Spectrometer (ThermoFisher Scientific, USA). Multivariate statistical methodology approaches to determine the number of ions present in complex versus simplified mixtures is being developed. We hypothesize that dynamic range limitations can be overcome by simplifying a complex mixture, thus enabling more ions to be detected. Ultimately, this project will be beneficial for compound identification in complex botanical extracts, as compound identification relies on the ability to detect the ions of interest.

Session 3b - Cosmeceutical, Wound Healing, Dermatologic

P15. Cutaneous inflammasome activation by pollution is modulated by topical application of berry extracts to human skin

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Living organisms are continuously exposed to environmental pollutants. Because of its critical location, the skin is a major interface between the body and the environment and provides a biological barrier against an array of chemical and physical environmental pollutants including ultraviolet (UV) radiation, diesel fuel exhaust, cigarette smoke (CS), halogenated hydrocarbons, heavy metals, and ozone (O₃). Although human skin acts as a biological shield against pro-oxidative chemical and physical air pollutants, the prolonged or repetitive exposure to high levels of these leads to the formation of reactive oxygen species (ROS) and has been associated with several skin conditions such as aging, atopic dermatitis, eczema, psoriasis and acne all characterized by a common denominator represented by an inflammatory status. The inflammasome, which is one of the cardinal characters in the inflammatory response, is a multiprotein complex that serves an important pro-inflammatory role in the innate immune system and is responsible for activation of inflammatory process by promoting the maturation of the cytokines Interleukin 1 β (IL-1 β) and Interleukin 18 (IL-18). The activation of the inflammasome can result in life-threatening systemic and local inflammation, particularly in the skin. As cutaneous cells express and activate caspase-1 in an inflammasome-dependent manner, its activation might be critically involved skin pathologies. One of the most successful approaches to prevent pollution induced skin damage is the topical application of natural compounds able to quench or at least prevent the oxidative damage. Berries are known to be beneficial to the skin, most often used for their anti-inflammatory and anti-oxidant properties. The aim of this study is to evaluate the protective effects of topical applied berries extracts on pollutants-induced skin damage. For this study human skin explants were pre-treated with berries extract and then exposed to ozone and the evaluation of the inflammatory response was assessed. The treatment with berries extracts showed a clear effect on the inflammasome regulation responses, that allows us to suppose that berry extracts are able to reduce and prevent skin inflammatory related responses and can be used to protect against outdoor stressors induced skin damage.

Session 4a – Functional Foods

P16. Processing and cooking change lentil (*Lens culinaris* Medikus) prebiotic carbohydrates concentration

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Lentil is a significant dietary source of prebiotic carbohydrates, including sugar alcohols (SA), raffinose-family oligosaccharides (RFO), fructooligosaccharides (FOS), and resistant starch (RS). The levels of these carbohydrates can change during processing and cooking. This study determined the changes in the concentration of SA, RFO, FOS, and RS in three lentil market classes (red, green, and Pardina) subjected to different processing methods (whole, dehulling, and splitting), cooking, cooling, and reheating. Dehulling and splitting of lentil decreased SA in red and green market classes but RFO and FOS significantly decreased only in dehulled split red lentil. Further, dehulling and splitting of red lentil significantly decreased RS concentrations compared to the whole seed. In some cases, SA, RFO, and FOS significantly increased with cooling but decreased after re-reheating. Cooling and reheating significantly increased lentil RS concentration for all market classes. Spanish Brown "Pardina" had the highest total prebiotic carbohydrates (9492 mg/100 g) of all market classes tested (range 6935-8338 mg/100 g). Overall, selection of lentil market class, processing, and cooking method should be considered to optimize nutritional value.

Session 5a - Transforming Traditional Botanical Medicine into Precision Medicines

P17. Assignment of the absolute configuration of highly oxygenated triterpenoids using X-ray, ECD, NMR J-BASED configurational analysis and HSQC overlay experiments.

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Highly oxygenated triterpenoids isolated from plants of the genera *Schisandra* and *Kadsura* have revealed a variety of important biological activities including potent anti-HIV, anti-HBV, and cytotoxic properties. Their 2D structures and relative configurations have been successfully elucidated by NMR spectroscopic methods. Assignment of their absolute configurations is critical since it influences the bioactivity and is essential for future efforts focused on synthesis and medicinal chemistry applications. It has proven difficult to determine the absolute configuration for the schiartane-type nortriterpenoids due to the presence of 12 non-contiguous stereogenic centers as well as conformationally flexible side chains. Herein, three new schiartane-type nortriterpenoids were isolated from *Kadsura longipedunculata*, we assigned the absolute configuration of micrandilactone I from the X-ray diffraction data; ECD combined X-ray diffraction data were used to determine the absolute configuration of micrandilactone J; ECD, HSQC overlay, NOESY, and J-based configuration were applied to determine the absolute configuration of non-crystallized schiartane-type nortriterpenoids 22, 23-di-epi-micrandilactone J. Micrandilactone I and 22, 23-di-epi-micrandilactone J showed moderate hepatoprotective activity against APAP-induced toxicity in HepG2 cells with cell survival rates of 53.0 and 50.2%, respectively, at 10 μ M (bicyclol, 49.0%), while micrandilactone J was inactive.

Session 5b – Anti-inflammatory, Anti-oxidant, Anti-cancer

P18. Discovery of cytotoxic compounds from fungi

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In the United States approximately 39.6% of individuals will be diagnosed with cancer within their lifetime, and for every 100,000 cases 171.2 will be fatal, according to the NIH. Fungi are an under investigated source for novel anticancer compounds. It is estimated that there are over 1.5 million fungal species that inhabit the earth, and less than 100,000 have been described, ¹ with only a fraction being chemically described.² In order to study the chemical diversity of fungi, multiple species from around the world were examined, with litter dwelling ascomycetes being the main source. Their bioactivity against human melanoma, human breast cancer, and human ovarian cancer cell lines were assessed. With the aim of decreasing hits from known active compounds, a mass spectrometer bases dereplication method was used to analyze the mass data that correlates with an in house data base. This allowed for testing of novel compounds from fungi.¹Blackwell, Am. J. Bot., 2011, 98, 426-438. ²Aly, Fungal Divers, 50 2011, 50, 3–19.

Session 6b – Antibiotic, Antimicrobials

P19. An Integrated Approach for Assessing Antimicrobial Constituents from *Angelica keiskei* Koidzumi

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Antibiotic resistance is a growing problem globally, and approximately two-thirds of antibiotics on the market originate from natural sources. However, natural products such as botanicals contain hundreds to thousands of individual constituents, and it becomes difficult to assign activity to individual components. Consequently, the most abundant compounds in a given extract are often presumed to be responsible for bioactivity. *Angelica keiskei* Koidzumi, or ashitaba, is a Japanese botanical rich in bioactive chalcones. The goal of this project is to garner a more complete understanding of ashitaba's antimicrobial efficacy by integrating bioactivity-guided fractionation with novel technologies including biochemometrics and molecular networking. Ashitaba root extract inhibited the growth of methicillin-resistant *Staphylococcus aureus* (MRSA) at 10 μ g/mL and was fractionated using normal- and reversed- phase chromatography. Bioactivity data were combined with mass spectral profiles to generate selectivity ratios predicting potential antimicrobial constituents, and fragmentation data were utilized to produce molecular networks to predict structural classes of active constituents. One second-stage and one third-stage molecular network contained accurate masses of chalcones 4-hydroxyderricin and xanthoangelol, the only known antimicrobial compounds from ashitaba, in addition to other known ashitaba chalcones. These networks contained masses matching seven of the top ten contributors to bioactivity based on our model, indicating that chalcones are likely responsible for ashitaba's antimicrobial efficacy against MRSA. Fifteen masses in networks of interest matched accurate masses of known bioactive chalcones from the literature that have not yet been associated with antimicrobial activity. Of these, five were predicted as contributing to bioactivity, including the top contributor. Two additional compounds in these networks were identified among the top ten contributors by the biochemometric model and did not match accurate masses of bioactive chalcones found from ashitaba, indicating that novel chalcones may be present. Isolation of putative antimicrobial compounds is underway to confirm predictions of this technique.

P20. The Antimicrobial Activity of crude Leaf Extracts of *Ocimum* spp (*O.basilicum* and *O.tenuiflorum*) accessions on Bacterial Pathogens

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Essential oils from medicinal plants are said to exhibit strong antimicrobial activities for control of pathogenic microorganisms. The genus *Ocimum* is member of the Lamiaceae family and is distributed worldwide from the tropical and subtropical regions of Asia, to Africa, Central and South America. *Ocimum* spp. contain a wide range of essential oils rich in phenolic compounds and a wide array of other natural products including polyphenols such as flavonoids and anthocyanins, alkaloids, terpenoids, steroids, and glycosides, that synergistically coexist. Our understanding of the full therapeutic effectiveness of these components are limited. In this study, the antimicrobial activity of chloroform as well as methanolic leaf extracts against human and plant pathogenic bacteria was assessed based on the inhibition zones. Each filtered extract at a concentration of 50mg/ml was applied on bacterial inoculated plates of Muller-Hinton agar. The agar well diffusion method was used to screen the antibacterial activity of the leaf extracts. There was a difference among four accessions of *O. basilicum* (22, 25, 48, 72), and four accessions of *O. tenuiflorum* (86, 90, 91, and 93), chloroform leaf extracts showed maximum antibacterial activity; 17-21mm against *Bacillus* and 21.5 - 25mm against *Xanthomonas*. The methanolic extracts of both species of basil did not exhibit any antibacterial activity. The results showed that chloroform leaf extracts exhibited good inhibition against the test bacterial strains. The study shows that *Ocimum* spp. are potential sources for bio-ecologically compatible antimicrobial, preservative agents and may be used in the management of plant bacterial diseases.

P21. Ambuic Acid and Analogs as Anti-Virulence Compounds Against MRSA

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There is an urgency for the development of new leads to combat the threatening antibiotic resistance of pathogenic bacteria. According to the CDC, the Gram-positive bacteria methicillin-resistant *Staphylococcus aureus* (MRSA) was responsible for 80,461 severe infections and 11,285 deaths in 2015. Pathogenic bacteria resistance to the antibiotics is increasing in severity, and unfortunately the pharmaceutical industry has not focused on anti-infectives for the past several decades. Natural products and their derivatives have provided antimicrobial medicines for decades and currently account for up to two-thirds of antibiotic agents on the market, making them an advantageous avenue to explore. One strategy to combat antibiotic resistance is to shutdown pathogenesis mechanisms of the invading bacteria. Bacteria produce an arsenal of virulence factors, which are controlled by a density-dependent regulatory system known as 'quorum sensing.' Targeting the pathways that produce these virulence factors is a promising new strategy for anti-infective therapy, which in turn could provide the host organism's immune system an opportunity to clear the infection with less use of antibiotics. Our research has focused on identification and evaluation of anti-virulence compounds from fungal sources. Ambuic acid, derived from the fungal genus *Pestalotiopsis*, has been shown to target virulence factor production in MRSA via the quorum-sensing mechanism. A one-strain, many compounds (OSMAC) approach was utilized on the strain of fungus, *Pestalotiopsis microspora* through variations in growth conditions to increase fungal biosynthetic production of ambuic acid and analogues. Furthermore, we have undertaken studies to identify structural characteristics that contribute to ambuic acid's potent bioactivity in reducing virulence production, which will further our understanding of the underlying mechanism of action and allow for post-biosynthetic modifications to improve its quorum quenching efficacy.

UNDERGRADUATE STUDENT RESEARCH (Madren Center, Auditorium Lobby)

Session 3a - Processing, Quality, Sourcing

P22. Conventional and Accelerated-Solvent Extractions of Green Tea for Metabolomics-based Chemometrics

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Metabolomics has emerged as an important analytical technique for multiple kinds of applications. However, the value of information obtained from metabolomics analysis highly depends on the degree to which the entire metabolome is present, and the reliability of sample treatment and analysis to ensure reproducibility across the study. Two extraction methodologies, accelerated solvent extraction and conventional solvent maceration extraction, were compared, using commercial green tea (*Camellia sinensis*) products as a test case. The accelerated solvent protocol was first optimized with regards to crucial variables using a D-optimal experimental design study. The accelerated solvent and conventional extraction methods yielded similar metabolite profiles for the green teas studied, however, the accelerated solvent extraction method consumed less solvent and required less active bench time to prepare the samples. This study demonstrated the potential of accelerated solvent as an effective extraction methodology to prepare samples for a metabolomic study.

Session 4b – Environments for High Value Plants and Fungi

P23. Influence of light intensities and fertilizer solutions on nutrient uptake in *Raphanus sativus*

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"Microgreen" seedling growth was investigated in *Raphanus sativus* 'Daikon' radish for one week period using varied light intensities (33-250 μmol LED) and fertilizer solutions (Hoagland, CropKing, and DI water). 'Hoagland' fertilizer yielded the tallest plants with greatest fresh mass gain, and largest dry mass. Plants from 'CropKing' fertilizer were smaller than those from Hoagland, and those from DI water were greatly reduced. Plants with the least light were the tallest and plants with the most light had the greatest dry mass. The greatest gain in fresh mass was when light levels were about 150 μmol . The largest plants with the greatest fresh mass had the greatest concentrations of potassium, calcium, and magnesium in dry matter. In fresh plants, the concentrations of magnesium and phosphorus were less due to dilution. Relative dry mass was greatest in plants in DI water due to an absence of solutes necessary for water uptake. Calcium concentrations were similar in the fresh and dry vegetables because it is very immobile, bound within plant cell walls. Additionally, potassium concentrations were similar in fresh and dry vegetables in relation to average harvest height. Most of the potassium, calcium, phosphorous, and magnesium in the microgreens was obtained from the fertilizer solutions. Our observations demonstrate how maximizing the nutrient quality of microgreens is influenced by environmental factors dealing with light intensity and the other nutrients in the solution. Maximizing mass and size of microgreens requires the least light intensity and produced the most nutritious end product in terms of calcium and phosphorus in fresh mass. Magnesium and phosphorus were taken up in great quantities and diluted with water. Moving forward from these finds, more trials will need to be performed to better quantify optimum growth performance and nutrient uptake parameters.

Session 5a - Transforming Traditional Botanical Medicine into Precision Medicines

P24. Natural Products from the Microbiome of *Salicornia virginica*

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With nature being an influential model for unique chemical space the secondary metabolites of many organisms are a source of continued investigation in regard to medicinal agents for emerging or neglected diseases. While many macroorganisms and environmental microbes have been analyzed, few investigators have studied the endophytic and endosymbiotic microbiomes of plants and animals. This project selected a common and accessible, yet unstudied macroorganism, *Salicornia virginica*, to study the bioactive compounds from the anaerobic and microaerophilic endophytes. *S. virginica* is common to most of the coastal environments of the Eastern United States and, due to its biological activity, was used by Native Americans as a topical treatment for rheumatism and pain. This plant was selected for analysis due to its ecological niche as a halophyte, its historical ethnobotanical uses, and current accessibility. Healthy specimens were collected from the Sewee Shell Mound trail of the Francis Marion National Forest. Tissue sections of the leaf, root, and stem were inoculated onto three types of microbial media and the resulting bacterial colonies were isolated and purified. Peak libraries were created from the extracts of several selected isolated endophytes, using High-Performance Liquid Chromatography (HPLC), and these libraries are being screened for biological activity by drug discovery programs at Eisai, Lilly, and the Henry and Josephine Ford Cancer Center. In parallel with the bioactivity assays, compounds exhibiting masses of 500 m/z units or more and structural novelty using a network analysis during HPLC-MS analysis were further purified and their structures elucidated using Nuclear Magnetic Resonance (NMR) spectroscopy.

Session 5b – Anti-inflammatory, Anti-oxidant, Anti-cancer

P25. Using Natural Products from the Microbiome of Healthy Plants to Strengthen Resistance in Endangered Species

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Due to habitat destruction, grazing and disease associated with the loss of wetlands in the Southeast, many local plants are becoming endangered. In order to strengthen resistance to disease and herbivory as well as assessing the medicinal uses of the endangered local flora, our lab has collected several varieties of plants and has performed a series of investigations using metagenomics and metabolomics. These investigations are designed to assess the potential of the microbiome to both strengthen disease resistance as well as identify molecules of value to human health. This project has focused on a comparison of the microbiome of *Oxypolis canbyi* to other highly successful plants in the family Apiaceae. Specifically, a comparison using metagenomics and metabolomics between *Conium maculatum* and *O. canbyi* is being applied to help identify key bacteria involved in the biosynthesis of coniine. Coniine is highly toxic and has been associated with both animal and human deaths from ingestion. *O. canbyi* is an endangered perennial found in very specific wetland habitats such as cypress ponds or Carolina bays. The inflorescence is a compound umbel, and the fruit produced is a schizocarp. *O. canbyi* can reproduce both sexually and asexually through the spread of rhizomes. Other than the description and conservation status of the plant, very little research has been completed. Sections were taken from various areas on the plant's leaves, stem, flower, and roots and bacteria from the microbiome purified. These extracts were then evaluated using High-Performance Liquid Chromatography (HPLC). From the data collected by the HPLC several peak libraries were created, which the drug discovery programs at Eisai, Lilly, and the Henry and Josephine Ford Cancer Center are assessing for biological activity.

Session 6b – Antibiotic, Antimicrobials

P26. Identification of New Quorum Sensing Peptide from *Staphylococcus caprae*

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Many Gram-positive bacteria contain an accessory gene regulator (agr) system, which is a quorum sensing system regulated by a small cyclic peptide called the auto-inducing peptide, or AIP. Although the structure of each AIP is similar across species, each has a different sequence, which can allow AIPs to act as quorum sensing inhibitors when introduced to another species. This has been shown in previous studies. To continue exploring such cross communications of quorum sensing systems—and the agr system in general—the sequence and structure of each AIP must be known. It was the goal of this study to use high-resolution mass spectrometry to identify the AIP produced by *Staphylococcus caprae* and explore its potential to inhibit the production of AIP by *Staphylococcus aureus*. A synthetic peptide of the same structure predicted for the *S. caprae* AIP caused potent inhibition of the *S. aureus* quorum sensing system.

P27. The Curative Effects of Moringa Oleifera on Cancer Cell Lines

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Moringa Oleifera of the Genus Moringaceae is an angiosperm that grows within tropical and subtropical climates and possesses anticancer properties when exposed to breast and colorectal cancer cell lines. The compounds within M. Oleifera that are responsible for the plant extract's ability to stymie angiogenetic processes, reproductive ability, and survivability of cancer cells are Eugenol (Al-Sharif et al 2013), isopropyl isothiocyanate, D-allose, and hexadecenoic acid ethyl ester (Al-Asmari et al 2015). These anti-cancer compounds each possess long chain hydrocarbons, sugar moiety, and an aromatic ring. The anti cancer effects of Moringa lie primarily within the leaves and bark of the plant (Jung 2014). It was found that concentrations between 250 µg/ml and 500 µg/ml produced anti-cancer effects within the leaf and bark extracts. In the case of the concentration being below 250 µg/ml there would be no produced effect, while above the concentration of 500 µg/ml the effects of the extract would become nonselective (Al Asmari et al 2015). The leaf and bark extracts were made by taking leaves from the branches of the plant and scraping bark from its trunk. The materials were treated using a Soxhlet apparatus after being ground into a coarse powder. The products were then treated with ethanol and placed back in the apparatus for 6-8 hours before being applied to the cell lines. It is my hope to continue this line of research with regards to other forms of cancer in order to if not cure this disease, then ease the living conditions of those afflicted with it moving forward. A potential outcome to this research could be an alternative to chemotherapy that is of greater effect on the cancer and of significantly lesser strain on the afflicted party.

P28. Identification of anti-virulence compounds against MRSA using mass spectrometry-based bioassays

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Antibiotic resistant organisms are responsible for over 2 million illnesses and 37,000 deaths annually in the United States. Infections from methicillin-resistant *Staphylococcus aureus* (MRSA) alone cause an annual economic burden of \$4.2 billion, and have high mortality rates; about 1 death in every 8 infections. With a dwindling supply of new antibiotics and a continual increase in the development of antibiotic resistance in bacterial pathogens, there is a high demand for new strategies for fighting bacterial infections. One strategy that has potential is inhibiting the production of virulence factors in the pathogen rather than inhibiting bacterial growth. Targeting virulence factors to fight bacterial infections provides three key advantages: virulence factors are common among many pathogenic strains of bacteria, resistance to virulence factors develops at a much slower rate, and this strategy allows for infections to be cleared naturally by the host immune system. Virulence is regulated in MRSA by the accessory gene regulation (agr) system. The inhibition of this system blocks cell-to-cell communication between bacteria, colonization, and host cell invasion and apoptosis. With this research, we employed a mass spectrometry based assay to facilitate the identification of compounds that inhibit the agr system in MRSA. Using this assay, a newly identified fungal compound and two analogues were determined to act as agr inhibitors.

P29. Selection of a New Cultivar Fenglei from a *Lonicera japonica* Population and its ISSR Analysis

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Flowers of *Lonicera japonica* have been used to produce flos lonicera, which is a popular traditional Chinese medicine. However, current *L. japonica* cultivars produce flowers that open in 2-3 days, the opened flowers must be harvested within this time frame. Additionally, chlorogenic acid (CGA) concentrations in these cultivars are low. This report describes a mutant isolated from a popular cultivar Juhuayihao, called Fenglei. A distinguishing characteristic of 'Fenglei' is that its flowers never open. 'Fenglei' flowers twice a year with more than 90% of the flowers produced in the first-round of flowering. Wild type plants flower three times a year, each accounting for 50%, 30%, and 20% of total number of flowers produced annually. Flowers were harvested three times a year for wild type plants but just once for 'Fenglei'. Fresh and dry weights of 1,000 fresh flowers, flower length, and flower diameter of 'Fenglei' were significantly greater than those of the wild type. Total flower fresh and dry weights per plant as well as flower yield per hectare of 'Fenglei' were significantly higher than those of the wild type. Dry flower yield of 'Fenglei' was 17.6% higher than the wild type. Chlorogenic acid content of 'Fenglei' was 48.3% higher than the wild type. 'Fenglei' not only produces higher flower yields, its flowers

also contain higher levels of chlorogenic acid. Furthermore, production of 'Fenglei' also cut labor costs as its flowers are harvested only once a year compared to three times for its wild type plants. ISSR was used to analyze 'Fenglei' along with other additional 19 cultivars. Results showed it is a mutant of *Lonicera japonica*.

P30. A perspective on forest farming of medicinal plants in Hunan Province, China

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Forests cover 59.64% of the Hunan's land surface, which makes it the seventh most forested Province in China. Hunan is also rich in Chinese medicinal plants, and it is estimated that there are 3,604 species in Hunan. With our society moving toward a sustainable lifestyle, forest farming becomes increasingly popular. Hunan is well positioned to be a leading province in China in forest farming of medicinal plants. In this report, we analyze how research findings generated from universities and research institutes in Hunan Province has led to the change in forest farming of medicinal plants and how the changes have increased forest farmers' income. During the last 10 years, 36 major provincial achievements were awarded to medicinal plant research, including plants from the genera *Lonicera*, *Eucommiae*, *Magnolia*, *Lilium*, *Lotus seeds*, *Panax*, *Cyclocarya*, *Dendrobium*, *Polygnotum*, and *Paris*, and the majority of the research discoveries or technologies have been used in extension programs to assist forest farmers in their production practices. This resulted in a net profit of \$0.45 billion for forest farmers. For example, new cultivars of *Lonicera macranthoides* developed by Hunan Academy of Forestry produced abundant flowers with yields 150% higher than those conventional cultivars. Content of chlorogenic acid, a key compound in these new cultivars is 40% higher than the conventional cultivars. These cultivars quickly replaced the conventional cultivars in Hunan. Longhui County alone planted 13,000 hectares and produced 11,000 tons of flos *Lonicera* annually, accounting for 50% of the national production. Production of these new cultivars netted about \$0.17 billion for forest farmers in Longhui County and greatly improved farmers' living conditions. This example illustrates the power of scientific discoveries that lead to change in medical plant production and improvement of forest farmers' incomes.

P31. Morphology and seed characteristics of *Epimedium sagittatum* collected from five regions in Hunan Province

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Epimedium sagittatum, commonly known as barrenwort or horny goat weed, is native to China and is an important traditional Chinese medicinal plant. Leaves of barrenwort contain flavonoids, which are considered to be the major active pharmaceutical components. Current research has largely focused on chemical constituents and limited attention has been paid to the morphological differences and seed characteristics of different landraces. In this study, five landraces were collected from five regions of Hunan Province: Yuanling, Sangzhi, Yizhang, Xinning, and Chengbu, and plant morphology and seed characteristics were evaluated in Tujiachong Experimental Station of Hunan Academy of Forestry. Results showed that plant heights ranged from 19.8 to 27.2 cm, and stem diameters varied from 0.04 to 0.08 cm. The largest leaf of the landrace collected from Chengbu was 35.72 cm² compared to that of 24.8 cm² collected from Xinning. Seed sizes and 1,000 seed weights were similar regardless of the plant origin. Plant heights, stem diameters, leaf lengths, the widest widths, and leaf areas were significantly correlated. The widest width leaf was also correlated with 1,000 seed weight. Genetic analysis of these parameters showed that plant height, leaf area, leaf length, leaf thickness, seed length, seed thickness, and 1,000-grain weight were mainly affected by environmental factors, while plant height, stem diameter, and leaf thickness were controlled genetically. Results from this study could help select landraces of *E. sagittatum* suitable for production in particular regions.

P32. Forest farming: Overstory plant species affect rhizome yield of *Coptis chinensis*

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Forest farming is the production of high-value specialty crops under the protection of tree canopy. In this study, we evaluated rhizome yield and concentrations of some key compounds of *Coptis chinensis* produced under canopy of (1) *Magnolia officinalis* and (2) mixed forests of *Phellodendri chinensis* and *Cunninghamia lanceolata* as well as (3) an open field surrounded by Chinese fir trees in Longshan County, Hunan Province, China from 2011 to 2016. Results showed that plants grown under *M. officinalis* produced 9,673.2 kg of fresh rhizomes per hectare in the sixth year after transplanting, which was 37.98% greater than that produced in the open field. The fresh weight was 8,093.55 kg/ha for those grown under the mixed *P. chinensis* and *C. lanceolata*, a 15.45% higher yield than those produced in the open field. Thus, the fresh rhizome yield produced under *M. officinalis* was 19.52% greater than that produced under mixed forests of *P. chinensis* and *C. lanceolata*. Chemical analysis of rhizomes indicated that there were no significant differences in concentrations of several key compounds. The contents of berberine, epiberberine, coptisine, and parmetine were 7.4-7.5%, 1.39-1.53%, 2.3-2.4%, and 1.9-2.0%, respectively. The concentrations of the four compounds meet the Chinese Pharmacopoeia requirements. Our results suggest that overstory plant species affect rhizome yield, not key compound concentrations of *C. chinensis*, and the production of *C. chinensis* under *M. officinalis* gives higher rhizome yield than a mixed forest of *P. chinensis* and *C. lanceolata*. This study provides additional evidence supporting the viability of foresting farming in the production of traditional medicinal plants.

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