FINAL PERFORMANCE REPORT

GRANT INFORMATION

AGREEMENT

AMS Agreement Number:	AM180100XXXXG023			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Award Amount:	$630,961.29			

RECIPIENT

Recipient Organization Name:	Oklahoma Department of Agriculture, Food, and Forestry
Recipient's Point of Contact	
Name:	Jason Harvey
Phone:	405-606-1477
Email:	Jason.harvey@ag.ok.gov

REPORT

Report Type:	Final Report
Date Report is Submitted:	1/6/2022

GRANT ADMINISTRATION

Amount Requested	Direct and/or Indirect Expended to Date
$49,901.54	$45,556.54 has been spent as direct cost

Project Title	Oklahoma Farmers' Market Annual Conference			
Recipient Organization Name:	University of Oklahoma Health Sciences Center			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Dr. Karla Finnell			
Phone:	405-271-2017 ext 46757			
Email:	Karla-Finnell@ouhsc.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

The purpose of the Oklahoma Farmers' Market Annual Conference (OKFMAC) is to increase the economic well-being of the local farm economy and support healthy communities by enhancing the growth, promotion and purchase of specialty crops offered by Oklahoma producers through local farmers' markets, direct marketing farmers and Agritourism sites.

OKFMAC provides specialty crop growers with education and statewide networking opportunities they can use to increase production and retail sales of specialty crops. The conference is timely in that it takes place prior to the start of the growing season and allows specialty crop growers to use the knowledge and resources acquired from the conference to increase the production and retail sales of specialty crops during the growing season.

The project benefits conference attendees through the acquisition of new knowledge, ideas, collaborations and resources that can be used to increase specialty crop production and retail sales in Oklahoma. The potential economic impact of the conference will be the increase of specialty crop production and retail sales throughout the state, and additional resources for the local rural economy

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Strengthen and diversify the network of specialty crop producers.	X	
2	Increase access to Oklahoma specialty crops and enhance nutrition education and consumption.	X	
3	Increase collaboration between specialty crop producers and local farmers' markets.	X	
4	Develop and improve marketing channels for specialty crops through new or expanded farmers' markets and development of new revenue streams such as SNAP and SFMNP.	X	

5	Develop capacity and knowledge that enhances the resources of conference participants.	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Registered 457 participants for the 2019 & 505 participants for the 2020 Oklahoma Farmers' Market Annual Conference, which included potential and active specialty crop producers, farmers market managers, agritourism site managers and community support organizations.	Objective 1: Strengthen and diversify network of specialty crop producers. Objective 3: Increase collaboration between specialty crop producers and local farmers markets.
2	Offered a session educating 50 attendees on basics of providing nutrition education and hosting cooking demos promoting specialty crops at farmers markets in addition to other nutrition nudges in 2020.	Objective 2: Increase access to Oklahoma specialty crops and enhance nutrition education and consumption.
3	Delivered 26 in-person unique sessions with 340 participants (2019) & 30 unique sessions with 454 in-person participants (2020). Education sessions covered emerging and best practices and resources relevant to specialty crop producers.	Objective 5: Develop capacity and knowledge that enhances the resources of conference participants.
4	Utilized the Whova event management app, which was downloaded by 274 attendees in 2019 & 334 in 2020. App provided a community forum for participants to share discussions – 668 messages in 2019 and 812 messages in 2020 were posted in the community forum. Maintained and updated OK Farmers Markets Facebook page (3,266 followers) to encourage collaboration, share resources, and digitally post recorded educational sessions from OKFMAC.	Objective 1: Strengthen and diversify network of specialty crop producers. Objective 3: Increase collaboration between specialty crop producers and local farmers markets.
5	In 2019 the number of farmers markets registered with ODAFF increased from 89 in 2018 to 96 in 2019 (7.8% increase) and the number of farmers markets approved by USDA FNS to redeem SNAP and SFMNP benefits increased from 40 in 2018 to 50 (25% increase). Additionally, in 2020 two farmers markets and five direct marketing farmers approved by USDA FNS to accept SNAP & SFMNP onsite at conference.	Objective 2: Increase access to Oklahoma specialty crops and enhance nutrition education and consumption. Objective 4: Develop and improve marketing channels for specialty crops through new or expanded farmers' markets and development of new revenue streams such as SNAP and SFMNP.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	**Development:** Addition of social media marketing pre-conference workshop	As indicated on previous conference feedbacks attendees have expressed interest in going into more depth on particular topics for longer periods than what can be offered during a typical session. To meet this request in 2020 a half day, pre-conference social media marketing workshop was held in partnership with ODAFF's Agritourism team and attended by 50 participants.
2	**Development:** Addition of plasticulture pre-conference workshop	As indicated on previous conference feedbacks attendees have expressed interest in going into more depth on particular topics for longer periods than what can be offered during a typical session. To meet this request in 2020 a half day, pre-conference plasticulture was held in partnership with Langston University and was attended by 34 participants.
3	**Development:** Addition of specialty crop farm tour post-conference workshop	To provide hands-on experience and introduce specialty crop producers to new and innovative growing practices an innovative growing practices post-conference tour was held in both 2019 and 2020. Registration reached capacity, that is 50 participants each year.
4	**Development:** Promotion of recorded conference sessions on social media	Recorded OKFMAC sessions have been posted to social media in the past. However, 2020 was the first year recorded sessions have been monetarily promoted as advertisements on Facebook. These recordings were posted to the Oklahoma Farmers Markets Facebook page and promoted to not only the 3,266 page followers but also to those who have exhibited agriculture and local food interests on Facebook. The nine promoted recorded session posts received 481 views, reached a combined 286,932 users, and received 21,183 engagements, significantly increasing the reach and spread of conference content.

#	Challenge or Development	Corrective Action or Project Change
5	**Challenge:** ODAFF reformatting their market registration list and COVID -19 impact on farmers markets	In 2020 ODAFF reformatted their farmers market registration list to only include active farmers markets. As a result, the number of registered farmers markets in Oklahoma decreased from 96 to 52. Additionally, the 2020 conference was held in February prior to the onset of the pandemic in Oklahoma. Due to COVID-19 many farmers markets did not open this season for safety concerns. Markets also did not reopen this season due to a reduction of vendors as a result of increased demand for local products by sales outlets outside of the farmers market.
6	**Challenge:** 2019 attendance was significantly affected due to an ice storm	Began recording certain sessions in order to increase reach and accessibility.

LESSONS LEARNED

The use of social media has been very beneficial and has significantly increased the reach of this conference. Due to space restrictions, in the future registration needs to be capped. However, those unable to attend in person, could attend virtually and still benefit from the information

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

All recorded OKFMAC sessions are on the Oklahoma Farmers Markets Facebook page and are available for 24-7 viewing. Session information and accompanying presentation are also available to view on the ONIE Project website. ONIE also facilitates the Oklahoma Farmers Market Network Facebook group where members may network and share resources to support the growth, marketing and sales of specialty crops in Oklahoma.

BENEFICIARIES

Number of project beneficiaries:.....892

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☑ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources

☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems

☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☑ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 3 Indicator 3.a:	The number of farmers markets approved by USDA FNS to redeem SNAP and SFMNP benefits increased from 40 in 2018 to 50 (25% increase). Additionally, in 2020 two farmers markets and five direct marketing farmers were approved by USDA FNS to accept SNAP & SFMNP onsite at the conference.
2	Outcome 3, Indicator 3.b.	In 2019 the number of farmers markets registered with ODAFF increased from 89 in 2018 to 96 in 2019 (7.8% increase). However, this outcome was not met in 2020 as explained in the Challenges and Developments section.
3	Outcome 8, Indicator 5.	The 2019 conference included a SNAP breakfast to educate direct marketing farmers and markets on the SNAP process and to encourage applying to be a SNAP accepting vendor with the on-site FNS representative, as well as an in-depth session on marketing to SNAP consumers. Nevertheless, in 2019, statewide SNAP redemptions for farmers markets and direct marketing farmers decreased from $125,552.22 in 2018 to $111,185.49 in 2019 (11.4% decrease). This decrease is attributed to the end of the marketing and expansion of the Double Up Oklahoma program. This loss does not reflect any loss of interest consuming specialty crops. Because of prior year losses attributable to

		crop failures, the baseline of $199,703 was too high. 2020 SNAP redemptions have also not met the originally projected baseline increase in sales. However, the reinstallation of the Double Up Oklahoma program and the emergence of the COVID-19 pandemic increased demand for local food and the distribution of P-EBT benefits have resulted in a massive increase in SNAP benefit redemptions at farmers markets with $189,668.44 of SNAP redeemed as of November 2020, a 51% increase from 2019.

DATA COLLECTION

ONIE has a data sharing agreement with OKDHS in which they receive a comprehensive list of all the FNS approved SNAP-accepting farmers markets and their total SNAP transactions on a weekly basis. ONIE partners with ODAFF and receives information on the number of registered farmers markets from the Office of Market Development.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$21,020.00	$22,767.38
Fringe Benefits	$7,378.00	$7,838.12
Travel	$564.00	$368.98
Equipment	$0.00	$0.00
Supplies	$3,238.00	$993.49
Contractual	$0.00	$0.00
Other	$37,800.00	$34,411.15
Direct Costs Sub-Total	$70,000.00	$66,379.12
Indirect Costs	$0.00	$0.00
Total Federal Costs	$70,000.00	$66,379.12

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

Information and registration for the conference was hosted on www.onieproject.org/okfmac. The conference also used the Whova cell app, https://whova.com/portal/ofmac_202002/, to share presenter information and presentations as well as to collect session feedback and facilitate digital networking amongst participants. Information about the conference in addition to recorded conference sessions can be found on the Oklahoma Farmers Markets Facebook page, https://www.facebook.com/OKFarmersMarkets

Project Title	Decontamination Of Produce By Cold Atmospheric Plasma			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Li Maria Ma			
Phone:	405-744-5290			
Email:	li.ma@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

With increasing numbers of foodborne illness outbreaks associated with the consumption of produce in recent years, the presence of foodborne pathogens on produce, such as tree nuts, fresh fruits and vegetables, is a worldwide food safety & human health concern. Postharvest decontamination treatment is a critical step in reducing food safety risk associated with produce. However, the current decontamination technologies are mostly based on chemical sanitizers (such as chlorine) which not only have limited inactivation efficiency but also consumer a large amount of water. Cold atmospheric plasma (CAP) is a partially ionized gas that is formed when high energy, such as high-voltage electric discharge, is applied to the gas under atmospheric pressure. It consists of free electrons, ions (charged particles), neutrals, reactive oxygen and nitrogen species (such as ozone, nitric oxide, hydroxyl, hydrogen peroxide, etc.), and UV photons. These charged particles and reactive species are capable of killing microorganisms including foodborne pathogens. Due to its relative low temperature (near room temperature), CAP has the ability to inactivate microorganisms without affecting the material being decontaminated. Consequently, it has been explored for sterilization of medical materials and devices, and more recently wound healing and food decontamination. CAP has several advantages over the commonly used decontamination methods in the food industry: minimum water consumption (as a dry process), short treatment time, low operational cost, and nontoxic nature. However, currently, there is no cold plasma-based

decontamination device that is commercially available for the food industry yet. Our research team has constructed a prototype CAP device and preliminary studies demonstrated its inactivation capability on three major foodborne pathogens. Based on our previous experience and literature review, there are a number of variables related to device design and operational conditions can be optimized to maximize foodborne pathogen inactivation by this simple and dry technology. These factors include the dielectric material, electrode arrangements, power input, pulse rate, and relative humanity of air. Our long term goal is to build a simple, flexible, and efficient CAP device for decontamination of produce.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	To assess the impact of electrode arrangements and dielectric materials on the inactivation of *Salmonella enterica* (model foodborne pathogen) on in-shell pecans (model produce) by cold atmospheric plasma	X	
2	To investigate the influence of power input and related operational parameters on the inactivation of the pathogen on pecans		X

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Assessed the impact of electrode arrangements and dielectric materials on the inactivation of *Salmonella enterica* (model foodborne pathogen) on in-shell pecans (model produce) by cold atmospheric plasma (prototype) therefore provided the foundation on improving the prototype design (reducing electrode width and gap) for better inactivation of foodborne pathogens on produce.	This is relevant to Objective one of this project, Outcome 6 indicator 3.
2	Presented results at seminars, symposium, and conference.	This is relevant to Outcome 6 indicator 4
3	Rebuilt a CAP device	Had to, relevant to both objectives of this project

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Manufacture of the designed actuators was delayed due to Covid-19 pandemic (later 2019) in China (where the manufacturer is located)	Adjusted the experimental timeline;

#	Challenge or Development	Corrective Action or Project Change
2	Early evaluation experiments had to be postponed due the lockdown of campus in spring semester against Covid-19	Adjusted the experimental timeline; A new graduate student has been recruited and is working on the project since August 2020
3	CAP device broke down in early 2021; Calibration devices (gas detectors and gas sensors) were not allowable purchases on this grant (the breakdown was unexpected so it was not budgeted in original budget)	Modified contract service to have the device to be rebuilt and calibrated; Squeezed PI's IDC account to solve the budget issue on this grant; Project finishing line is shifted again.
4	It became apparent that the device might not have been performing at its best for a sometimes before its complete breakdown, therefore added some doubts with the early data collected (see first part of the results)	The entire trials were repeated with rebuilt CAP device (see 2nd part of the results);
5	Due to the time taken to rebuild the CAP device and repeat of the early trials, not enough time left to complete Objective 2 of the project	Objective 2 of the project is a critical part of our long term goal so it is ongoing with support from PI's departmental funding for the graduate student.

LESSONS LEARNED

Have contingency plan, budget the unexpected, and communicate with funding agency often.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

We are planning to complete the objective 2 of the project and submitting additional proposals for in-field testing of CAP (the rebuilt) device for produce decontamination

BENEFICIARIES

Number of project beneficiaries: 1,000

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources

☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems

☑ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 6, indicator 3	Results from Objective 1 had been shared at meetings and conferences with total number of attendance over 1000.
2	Outcome 6, indicator 4	Best electrode arrangements and dielectric materials have been selected whereas power input and related operational parameters are still needed to be studied

DATA COLLECTION

Objective 1:
To assess the impact of electrode arrangements and dielectric materials on the inactivation of *Salmonella enterica* (model foodborne pathogen) on in-shell pecans (model produce) by cold atmospheric plasma.

The variables tested were dielectric material (Teflon, ceramic), copper electrode width (0.1, 0.5, and 1.0 cm), and gap distance of electrodes (0.1, 0.5, and 1.0 mm)

1. Five types of actuators (A1 to A5, listed in Table 1) were designed and had them constructed by HuaXing PCBA Limited.

Table 1. Actuator design

Actuator	Electrode width(cm)	Electrode gap (mm)
A1	0.1	0.5
A2	0.5	0.1
A3	0.5	0.5
A4	0.5	1.0
A5	1.0	0.5

2. Samples inoculated with Five-strain mixture of *S. enterica* (ca. 10^7 cfu/sample) were exposed in triplicate to CAP generated by each actuator for 2 and 5 min at a distance of

2 and 5 cm. Three inoculated samples without CAP treatment served as control in each trial for each actuator.

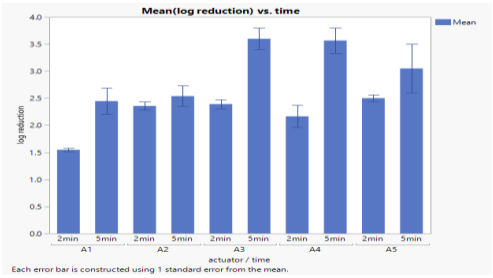
3. Immediately after each CAP treatment, inoculated *S. entericia* were recovered from samples and enumerated and log reductions were calculated against controls
4. Analysis of variance (ANOVA) was used to compare the treatments with significant difference defined at $p<0.05$ (SAS). All treatments were conducted in triplicate in each trial and at least two independent trials ($n\geq6$)

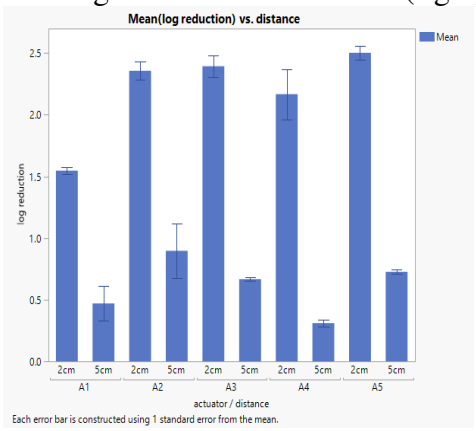
Results:

Actuators built with ceramic as dielectric material produced tiny dusts which were consistently deposited on the samples during CAP treatment. As such issues won't be suitable for food treatment, further actuator evaluations were conducted with actuators built with Teflon F4B only

Part 1 (old CAP device)

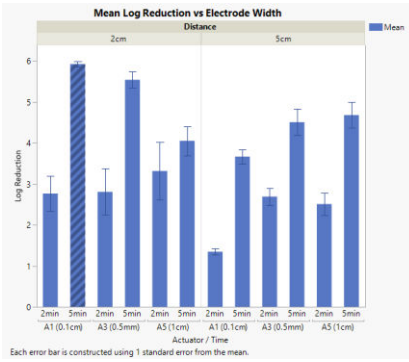
1. Log reductions vs. time (left) and Log reduction vs. distance (right)

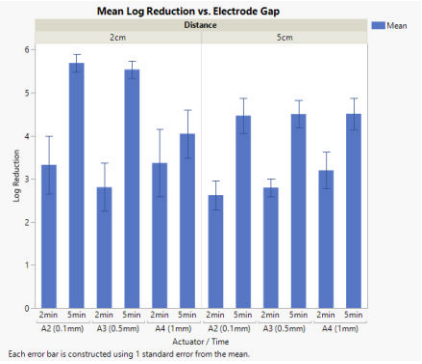




Part 2 (rebuilt CAP device)

2. Log reductions vs. electrode width (left) and Log reduction vs. electrode gap (right)





Conclusions:

- Long treatment time and shorter treatment distance result in higher log reduction of *S. enterica* (A1, A2, and A3);

- Smaller electrode widths (0.1 and 0.5 cm vs. 1.0 cm) improve pathogen inactivation efficiency significantly;
- Smaller electrode gaps (0.1 and 05 mm vs. 1.0 mm) improve pathogen inactivation efficiency significantly;
- A2 and A3 are selected for objective 2 evaluations (investigating the influence of power input and related operational parameters on the inactivation of the pathogen on pecans)

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$35,228.00	$41,080.73
Fringe Benefits	$2,693.00	$2,383.77
Travel	$4,960.00	$1784.59
Equipment	$0.00	$0.00
Supplies	$24,540.00	$10.241.51
Contractual	$5,200.00	$9192.50
Other	$0.00	$0.00
Direct Costs Sub-Total	$72,621.00	$62,517.21
Indirect Costs	$0.00	$0.00
Total Federal Costs	$72,621.00	$62,517.21

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Assessing Pecan Oil For Nutritional Potency In Oklahoma
Recipient Organization Name:	Oklahoma State University

Period of Performance:	Start Date:	9/28/2018	End Date:	9/27/2021
Recipient's Project Contact				
Name:	Niels Maness			
Phone:	405-334-1205			
Email:	Niels.maness@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Scientists at Oklahoma State University from Horticulture and LA in Stillwater and from Biochemistry at the Center for Health Sciences in Tulsa teamed with pecan production experts at the Noble Research Institute in Ardmore to document the nutritional potency of pecans produced throughout Oklahoma. The pecan varieties 'Pawnee' and 'Kanza' were harvested from northwest (Cherokee), northcentral (Cleveland and Perkins), southeast (Ardmore) and southcentral (Charlie, TX) Oklahoma to determine whether nutritionally vital phytochemicals in the oil (fatty acids, tocopherols, phytosterols and squalene) varied for pecans produced across the state. Since the majority of pecans produced in Oklahoma are from native populations of trees, the investigators also sampled populations from northeast (Collinsville), southeast (Haworth, Tom and Sawyer) and southcentral (Burnyville) Oklahoma to determine natural variability in these important oil phytochemicals. Storage conditions to maintain nutritional potency from cold pressed pecan oil was tested. Results were extended to stakeholders on-farm and at a grower conference. Our results were the first to establish oil nutritional potency of Oklahoma pecans.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Prospect various varieties and native populations of pecans growing in Oklahoma for high production of oil phytochemicals with potential nutritional value.	X	
2	Document regional variability of pecan oil phytochemicals for native populations and two varieties well suited for production in Oklahoma.	X	
3	Establish a storage procedure which maintains high levels of phytochemicals in pecan oil	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	a) Although native pecans from all locations contained less nutmeat than	Objective 1: Prospect various varieties and native populations of pecans growing in

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	the two improved varieties studied ('Pawnee' and 'Kanza'), oil contents within nutmeats of native pecans and improved varieties were indistinguishable. This data is important because it disproves some theories that native pecans are higher in oil content than improved varieties. b) For all pecans tested there was an inverse relationship between oil content of oleic acid (monounsaturated and the major fatty acid) and linoleic acid (polyunsaturated and the second most prevalent fatty acid). There was no clear differentiation between improved varieties and native populations but there was some difference between relative concentrations of these fatty acids at selected locations for the improved varieties which will be discussed with objective 2. c) Gamma tocopherol was by far the highest tocopherol species in all pecan nutmeats, exhibited year to year variability in content (at most locations it was higher in 2020 than in 2019) but any variety or native population difference was location-specific. d) Squalene was present in all pecan oils but was higher in both improved varieties than in native pecans. Although there were variety and year effects which differed at each location, our data suggests oils obtained from 'Pawnee' or 'Kanza' are richer sources of squalene than oils from native populations. e) Beta-Sitosterol was the major phytosterol in all pecan oils and was mostly stable in concentration across varieties, native populations and	Oklahoma for high production of oil phytochemicals with potential nutritional value.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	locations. This data indicates that oils obtained from all pecans tested have approximately equivalent beta-sitosterol concentrations; pecan source should have little impact on beta-sitosterol oil content.	
2	a) While substantial year to year variability existed at most locations, higher production of oleic acid (and lower production of linoleic acid) was evident for both 'Pawnee' and 'Kanza' at McMillian (south-central OK) and Cherokee (north-western OK). It is unclear why this difference persisted at these two locations but it would appear that pecans from McMillian or Cherokee might be less susceptible to oxidative rancidity than pecans produced at the other locations we tested. It is important to note that no such difference in fatty acid content was noted for any native populations sampled from south-eastern, south-central and north-eastern OK. b) While we noted slightly higher oleic acid at the McMillian and Cherokee locations (indicating oil within pecans from these locations may be slightly less susceptible to oxidation), gamma-tocopherol contents (thought to function as an antioxidant and protect fatty acids from oxidation) were not notably different at these locations – if oil within improved varieties from McMillian and Cherokee were inherently less susceptible to oxidation they did not have a complimentary layer of protection with increased gamma-tocopherol. We did note somewhat lower gamma tocopherol in oils from native populations	Objective 2: Document regional variability of pecan oil phytochemicals for native populations and two varieties well suited for production in Oklahoma.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	near Sawyer (Southeastern OK) and Collinsville (Northeastern OK). It is unclear what significance this difference represents. Overall our data suggests oil obtained from either 'Pawnee' or 'Kanza', or from three of the five native populations sampled, should be good sources of gamma-tocopherol.	
3	We conducted storage evaluations of cold pressed oils which were immediately placed into room temperature (70-75 F), refrigerated (40 F) or frozen (0 F) storage, or placed into storage after room temperature storage for 7 years prior to the study. Oils were assessed for beta-sitosterol content after 6 months of storage and for gamma-tocopherol and squalene after 6 and 13 months of storage. In all cases storage at room temperature resulted in loss of phytochemicals. Although some benefit (less loss of phytochemicals) was evident for frozen versus refrigerated storage, by far the largest benefit was obtained by reducing storage temperature to at least refrigerated storage conditions. Two other findings were evident: 1) For gamma-tocopherol the increase in storage duration from 6 to 13 months resulted in an across the board decrease in concentration. Pecan oil should not be stored for prolonged periods (longer than 6 months) if highest concentration of gamma tocopherol is desired. 2) The pecan oil placed into storage after 7 years storage at room temperature exhibited substantially lower phytochemical contents than freshly pressed oils. Storage condition still exhibited some beneficial effect in maintaining phytochemical content. It is not surprising to conclude that oils miss-handled prior to storage will exhibit	Objective 3: Establish a storage procedure which maintains high levels of phytochemicals in pecan oil.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	lower phytochemical content going into storage. The added expense of storage temperature control would be best applied to freshly pressed pecan oil.	

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	The HPLC system originally planned to conduct this work was in use for another active research project	Purchased a refurbished HPLC to conduct work and completed the objectives of this project.
2	Small number of nuts available for harvest at some orchard locations in 2020	2020 appeared to be an "off" production year at most locations, but particularly at Cherokee (and perhaps native pecan orchards). Production was low to moderate at Cleveland, moderate at McMillian and normal at Perkins. We have taken note of the severity of the 2020 "off" production year and will discuss this in the "lessons learned" section.
3	Tested pecan oil efficacy for inhibition of intestinal cancer cell growth	This was not a part of our original objectives but we were able to conduct a preliminary study on pecan oil's ability to inhibit intestinal cancer cell line growth. Both pecan oil and gamma tocopherol inhibited cell growth, with little impact on growth of a mineral oil control. Although we are encouraged by this seemingly positive use of pecan oil, we do note that there were no normal cell lines included so it is impossible to say whether the inhibition of cell line growth was selective to cancer cells or would exert a similar effect on all cells.
4	Tested the impact of early harvest on nut weight and oil phytochemical contents at one location	This study was also not a part of our original objectives but was of interest since dogma indicated that once shuck split occurs the nuts are mature and no significant change in weight and oil will occur. We hand harvested nuts after shuck split (trees were at 80% shuck split) and then conducted a second later harvest two weeks after that date, for 'Pawnee' and 'Kanza' grown at the Cimarron Valley

#	Challenge or Development	Corrective Action or Project Change
		Research Station close to Perkins. Nutmeat weight increased slightly in the later harvest (from 47 to 50 gm per kernel in 'Pawnee' and from 34 to 38 gm per kernel in 'Kanza'), indicating that active import was still occurring even after shuck split had occurred. Gamma-tocopherol continued to increase slightly as a component of the pecan oil; beta-sitosterol and squalene were relatively static during the two week period. These results indicate that shuck split is not necessarily a trigger for pecan harvest – a grower should consider shuck split as starting the harvest clock. If predation loss potential is low, waiting a couple of weeks to harvest can slightly increase yield and concentration of gamma-tocopherol in the nut oil.

LESSONS LEARNED

Pecan oil nutritional profile may be influenced by the "on" or "off" production cycle of the trees: At the Cherokee location trees of all cultivars were in an "off" production season in 2020. There was no effect on kernel oil content (Figure 1; varieties at all locations held steady at 70 to 72% oil) but gamma tocopherol (Figure 2) and squalene (Figure 3) levels in the oil were consistently lower, and beta-sitosterol (Figure 4) was consistently higher, in the 2020 "off" production cycle compared to the 2019 "on" production cycle at Cherokee whereas they were slightly higher or static in concentration at the other locations in 2020 compared to 2019.

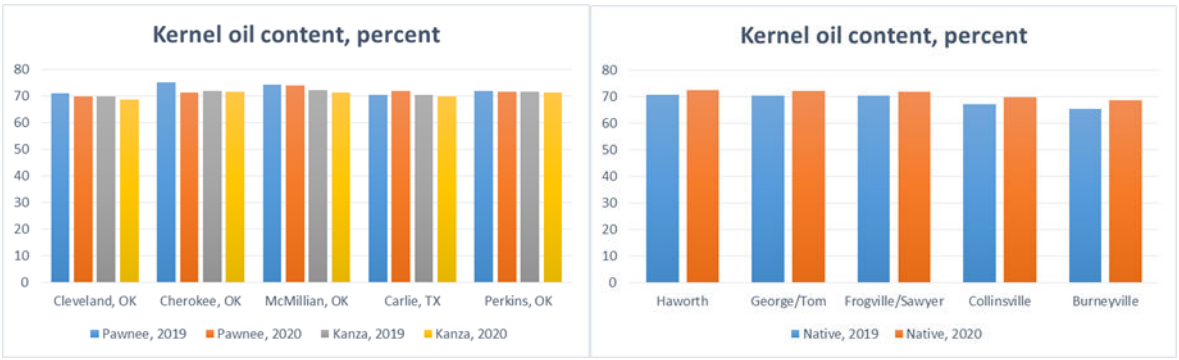


Figure 1: Kernel oil content (gm oil/100 gm pecan kernel) for 'Pawnee', 'Kanza' and native pecan populations at various locations in Oklahoma harvested after the 2019 and 2020 growing seasons.

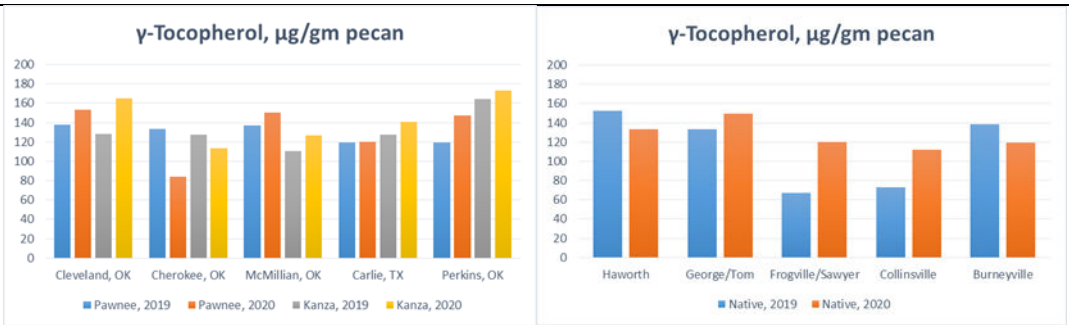


Figure 2: Pecan oil gamma-tocopherol concentration (µg/gm pecan) for 'Pawnee', 'Kanza' and native pecan populations at various locations in Oklahoma harvested after the 2019 and 2020 growing seasons.

Figure 3: Pecan oil squalene concentration (µg/gm pecan) for 'Pawnee', 'Kanza' and native pecan populations at various locations in Oklahoma harvested after the 2019 and 2020 growing seasons.

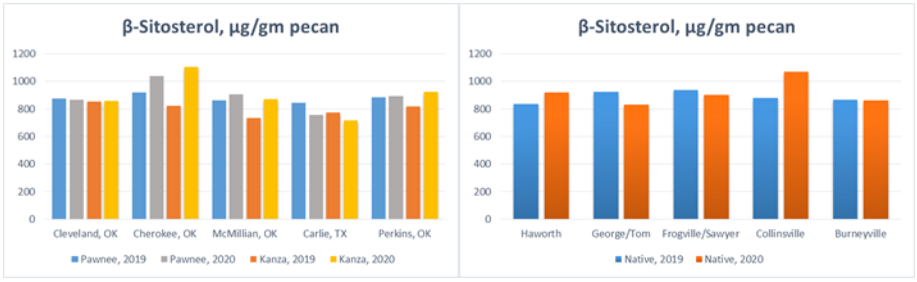


Figure 4: Pecan oil beta-sitosterol concentration (µg/gm pecan) for 'Pawnee', 'Kanza' and native pecan populations at various locations in Oklahoma harvested after the 2019 and 2020 growing seasons.

We are unsure whether the differences we see for the 2020 production season for both 'Pawnee' and 'Kanza' during the severe "off" production cycle at Cherokee was due to metabolic changes triggered during tree shifts into a non-production cycle or the northern location of the trees (Cherokee was the farthest north location sampled in this study). We do believe relative tree productivity ("on" or "off" production cycle) should be accounted for and comparison years should be based on similar production cycles.

Native populations were poorer sources of squalene than the improved varieties we tested (Figure 3). This indicates that squalene nutritional potency should be higher in oils from 'Pawnee' or 'Kanza' versus oils obtained from native pecans.

A notable spike in beta-sitosterol oil concentration was identified in 2020 for 'Pawnee' and 'Kanza' at Cherokee and for native populations near Collinsville. We have already pointed out that 2020 was a severe "off" production cycle at Cherokee, and while we do not have production cycle individual tree information for the native population near Collinsville, we know 2020 native pecan utilized production in Oklahoma was down 3 fold in 2020 (5,070,000 pounds) compared to 2019 (16,960,000 pounds). Without tree-specific production cycle information we are unable to assign "off" production cycle as an indicator of higher beta-sitosterol concentration in the oil.

Timing of pecan harvest may influence final pecan nut weight and phytochemical oil content but not shell-out percent or final nutmeat oil content: At the Perkins location we harvested nuts from 'Pawnee' and 'Kanza' at shuck split (80% nuts on trees were at shuck split) and once again approximately two weeks after shuck split. The nuts harvested two weeks later gained some weight in terms of whole nut and nut meat weight, but shell-out percent and oil content were unchanged (Figure 5). Beta-stigmasterol was relatively unchanged by the harvest delay (Table 1), as was squalene (Table 2) but gamma-tocopherol was increased in the later-harvested nuts (Table 2). This data indicates that pecan weight and certain oil phytochemicals may be increased after shuck split, indicating that a delay in harvest after shuck split may result in higher nut production and result in oils higher in selected phytochemical potency (particularly gamma-tocopherol).

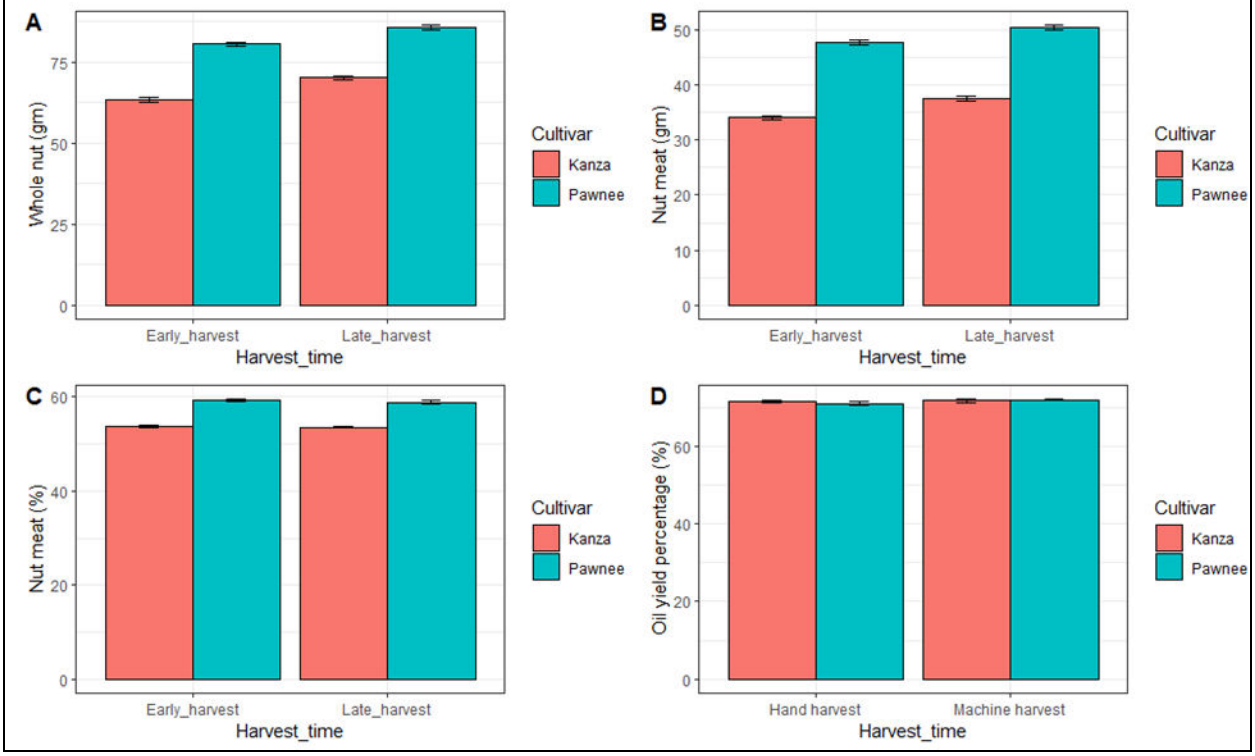


Figure 5. Whole nut weight, nut meat weight, nut meat percentage and oil yield percentage of Kanza and Pawnee cultivars harvested at different times: early harvest when 80% of nuts reached shuck split; late harvest at 2 weeks post 80% of nuts reached shuck split.

Table 1. Phytosterol contents of Kanza and Pawnee cultivars harvested at different times: early harvest when 80% of nuts reached shuck split; late harvest at 2 weeks post 80% of nuts reached shuck split. Unit: microgram per gram (µg /g)

Cultivar	Timing of harvest	Campesterol (µg/gm)	Stigmasterol (µg/gm)	β-sitosterol (µg/gm)
Kanza	Early	31.7±1.6	26.9±2.9	765.1±19.1
	Late	31.4±0.8	22.5±0.5	816.6±26.4
Pawnee	Early	41.9±5	26.4±2.9	912.9±17.3
	Late	36.3±1.1	19.9±0.5	884.1±37.7

Table 2. Squalene and tocopherol contents of Kanza and Pawnee cultivars harvested at different times: early harvest when 80% of nuts reached shuck split; late harvest at 2 weeks post 80% of nuts reached shuck split. Unit: microgram per gram (µg /g)

Cultivar	Timing of harvest	Squalene (µg/gm)	δ-tocopherol (µg/gm)	γ-tocopherol (µg/gm)	α-tocopherol (µg/gm)
Kanza	Early	220.3±1.9	5.1±0.5	121.1±0.6	4.4±0.9
	Late	207.7±8.3	6.4±0.8	164.6±3.1	5±0.9
Pawnee	Early	168.9±9.4	9.5±0.7	132.2±1.6	3.4±0.3
	Late	178.6±5.5	9.8±2.2	144.2±1.8	6.7±1.1

In order to evaluate ways to maintain high phytochemical content in stored pecan oils we initiated a trial early in 2020 to test three temperatures of storage [room temperature (70-75 F), refrigerated (40 F) and frozen (0 F)] over durations of 6 or 13 months and assess concentrations of gamma-tocopherol and squalene during the storage period. We tested two oils obtained from our cooperator in Coleman, OK; a freshly-pressed oil (pressed the day before storage was initiated; initial concentrations of gamma-tocopherol and squalene were 240 µg/gm oil and 220 µg/gm oil, respectively, Figure 6) and a degraded oil (pressed 7 years prior to placement into storage, and previously stored at room temperature; initial concentrations of gamma-tocopherol and squalene were 135 µg/gm and 95 µg/gm respectively, Figure 7).

There was an advantage of storing oils at refrigerated or frozen temperatures, especially over long durations. After 190 days of storage (approximately 6 months), gamma-tocopherol was reduced by 34 µg/gm oil in the room temperature treatment, versus only by 16 and 11 µg/ oil in the refrigerated and frozen storage treatments, respectively, for the freshly pressed oil (Figure 6). The same general trend was true for storage of squalene. After 409 days of storage (approximately 13 months) we noted a general decline in gamma-tocopherol for the freshly pressed oil – while it still appeared advantageous to store this oil cold, the general decline indicates that oils utilized for their gamma-tocopherol content should not be stored for up to one year – while our data does not delineate the longest possible storage duration, it does

indicate gamma-tocopherol in oils are stable to storage for up to 6 months (preferably under refrigerated or frozen conditions). Squalene in freshly-pressed oils appeared to be somewhat more stable to storage – the same general trend of refrigeration (or freezing) required to maintain high levels was apparent but losses during the prolonged 13 month storage period were not nearly as pronounced.

We included a storage evaluation of a degraded pecan oil obtained from the same supplier to evaluate whether storage temperature could delay further degradation in an already degraded pecan oil. While the oil included was severely degraded (phytochemical levels started at about half the concentration present in the freshly pressed oil) we did note less loss in samples stored refrigerated or frozen (Figure 7). We would not recommend use of the degraded oil for nutritional markets but our data does indicate that proper storage (refrigerated or frozen storage) can maintain higher levels of gamma-tocopherol and squalene, even after degradation.

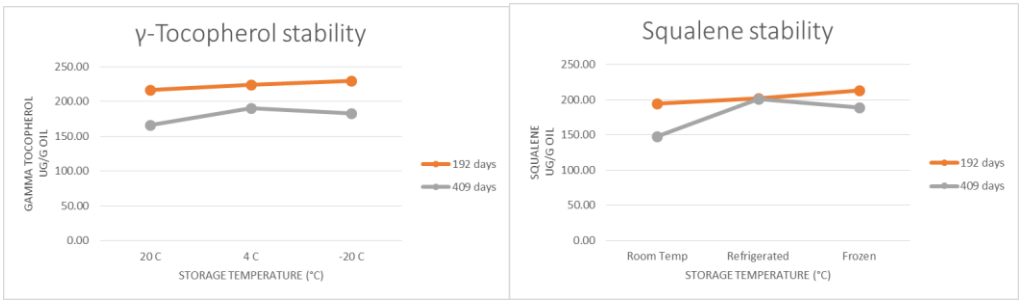


Figure 6. Gamma-tocopherol and squalene stability to storage for freshly cold pressed pecan oil stored at room temperature (70-75 F), refrigerated (40 F) and frozen (0 F) conditions for 6 or 13 months.

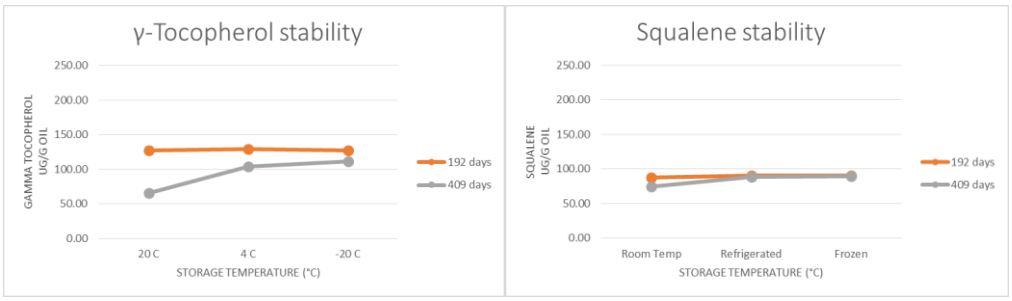


Figure 7. Gamma-tocopherol and squalene stability to storage for seven year old (degraded) cold pressed pecan oil stored at room temperature (70-75 F), refrigerated (40 F) and frozen (0 F) conditions for 6 or 13 months.

Our storage data could not discern a clear advantage of freezing over refrigeration to maintain pecan oil phytochemical content, but there was a clear advantage of the two cold storage conditions over room temperature storage. Within the limits of our data we can recommend storage of freshly cold pressed pecan oil at or below 40 F for periods not to exceed 6 months to maintain pecan oil nutritional potency.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Some of the results were disseminated to pecan growers nationally through a paper in Pecan South (How Harvest Timing Affects Nut Quality: A Study of Fatty Acids, Tocopherols,

Phytosterols, and Squalene. Vol. 54(9), Nov. 2021) and the data will be published in refereed publications in 2022. Results will also be presented at the yearly OPGA meeting in 2022.

BENEFICIARIES

Number of project beneficiaries:.....>50 pecan growers in Oklahoma

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☑ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☑ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 2, indicator 4: The number of new specialty crop products was 2 [nutrient dense pecans (1) and pecan oil (2)]. These products are considered "new" because of their targeted use for diabetic nutrition and skin UV care, both markets of which pecans are not currently promoted for.	We assessed pecan nutritional density for two varieties ('Pawnee' and 'Kanza') grown at 5 locations within or just outside of Oklahoma (McMillian, south eastern OK; Charlie, TX, 20 miles south of south-central OK; Perkins, north-central OK; Cleveland, north-eastern OK; Cherokee, north-western OK). We also sampled from 5 native pecan populations (Haworth, far south-eastern OK; Sawyer, south eastern OK; Tom, south-eastern OK; Burneyville, south-central OK; Collinsville, north-eastern OK). Results indicated no obvious phytochemical differences between locations. As a group, native pecans

		contained about the same amount of oil as improved varieties, produced smaller nuts with lower shellout percent than improved varieties and their oil contained similar phytochemical profiles to improved varieties with the exception that squalene was present at lower concentrations in native pecan oils compared to improved varieties. This implied that the two improved varieties may have been better for UV protection than the native pecans. There was substantial variation in all phytochemical oil contents between years and within variety/native population but on average pecans were 68 to 72% oil and oils contained 750-900 µg/gm beta-sitosterol, 100-160 µg/gm gamma-tocopherol and 140-230 µg/gm squalene (improved varieties; native pecan oils contained 70-150 µg/gm squalene). We assessed nutrient density in cold pressed pecan oil prior to and after 13 months of storage. Three storage conditions [room temperature (70-75 F), refrigerated (40 F) and frozen (0 F)] were tested for durations of 6 or 13 months, using freshly-pressed and previously stored pecan oils obtained from a processor in Coleman, OK. Although some benefit was evident for frozen versus refrigerated storage in that more (but not significantly more) phytochemicals were maintained in oils, by far the largest benefit was obtained by reducing storage temperature to at least refrigerated storage conditions (40 F). There was some difference in lability to storage at each temperature between the phytochemicals tested: Gamma-tocopherol content degraded universally at all storage conditions between 6 and 13 months of storage. Because of this, storage durations longer than 6 months, even in frozen storage, are not recommended to maintain high levels of gamma-tocopherol for diabetic skin care.

		Squalene was not as sensitive to degradation and older (1 year old) oils, properly stored at cold or freezing temperatures, should still be good sources of squalene for skin UV protection.
2	Outcome 5, indicator 7: Two viable technologies/processes were developed or modified to increase specialty crop distribution and/or production [pecan varieties/native pecan populations with high and stable nutritional components for diabetes and skin UV care (1) and modification of pecan oil extraction technologies to maintain high nutritional potency for diabetic and skin UV care (2)].	Within the varieties and native populations we sampled it appeared that year and location may impact oil nutritional potency but varieties or native pecans were equally good sources of all phytochemicals sampled except squalene – varieties appeared to be a better source of squalene. The cold press oil extraction technology produced oils with no detectable degradation and with similar phytochemical potency to oils produced under controlled laboratory conditions. We accepted this technology for oil production suited for a nutritional market. We instead assessed oil storage temperature as a means to maintain high nutritional density. As noted in outcome 2, indicator 4 we found that freshly pressed oil nutrient density could be maintained for at least 6 months at storage temperatures of 40 F or below – exceeding 6 months of storage at cold temperatures was particularly deleterious for gamma-tocopherol content (diabetes skin care) but less so for squalene (skin UV care). Oils in which phytochemicals had already degraded did positively respond to storage at refrigerated or frozen conditions, but the storage cost may not be justified compared to more phytochemically potent freshly pressed oils.
3	Outcome 8, indicator 4: One new small business activity can result from our grant results – although no modification in cold press extraction parameters is necessary to produce nutritionally potent pecan oil for diabetic and skin UV care, cold storage is necessary to retain compounds, especially gamma tocopherol for diabetic care.	We evaluated phytochemical yield of oils obtained under controlled laboratory conditions to oils obtained using the cold press technology utilized by our cooperator in Coleman, OK and found essentially no difference in phytochemical potency. Our assumption was incorrect in that the same facility used to produce general-use pecan oil should also produce phytochemically-rich pecan oils. We did assign a shelf life for gamma tocopherol of approximately 6 months in refrigerated storage to maintain potency for oils utilized for diabetic care.

DATA COLLECTION

See the “Lessons Learned” section.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$53,640.00	$37,585.75
Fringe Benefits	$14,174.00	$11,751.29
Travel	$3,460.00	$754.94
Equipment	$19,081.00	$16,430.00
Supplies	$12,403.00	$15,197.02
Contractual	$1,200.00	$1,380.00
Other	$0.00	$0.00
Direct Costs Sub-Total	$83,099.00	$83,099.00
Indirect Costs	$0.00	$0.00
Total Federal Costs	$83,099.00	$83,099.00

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Developing Traffic Tolerant Turf Bermudagrass For Sports Fields In Oklahoma			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient’s Project Contact				

Name:	Yanqi Wu
Phone:	405-744-9627
Email:	Yanqi.wu@okstate.edu

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Bermudagrass (*Cynodon dactylon* x *C. transvaalensis* and *C. dactylon*) is the most extensively used turfgrass in sports fields in Oklahoma and other southern states due to its traffic tolerance and exceptional recuperative potential relative to other turfgrasses. The turf bermudagrass development program at Oklahoma State University bred and selected 350 advanced genotypes for turf quality and adaptation from more than 50,000 plants in numerous field trials. However, traffic tolerance of the advanced selections has not been evaluated yet. In this proposed project, we evaluated traffic tolerance and related turf performance parameters in a replicated field trial under simulated traffic stress in response to stakeholders' requests. Our major goal was to select one or a few genotypes that have traffic tolerance superior to commercial standard cultivars. The results of this project have been disseminated through turf field days, turf conferences and social media to sod producers, sports field managers, and industry professionals in OK and beyond. We collected data that enabled us to release one bermudagrass selection improved in traffic tolerance to the turf industry. Ultimately, a superior traffic tolerant bermudagrass developed in the project will produce a higher quality and safer turf surface for sports fields used by students in schools and other athletes in professional organizations while reducing maintenance costs and increasing sustainability of athletic fields.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Evaluate traffic tolerance in advanced turf bermudagrass selections for use in sports fields	X	
2	Disseminate research findings through a peer-reviewed journal, Oklahoma Turf Research Foundation Annual Conference, turf field days and social media	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Experimental bermudagrass plants (350 genotypes) were grown in pots and selected for good roots, turfgrass morphological traits, resulting in 87 best selections. Each of the best selections and nine standards were grown in 96 conetainers and a total of	Objective 1: Evaluate traffic tolerance in advanced turf bermudagrass selections for use in sports fields

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	9,408 plants were prepared in a greenhouse in the winter between 2018 and 2019. The prepared plants were transplanted into a field nursery in a randomized complete block design with three replicates. Each plot measures 4' wide by 8' long in early summer, 2019. A traffic simulator was made and employed to apply traffic pressure in September to November of 2019 and September to October of 2020.	
2	Shear strength and surface hardness, normalized difference vegetation index [NDVI], digital images, and visual quality ratings, fall color retention and spring greenup were collected. The data collected in the two years were completely analyzed. The results indicated that six week traffic resulted in significant shear strength reduction and increase in surface hardness. Bimini, 18-7-3, U3, OSU1217 and TifTuf showed higher tolerance to simulated cleat traffic. U3, 17-5200-31x13, and OSU1629 had good green color retention in fall. Tahoma31, OSU1609, Latitude36 and NorthBridge were in top statistical group for spring green-up among other bermudagrass entries.	Objective 1: Evaluate traffic tolerance in advanced turf bermudagrass selections for use in sports fields
3	The traffic experiment was demonstrated in the 2019 Oklahoma Turfgrass Field Day on September 25. The traffic experiment was included in an oral presentation 'Oklahoma State University turfgrass breeding program and cultivars update' in the 74th Oklahoma Turfgrass Conference, November 20, 2019. The traffic experiment was demonstrated for Mr. Jonathan Brown of Bethel Turf Farms in Arcadia, Florida and to the 2020 class (13 students) of Plant Breeding Methods in the fall of 2020. The traffic experiment was reported in a poster presentation 'Evaluation of traffic tolerance among commercial and experimental bermudagrasses' in the Agronomy Society of America-Crop Science Society of	Objective 2: Disseminate research findings through a peer-reviewed journal, Oklahoma Turf Research Foundation Annual Conference, turf field days and social media

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	America-Soil Science Society of American annual meetings in November, 2020. The experiment was also shown in Oklahoma Gardening television episode on sports field safety "Research for beautiful, resilient, and safer athletic fields" Nov 12, 2020.	
4	Mr. Shehbaz Singh as a graduate student implemented the field investigation, wrote a thesis entitled 'Evaluation of fall traffic tolerance and surface playability of selected bermudagrasses', and earned an M.S. degree in May, 2021. A factsheet entitled 'Comparison of bermudagrass cultivars for athletic field use in Oklahoma' was written and is to be published. A manuscript entitled 'Evaluation of fall traffic tolerance among commercial and experimental bermudagrasses' was submitted to *Agronomy Journal* for consideration as a potential research publication. Research results were presented entitled "Updates on warm-season turfgrass cultivar development" at the 75th OK Turf Conference, Nov 16, 2021. Multiple tweets about the project were sent out to turfgrass professionals (now >1,700 followers) on Twitter over the project period.	Objective 2: Disseminate research findings through a peer-reviewed journal, Oklahoma Turf Research Foundation Annual Conference, turf field days and social media

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	N/A	

LESSONS LEARNED

We felt that around 50 entries would be a preferred number for this kind of field-based investigation, rather than 96 entries in this study.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

We selected OKC1876 for intellectual property disclosure at Oklahoma State University in September, 2021. This investigation provided data for traffic tolerance and sod tensile strength on the disclosure.

BENEFICIARIES

Number of project beneficiaries: 5

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☑ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 4, Indicator 1	This study indicated more than 10 OSU turf bermudagrass experimental cultivars that were developed to have improved traffic tolerance for athletic field use. Of the elite group, OKC1876 have been disclosed as a new intellectual property.
2	Outcome 4, Indicator 2c	OKC1876 has been sent to test on sod farms towards commercialization in OK, VA, FL, TX, CA, and AZ. Its profitability will be known once the grass is in commercial production.
3	Outcome 5, Indicator 1	OKC1876 has been developed for sod producers in Oklahoma and the region with similar climate.
4	Outcome 5, Indicator 3	OKC1876 is proposed to release for commercial production in spring 2022. It is expected to produce the grass on 20-30 sod farms in OK and other states.
5	Outcome 5, Indicator 8	We reached more than 1500 turf professionals including sod producers,

		athletic field managers, public ground managers in OK and other states through our outreach activities in turf conferences, turf field days, and social media (i.e., Twitter, Facebook, and Instagram)

DATA COLLECTION

A 2-year field study was conducted in Stillwater, Oklahoma, to evaluate 9 commercially available and 87 experimental bermudagrasses for fall traffic tolerance, fall color retention, and spring green-up. The experiment was arranged as a split-block design with three replications, and plots were subjected to either non-trafficked conditions or simulated cleat traffic for 6 weeks in the fall of 2019 and 2020 using a Baldree Traffic Simulator. Bermudagrasses were evaluated for percent green cover by digital image analysis. Six experimental entries 17-5200-4x11, 17-4200-19x9, 18-7-2, OSU1664, OSU1217, and 17-4200-36x19 were deemed as having excellent turf traits and traffic tolerance due to fewer consistent traffic effects on percent green cover in fall. Entries 18-8-3, 17-4200-36x19, 18-9-9, TifTuf, Tifway, OSU1638, OSU1611, 18-8-7, 17-5200-4x11, and 15-4x15 demonstrated excellent fall color across both traffic treatments. There was a large group of entries that had early spring green-up across both traffic treatments including OSU1609, OSU1661, OSU1217, Tahoma 31, NorthBridge, Latitude 36, OSUBF#5, and OSU1117. Findings illustrate the potential for new bermudagrasses to enhance the sustainability of highly trafficked turf surfaces in the transition zone climate

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$55,281.92	$67,078.21
Fringe Benefits	$12,800.00	$8,383.83
Travel	$3,500.00	$2,399.72
Equipment	$0.00	$0.00
Supplies	$19,500.00	$12,944.77
Contractual	$518.08	$200.00
Other	$0.00	$0.00
Direct Costs Sub-Total	$91,600.00	$91,006.53
Indirect Costs	$0.00	$0.00
Total Federal Costs	$91,600.00	$91,006.53

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A.

Project Title	Tomato Production In Greenhouse, High Tunnel And Field Along With Quality Analysis For Local Fresh Market Production			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Dr. Bruce Dunn			
Phone:	405-744-6462			
Email:	bruce.dunn@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

The human population is expected to reach 8.9 billion people by 2050 (USAID, 2004), and the main challenge will be to supply fresh produce that is needed for a quality of life while maintaining a healthy planet. Many people have begun to source local foods and markets. Local food increased to $11.7 billion in 2014 from about $5 billion in 2008, according to the USDA. Although the local food movement is still small in comparison to conventional food consumption methods, it is experiencing an exponential increase each year. In 2009, the Food Marketing Institute conducted a national study asking Americans why they buy local. The top three reasons listed were freshness (82%), supporting the local economy (75%), and knowing where the product came from (58%). In 2003, the Food Processing Center found that specific reasons Americans purchased locally grown food included higher or better quality, fresher products, positive relations with growers, and opportunity to purchase unique products.

As a result, there has been in increase in the number of small-scale vegetable farms producing for the local market and tomatoes have been a staple crop for these farms. In 2015, approximately 94,300 acres with a total value of $1.22 billion worth of fresh market tomatoes were harvested. Over the past few decades, per capita use of tomatoes has been on the rise as a result of enduring popularity of salads and submarine sandwiches. Tomatoes are warm season crops and are sensitive to frost at any growth stage, so field planting occurs after the first frost. Tomatoes can also be grown in greenhouses and under plastic covered high tunnels

to extend the production season. The emergence of greenhouse tomato production allows producers to grow fresh tomatoes year-round but is still an emerging market that is dominated by field grown tomatoes.

The challenge is to match the rapidly changing demand for local food and to do it such a way that is environmentally and socially sustainable. Thus, in the last 10 years, there has been increasing interest in hydroponic or soilless techniques for producing greenhouse horticultural crops. Hydroponics is a technique of growing plants without soil using water, soilless substrates, and nutrient solutions (Arancon et al., 2015). Crops grown using soilless methods include vegetables, herbs, fruit, and ornamentals, and is the fastest growing area of specialty crops. The US hydroponic industry has grown at an annual rate of 3.6% in the last five years and a value of $607 million. The conversion from traditional water wasting methods to more environmentally friendly recirculating systems is likely to become more common in the greenhouse industry (David et al., 2005). Hydroponic production recirculates the nutrient solution and water providing an environmentally friendly production practice (Jung et al., 2004). Rouphael et al. (2004) reported that plants grown in a hydroponic system had increased growth, yield, and quality compared to plants grown in soil. Although pretty much every greenhouse vegetable operation has lettuce and basil, most growers are looking to diversify with other high value crops that are hard to find fresh, local year-round tomatoes. Greenhouse grown tomatoes now account for 37% of the quantity of fresh tomatoes sold. County extension agents and investigators in this grant get several calls a month looking for information, access to see production systems, and information on what to grow and how to grow produce for local markets.

Information on crop cycles, potential yields, and quality is needed to expand local greenhouse produce production in Oklahoma. Research at Oklahoma State University and Langston University evaluated tomato production in three different growing systems (greenhouse, field, and high tunnel) to compare yield and quality to support local market production. This research evaluated three cultivars of two different types of tomato (slicing and cherry) using similar cultivars adapted to each system.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Evaluate a high value alternative specialty crop (tomato) in three different production systems (greenhouse, field, and high tunnel) to support and expand local fresh markets.	X	
2	Develop objective tests of quality for tomato to compare production systems and to establish standards, so growers can fine tune improvements in production and postharvest handling.	X	
3	Disseminate research findings and learn from other growers or researchers to help solve common problems to advance the industry.	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	BHN268 had some of the highest yields in the field but lowest yields in the greenhouse. Sakura produced greater fruit size than the other two cherry tomato cultivars in both the field and greenhouse.	This supports objective 1 in that growers should select cultivar based on there production system in that not all cultivar do well in a particular system.
2	Lycopene content in both slicer and cherry tomato cultivars was influenced by the interaction of production type, cultivar, and harvest time with BH964 and Geronimo having the greatest lycopene content. For cherry tomatoes, BHN268 was greatest for field production while Sakura was greatest for greenhouse production.	This supports objective 2 in that growers interested in quality should consider those cultivars for higher lycopene content.
3	Results were published in HortScience and trial reports.	This supports objective 3 in that knowledge was shared to growers.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Langston had delays on getting their high tunnels built and expenses processed through their financial system for the subaward.	We partnered with a grower who had high tunnels and took back the subward to handle the financial transactions.

LESSONS LEARNED

Each production system had different number of plants and replications, which made it hard to compare yield among systems. If someone was to do a similar project, we would recommend setting up a similar experimental design for yields could be compared among systems.

Tomato roots grew through the Dutch buckets halfway through production and would clog the drain causing water to over fill the buckets. Some form of mesh or root pruning chemical (copper) should be considered.

A combination of ½ g per gallon Decathalon and 2 oz per gallon on Azaguard burned the tomato leaves. A combination of Enstar and neem oil should be used instead.

Raised beds allowed for a longer production season as plants could be planted in the spring despite constant rains. A stress, in the form of water stress, was imposed on plants as well as placing transplants outside of the greenhouse 4 weeks before field planting.

Lycopene content varied among age of fruit and time of year, so to better quantify content it is best to analyze among those groups and not just fully ripe fruit at one time in the production season.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

There are no current plans to continue this project. Knowledge gained will continue to be shared with growers interested in greenhouse, high tunnel, or field production of tomatoes. Results are available through the trial reports and publication.

BENEFICIARIES

Number of project beneficiaries: 200

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☑ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 2, Indicator 3	Lycopene analysis was developed and utilized in the lab on tomatoes grown in the field, high tunnel, and greenhouse over both seasons.
4	Outcome 5, Indicator 7	Yearly field tomato data was shared in the yearly vegetable trial reports. This report is viewed by ~300 growers each year either online, field days, or through grower site visits. Results of this study was also published in a journal. Singh, H., B. Dunn, L. Brandenberger, N. Maness, L. Carrier, and B. Hu. 2021. Greenhouse and open field production of cherry and slicer

		tomatoes: yield and fruit quality. HortScience 56:946-953

DATA COLLECTION

Greenhouse: Experiment was conducted at the Research Greenhouses located in Stillwater, OK. under a 40% shade cloth and temperatures set at 75/65°F day and night, respectively. There were three cultivars each of slicing and cherry tomatoes put into Dutch buckets (See table 1 below). Plants were grown from seed on 19 January 2019 and 7 Feb. 2020 into oasis cubes and transplanted into the hydroponic systems on 18 March 2019 and 25 March 2020, respectively. There was one plant per bucket and plants were trellised and pruned to a single stem. Peter's 5-11-26 (J.R. Peters, Allentown, Pennsylvania) will be used for nutrition and maintained at pH of 5.5-6.5 and EC of 1.5-2.5. Each cultivar had 10 single plant replicates and were replicated in a second greenhouse. Data collected included days to first harvest, number of fruits, fruit weight, plant nutrient analysis, water nutrient analysis, and notes on any plant growth abnormalities.

Table 1.

Variety	Source	Type
BHN 268	Rupp	determinate cherry
BHN 964	Rupp	determinate 10 oz fruit
Favorita	Paramount	indeterminate greenhouse Cherry
Geronimo	Johnny's	indeterminate greenhouse lg fruit
Sakura	Johnny's	inteterminate greenhouse lg. cherry
Trust	DeRuiter	indeterminate beefsteak greenhouse

Field: The field experiment took place at the Botanic Gardens in Stillwater, OK. Tomatoes were direct seeded into soilless media (Sungro Professional Growing Mix) in the finish containers (Landmark plastic; 4 x 9 (36 cell) six-packs) on 15 March 2019 and 9 March 2020. Raised beds and drip tape were installed. Tomatoes were transplanted into all plots on 16 May 2019 and 21 April 2020 with in-row spacing at two feet apart with a total of six plants per treatment plot. Tomatoes were supported using the stake and weave method with baling twine and metal pipes. Nutrient needs of the crop according to soil test results were met using blossom booster fertilizer (10N-13.1P-16.6K; J.R. Peters, Inc.) and urea (46N-0P-oK) to provide an equivalent rate of 74N-38.0P-48.1K kg/ha^{-1} in 2019 and 93N-14.9P-18.3K kg/ha^{-1} in 2020. Insect pests included tobacco horn worm and yellow-striped armyworms which were treated with Permethrin one time applied at a rate of 0.10 lbs. ai/acre. The experimental design included a randomized block design with three replications. Treatment plots consisted of free-standing raised soil beds with drip irrigation tape buried in the middle. Harvest started on 12 July 2019 and continued until 4 September 2019 and in the second-year harvest began on 15 June 2020 and continued until 31 Aug. 2020 a total of 13 harvests were recorded. Fruit were determined as marketable or culls, and those in both categories were counted, then weighed for each plot.

High Tunnel: The high tunnel experiment was conducted at the research farm located in Langston, OK. The same three cultivars of slicing and cherry tomatoes were planted in ground beds located within a high tunnel structure or on raised beds for the field

production. Plants were grown from seed in a greenhouse in Stillwater on 15 March 2019 and 9 March 2020 then transplanted 9 May 2019 and 21 April 2020, respectively. Plants were staked, trellised. Plants were watered and fertilized with 20-20-20 peters for 30 minutes daily. Plants were placed 18 inches apart in a row. Rows were 4 feet apart. Side walls of the hoop structure were open all summer and the hoop house ran 10-15 degrees warmers than the outside. Data was collected on fruit weight.

Lab Analysis: Usually one red tomato from the large varieties was selected from for lycopene determination. Depending on size of the cherry tomatoes, 4-7 red tomatoes were selected for processing. Tomatoes were numbered and weighed. Color measurements were made on the selected tomatoes using a Minolta chromameter. Tomatoes were then diced, added to a grinding vessel & mashed prior to grinding with homogenizer for 1-3 minutes on ice. After grinding a 1-1.2 g sample was added to a 120ml brown bottle containing 50 mg BHT. Twenty –five mls of 95% ethanol were then added to the brown bottle. Bottles were kept on ice until 3 cultivars had been ground & samples weighed. Bottles were then transferred to the fume hood; 50 mls hexane & 25 mls acetone were added to each bottle. Samples were ground for 30 seconds with Polytron on ice. Bottles were capped & placed on shaker for 10 min @ 100 rpm @ room temperature. Fifteen mls of deionized water was added to each bottle & shaken vigorously for 1 minute by hand. After 15-20 minutes, samples for reading on the spectrophotometer were taken from the top layer, filtered through Whatman #1 filter paper using a syringe filter & measured on spectrophotomer @ 503 nm.
Lycopene calculation: =((((abs@503nm/0.172)*50)/wt of puree)*0.5369)

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$44,000.00	$55,960.13
Fringe Benefits	$19,026.00	$16,848.86
Travel	$1,200.00	$195.75
Equipment	$0.00	$0
Supplies	$10,998.00	$9,063.29
Contractual	$19,406.00	$7,061.89
Other	$4,500.00	$9,960.00
Direct Costs Sub-Total	$99,130.00	$99,089.92
Indirect Costs	$0.00	$0
Total Federal Costs	$99,130.00	$99,089.92

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Identification Of Factors Affecting Sod Tensile Strength And Wear Tolerance Of Warm-Season Turfgrass			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Charles Fontanier			
Phone:	405-744-6424			
Email:	Charles.fontanier@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

To be a quality bermudagrass, new cultivars must have high sod tensile strength and good sod handling quality. At present sod tensile strength and sod handling quality of a new cultivar is determined from fully established and mature field plots. The method is destructive to the plot, can be difficult to measure consistently, and is time consuming and expensive. However, morphological and physiological characteristics thought to convey increased sod tensile strength and handling quality can be measured relatively quickly and can be evaluated in early stage of establishment even in the greenhouse. Development of new information on morphological and physiological characteristics of existing turfgrass cultivars could be important towards development of a rapid screening technique for selection cultivars showing potential for good wear tolerance, sod tensile strength, and sod handling quality. In the future, application of this research could lead to isolation of responsible genes for wear tolerance and sod tensile strength which would further enhance new cultivar development efficiency. The objective of this project was to identify the morphological and physiological factors that affect sod tensile strength to help in selecting bermudagrasses that have high handling quality and are best adapted to Oklahoma.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	To evaluate the wear tolerance, sod tensile strength, and sod handling quality of selected warm-season turfgrass.	X	
2	Measure the difference in morphological and physiological characteristics among turfgrass cultivars varying in apparent sod tensile strength.	X	
3	Develop an index that relates measured morphological and physiological characteristic to tensile strength and wear tolerance of warm-season turfgrass sod for more efficient screening for these traits.	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Measured sod tensile strength and wear tolerance in the field for 25 bermudagrasses varying in apparent morphology.	Objective 1
2	Determined lignin, cellulose, hemicellulose, starch, sucrose, glucose, and fructose concentrations of selected bermudagrasses.	Objective 2
3	Determined rhizome density, diameter, and tensile strength of selected bermudagrasses.	Objective 2
4	Used laboratory measurements and multiple linear regression to predict sod tensile strength of selected bermudagrasses.	Objective 3

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	N/A	

LESSONS LEARNED

Most of the lessons learned in this project revolve around time management. The procedures for separating rhizomes from roots was labor intensive and future projects should avoid separating roots as they are likely negligible contributors to the final mass. We also required substantial modification to published laboratory procedures to obtain valid results for our bermudagrass rhizomes. Published values for rhizome carbohydrate concentration vary wildly depending on time of sampling and cultivar. Additionally, values are often reported in non-standard ways including fresh weight and dry weight basis, with or without roots, or with incomplete data sets. These are issues that are not uncommon in research but take time to correct.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Results were presented at an OSU undergraduate research poster expo in July 2021. The student will present her findings again at the Southern Region ASHS meetings in February 2022.

BENEFICIARIES

Number of project beneficiaries:52 seed and sod producers in Oklahoma and 40 licensed sod producers across the U.S.

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 5, Indicator 1	We identified cellulose, total nonstructural carbohydrates, and rhizome diameter as critical components of sod tensile strength in bermudagrasses. Improvements in this trait will enhance competitiveness of bermudagrass sod producers and promote more sustainable turfgrass systems in Oklahoma.

DATA COLLECTION

A field study was conducted from 2019-2021. Experimental plots of bermudagrass (*Cynodon* spp.) were established from plugs on June 5, 2019 at the Oklahoma State University Turfgrass Research Center in Stillwater, OK. Twenty-five named cultivars and experimental breeding lines varying in STS were sampled as described below. The nine commercial cultivars used were Astro, Bimini, Celebration, Latitude36, Northbridge, Tahoma31, TifTuf, Tifway, and U3. The sixteen experimental breeding lines used were OSU1117, OSU1337, OSU1402, OSU1406, OSU1628, OSU1666, OSU1670, OSU1682, 17-4200-19X13, 18-7-1, 18-7-3, 18-7-6, 18-8-4, 18-8-6, 18-8-7, and 18-9-2.

On June 9, 2020, one year after planting, a 12×12-in sod pad sample was collected from each of the twenty-five plots using a sodcutter for STS measurement. The sod pad was then clamped to a split platform where one half is mobile and the other half is stationary. A battery operated hydraulic pull was used to separate the halves of the platform and, as the sod pad was ripped in two, a digital force meter (Chatillon Model DFIS, John Chatillon & Sons, Inc., Greensboro, NC) measured the peak tensile strength in kg dm^{-2}. After measurement, the sod pads were placed back in their respective plots and allowed to resume growth.

A separate 12×12-in sod pad sample was collected from each of the twenty-five plots using a sodcutter. Immediately after collection, each sample was separated into rhizomes and stolons, then washed with water using a spray nozzle. Ten representative rhizomes were removed for subsequent testing morphological properties. Remaining samples were then dried in an oven at 80 °C for 48 hours. Once dried, the rhizome samples were processed further to remove soil, roots, and leaves. For each sample, 15 g of rhizomes were weighed and finely ground to pass through a 1 mm screen using a UDY mill.

Carbohydrate extraction was performed using a 0.050 g sample in 2 ml of boiling 95% ethanol three times, and then brought to 10 ml with 95% ethanol. Starch content of the leftover pellet was determined after digestion with α-amylase and amyloglucosidase in 0.1 M sodium acetate (pH 4.5) at room temperature for 2 h followed by 60 °C overnight. Samples were then extracted with 2 ml water three times and brought to 100 ml with water.

Reducing sugars (glucose and fructose) were measured from 2 ml of dried sugar extract, sucrose was converted into reducing sugars with invertase and measured from 0.1 ml of dried sugar extract, and starch was measured from 0.5 ml of starch digestion extract using the Nelson-Somogyi colorimetric procedure at 520 nm (Maness, 2010). All sugars were quantitated as glucose equivalents using a standard curve from 0 to 50 μg ml^{-1}. Sucrose quantity was determined by multiplying glucose equivalents by 0.95, and starch quantity was determined by multiplying glucose equivalents by 0.90 to account for water gained during the respective enzyme hydrolysis steps prior to analysis.

Structural carbohydrates were quantified using sub-samples of the ground rhizomes submitted to the Soil Water and Forage Analytical Laboratory for analysis of acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL). Cellulose was calculated as ADF – ADL; hemicellulose was calculated as NDF – ADF; and lignin was calculated as ADL.

Morphological features of the rhizomes included average length, diameter, fresh weight, dry weight, and tensile strength, which was measured using a Instron device which captured peak force needed to break an individual rhizome.

Data were analyzed using multiple linear regression (SPSS) and a backwards elimination method to identify variables which contributed most to predicting sod tensile strength (field-based measurement). The model suggested total nonstructural carbohydrates (TNC) and cellulose were the only significant morphological drivers of sod tensile strength, while rhizome diameter was the strongest driver in general.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$46,000.00	$45,377.95
Fringe Benefits	$9,466.00	$7,224.57
Travel	$0.00	$0.00
Equipment	$0.00	$0.00
Supplies	$7,500.00	$2,865.25
Contractual	$0.00	$5,460.23
Other	$0.00	$2,038.00
Direct Costs Sub-Total	$62,966.00	$62,966.00
Indirect Costs	$0.00	$0.00
Total Federal Costs	$62,966.00	$62,966.00

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

1. Hobbs, A., N. Maness, and **C. Fontanier**. 2021. Carbohydrate content of rhizomes as potential indicator of sod tensile strength in Cynodon spp. REEU Research Symposium. Aug. 12. (undergraduate student)
2. Hobbs, A., N. Maness, and **C. Fontanier**. 2021. Carbohydrate content of rhizomes as potential indicator of sod tensile strength in Cynodon spp. OSU Summer Undergraduate Research Poster Expo. July 28. (undergraduate student)

Project Title	Increasing Pecan Consumption Through Value-Added Product Development			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Nurhan Turgut Dunford			
Phone:	405-744-7062			
Email:	Nurhan.Dunford@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

In Oklahoma, annual pecan production is over 16 million pounds (10-year average production). Despite the large production, value-added processing of pecans is not well developed in the state. It is imperative that value-added processing of pecans grown and shelled in the state is encouraged and supported by the applied research and development work carried out at the state research institutions in collaboration with the industry and the government agencies.

Currently, pecan nuts are shelled to obtain nut meat (also referred to as pecan halves), which is marketed and consumed as commodity products. Industrial processing of pecan nuts results in a large amount of shells that represents about 40–50% of the nut weight. Nut shells are sold as gardening aid (mulch), which is a relatively low value product. Current nut shelling process produces two streams of byproducts: 1) coarse shell material remaining on ¼ inch screens, and, 2) finer nut fractions falling through the ¼ inch screens during shell and meat separation. From this point on, the stream 2 will be abbreviated as fluffy powder (FP). About 200-300 pounds of FP/day is produced in a typical shelling facility operating in Oklahoma. The shell resellers do not care for this product and this stream is basically ends up in waste.

Previous studies had shown that pecan shells are rich in phenolic compounds. Higher levels of phenols and tannins were found in the shells than in the edible part (pecan meat or halves). Phenolic compounds have nutritional and medicinal value owing to their potent antioxidant properties.

The scientific literature lacks research data on biological activity of pecan shell extracts obtained from nuts grown and processed in Oklahoma. It is well established by plant scientists that cultivar and growth location can potentially have a significant effect on the level of phenolics and composition of other compounds in plants. Hence, it is imperative that potential value-added processing options for Oklahoma grown pecan are explored. Furthermore, there is no study on the chemical composition and value-added processing of industrial byproducts.

Hence, the long term goal of this project is to develop an integrated and sustainable pecan processing system that will produce high-value health beneficial functional foods, cosmetics, and food and industrial ingredients that can be used to improve food safety and quality. To achieve this goal, various extraction processes will be designed and optimized and their efficiency to produce extracts enriched in bioactive compounds from various parts of pecan nuts will be examined. Furthermore, antioxidant capacity of these extracts and their effects on common food pathogens and human cancer cells will be tested. The successful completion of this project will benefit farmers and processors in Oklahoma by enhancing the competitiveness of their specialty crop, pecans, through increased consumer usage by providing natural health beneficial and safe food products.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Examine chemical composition of pecan nut meat and by-products and waste streams generated during processing and shelling at factories operating in Oklahoma.	X	
2	Design and optimize processes that will produce extracts enriched in bioactive compounds.	X	
3	Test the efficacy of these extracts as antioxidants and antimicrobial agents.	X	
4	Investigate the effect of pecan extracts on the viability of human cancer cells.	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Samples from 3 different pecan varieties, Pawnee grown in Sapulpa, OK, Native from Bristow, OK and Stuart from Sand Springs, OK, were collected from our industry collaborator, Valley View Pecan Company, Shawnee, OK. They were sampled and processed separately. There were 6 samples examined in the study, one sample from each byproduct stream/each variety. All the samples were analyzed for their oil, protein and ash contents.	**Objective 1:** Examine chemical composition of pecan nut meat and by-products and waste streams generated during processing and shelling at factories operating in Oklahoma.
2	Samples from the pecan shelling industry byproducts were extracted using 4 different techniques; aqueous ethanol (70% ethanol), pressurized water (4 different temperatures; 80, 100, 125 and 150 ^{o}C), microwave and	**Objective 2:** Design and optimize processes that will produce extracts enriched in bioactive compounds

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	sonication aided extraction. Chemical composition of the extracts were analyzed and variations by variety and extraction methods were evaluated.	
3	Antioxidant capacity of the extracts were evaluated using 3 different tests; 1) 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity, 2) ABTS, 2,2′-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) and 3) FRAP (Ferric Reducing Ability of Plasma). Antimicrobial activity of the crude pecan extracts was tested using the bacterial strains *Escherichia coli* DSM 1116 and *Salmonella* 209 *typhimurim* CCM 5445 and the fungal strains *Penicillium capsulatum* DSM 2210, *Mucor hiemalis* 210 DSM 2656, *Aspergillus clavatus* DSM 816. Similarities and differences in antioxidant and antimicrobial efficacy of the extracts were assessed to determine the potential applications of these extracts in food and non-food formulations and enhance shelf-life and overall quality of the final products.	**Objective 3)** Test the efficacy of these extracts as antioxidants and antimicrobial agents.
4	The cancer cells A549 (human, lung carcinoma), Neuro 2A (Mus musculus, neuroblastoma), Hela 135 (human cervix adenocarcinoma), and VERO (African green monkey kidney) normal cell line 136 were used to investigate effect of pecan shell extracts on cell growth and viability.	**Objective 4)** Investigate the effect of pecan extracts on the viability of human cancer cells.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Finding qualified personnel and keeping the employees on the project were very challenging because of the limited funding and very short project duration (1 year).	An extension to the project completion date was requested and approved by ODAFF.
2	COVID 19 pandemic slowed down the progress on the project because of the restrictions imposed by the CDC and the university.	An extension to the project completion date was requested and approved by ODAFF.

LESSONS LEARNED

Although the original funding request by the PI of this project was for 2 years, ODAFF approved it for one year with reduced funding amount. Obviously, it is very difficult for researchers to turn down any research grant. So, the PI tried to do the best she could with the available funding and timelines. The most important lesson learned from this process is that in general, one year projects which are heavily based on very complex and expensive experimentation are not conducive to attaining long term impact in the field. The PI of the project was very successful and completed all the proposed tasks with the help of her no-cost international collaboration and availability of very small amount of internal support. Unfortunately, in spite of the success of this project, the follow up proposals on the same topic were not funded by ODFAFF, limiting the long term impact of this research. Hence, I learned through this process that, the PI should not have taken on this project for one year with reduced funding.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Unfortunately, I do not have any resources to continue with the project. However, I will continue to work on analyses of the experimental data collected and prepare manuscripts for publication

BENEFICIARIES

Number of project beneficiaries: 600

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☑ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☑ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	**Outcome 2 Indicator 4:** There will be at least one extract with antioxidant and/or cancer cell growth suppression properties that will encourage consumers to purchase functional foods and nutraceuticals formulated with pecan extracts.	Type of byproduct, variety and extraction method had significant effect on the biological activity of pecan shell extracts. The highest antioxidant capacity, over 90% inhibition of 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radicals was obtained with the aqueous ethanol extracts from Pawnee and Native varieties. This result demonstrates that the pecan extracts were able to neutralize over 90% of the DPPH free radicals present in the test solutions and consequently slowing down the oxidation reactions caused by the free radical chain reactions. Antioxidant capacity of the other extracts examined in this study was lower than 90%. Hence, aqueous ethanol extracts from Pawnee and Native varieties have the highest potential to enhance oxidative stability of food and non-food products. In general, cancer cell viability varied with the cell line, extract type, and extract dosage. Only one pecan shell extract from Pawnee byproduct stream FS at high concentrations (12.5 and 25 microgram/mL) resulted in proliferation of A549 cells (human lung carcinoma). All the other extracts resulted in reduced cancer cell viability. The lowest (2.4% at Pawnee shell extract dosage of 50 microgram/mL extract) and the highest (94.8% at Pawnee FS extract dosage of 6.125 microgram/mL dosage) cancer cell viabilities were found for Hela and for Neuro 2A cancer cell lines, respectively. Both Pawnee extracts had minimal adverse effect on the healthy cell line Vero. Hence, these results indicate that Pawnee shell extract has the most promising anticancer activity. However, further research is needed to test these extracts in various product formulations and in animal and clinical studies to determine their commercial viability.

2	**Outcome 6 Indicator 4:** There will be at least one extraction technique that will produce extracts with antimicrobial activity. Antimicrobial extracts can be marketed as processing aid or food ingredients improving pecan consumption and food safety.	Aqueous ethanol pecan shell extracts from Pawnee, Native and Stuart varieties showed some antimicrobial activity against bacteria, *E. coli* DSM 1116, over 5 mg/disk loading. The most effective extract which inactivated/killed 75% of the *E. coli* present in the test solution was obtained from Pawnee variety. None of the water extracts displayed detectable degree of antimicrobial activity. Further research is needed to confirm the results in food formulations.

DATA COLLECTION

We collected analytical data on chemical composition of the pecan shell samples and extracts. Experimental data on antimicrobial and anticancer efficacy and antioxidant capacity of the extracts were also gathered. Standard/official analytical methods were used for all the tests. All analytical tests for sample characterization were carried out at least in duplicate. Data means were compared using the least significance difference (LSD) method. All statistical tests were performed at the p = 0.05 level of significance. Principal component analysis (PCA) and Pearson correlation coefficient calculations were performed using MINITAB 15. Similarities and differences between main groups and observations were presented as score plots. The loading plots was used to explain the relationship between variables in the score plots and cluster observations.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$35,000.00	$39,815.40
Fringe Benefits	$8,166.00	$3,794.55
Travel	$0.00	$0.00
Equipment	$0.00	$0.00
Supplies	$7,500.00	$6,740.53
Contractual	$0.00	$0.00
Other	$0.00	$296.08
Direct Costs Sub-Total	$50,666.00	$50,646.56
Indirect Costs	$0.00	$0.00
Total Federal Costs	$50,666.00	$50,646.56

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

Publication in peer reviewed journal: Sevimli, Canan; Oz, Ahmet; Gezgin, Yuksel; Al Sharqi, Shaymaa; Gumus, Zinar Pinar; Dunford, **Nurhan Turgut**. 2021. Biological Activity of the Extracts from Pecan Shelling Industry Byproducts. Trans ASABE 64(3):869-877.

Project Title	U can U-pick! Resources for producers considering starting a u-pick operation.			
Recipient Organization Name:	Oklahoma Department of Agriculture, Food and Forestry			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Micaela Danker			
Phone:	405-740-0794			
Email:	Micaela.danker@ag.ok.gov			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

The Oklahoma Agritourism program will undertake a project to help specialty crop producers understand the benefits, risks and best practices involved in operating a u-pick farm. This project will create an educational binder for producers that outlines facts about the most popular u-pick crops in Oklahoma in order to aide in researching and setting up their u-pick operation. This project will also enlist successful Oklahoma u-pick producers to participate in educational videos showcasing best practices in use on their farm. These videos will be aggregated and promoted to potential producers on the Oklahoma Agritourism producer website and YouTube channel.

With the demand for fresh, local produce on the rise, the Oklahoma Agritourism program, has dedicated a significant amount of time and funding to educate consumers about the availability of u-pick farms in Oklahoma. Because of the overwhelming popularity of u-pick farms in the state, there is an increased interest from farmers looking to diversify into specialty crops and new farmers considering u-pick as a business option. Agritourism program staff consult on 10-15 potential u-pick farms each year and expect that interest to grow. Completion of this project is needed in order to facilitate this growth and increase production and consumption of specialty crops in Oklahoma.

The Oklahoma Cooperative Extension Service maintains many useful fact sheets that serve as resources for growers of specialty crops. However, correlating information on operating a u-pick farm with these specialty crops does not exist. Setting up the business with customer experience in mind is vital to the success of the operation and therefore the competition of the specialty crop. Subjects such as optimal width and substance between rows, harvesting from trellis or shrub, take-home containers, selling by weight or volume, ease of access, open hours, parking, etc., have become the most frequently asked questions to Agritourism advisors with only verbal answers based on experience available.

By using successful existing producers as a baseline, in addition to resources available through the North American Farmer's Direct Marketing Association and other partner institutions, the program will be able to give potential u-pick farm operators the facts needed to make business, planting and infrastructure decisions for their farm. The project will also allow farmers to keep all research about their potential operation in one place with the "U Can U-pick" information binder while giving them insight to peer farmers with the integrated YouTube channel.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Educate producers about best practices on u-pick farms.	X	
2	Educate producers about risks and liability on farms.	X	
3	Help producers provide an enjoyable on-farm experience for consumers of specialty crops.	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	18 producer educational videos linked onto the Oklahoma Agritourism website	Objective 1, 2, 3 Each video highlighted a u-pick farm in Oklahoma. Each video included interviews and b-roll footage about best practices, risks and liability, and how to create enjoyable consumer experiences.
2	30-page educational binder was created and printed	Objective 1, 2, 3 50 educational binders were created to have as a resource to pass out to potential u-pick producers. The binder contained information and fact sheets about best practices for the most common specialty crops grown at Oklahoma agritourism venues as well as agritourism risks and

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
		liability and ways to create enjoyable consumer experiences.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	One challenge we faced was issues with linking the educational videos to the Oklahoma Agritourism website. The Oklahoma Agritourism program recently switched marketing agencies and with that switch we had issues with login information to make changes to our website.	This challenge pushed back our project deadline further than we planned for. We were hoping to release our educational videos to the public in the spring of 2021, but we weren't able to until fall of 2021.
2	State agency imposed travel restrictions in place due to COVID 19	We have had difficulties getting out and surveying our producers at this point and do not have any results for how many producers have adopted recommended practices
3	We budgeted $9,675 for contractual and spent $20,000.	For the contractual budget line, we had originally planned on hiring two separate individuals, a freelance web designer and freelance graphic artist to integrate our videos on our website and to layout and create the educational binder. We could not find freelancers for either position and decided to go with Oklahoma Agritourism's existing marketing agency to fulfill both jobs. We were able to supplement funds from the personnel budget to assist with the higher rates and higher-quality products from the marketing agency.

LESSONS LEARNED

N/A

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

The results of number of beneficiaries are truly only in its infancy. We have only passed out 3 of the 50 binders so far and our videos are just now picking up traction. These resources will be great to have as we move forward in specialty crop consultations, coordinate state conferences and make connections with potential u-pick producers in the future. We hope to create postcards/fliers with a QR code that links to the videos and digital version of the binder that we can pass out and share with all Oklahoma producers we come in contact with.

BENEFICIARIES

Number of project beneficiaries: 50

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☑ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☑ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 3, Indicator 4.i	Four (4) new u-pick venues have started since the start of this grant.
2	Outcome 4, Indicator 2.a	With State agency imposed travel restrictions in place due to COVID 19 we have had difficulties getting out and surveying our producers at this point and do not have any results for this Outcome yet

DATA COLLECTION

3 of 50 educational binders have been passed out to potential producers. All 3 binders were passed on to producers growing specialty crops but not official members of the Oklahoma Agritourism program yet. Two of the three producers have had site visits by the agritourism coordinators and will be approved for official u-pick farms to open in the spring of 2022. The educational videos were uploaded to Youtube and linked to our website. The 18 videos have 3-42 views each. These numbers will only continue to grow as we are able to connect with more producers and share these resources.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$8,400.00	$2,157.78
Fringe Benefits	$0.00	$0.00
Travel	$0.00	$0.00
Equipment	$0.00	$0.00
Supplies	$1,925.00	$0.00
Contractual	$9,675.00	$20,000.00
Other	$2,400.00	$6,24.76
Direct Costs Sub-Total	$22,400.00	$22,782.54
Indirect Costs	$0.00	$0.00
Total Federal Costs	$22,400.00	$22,782.54

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

Here is the link to view the educational videos and the digital version of the informational binder: http://oklahomaagritourism.com/producers/additional-resources/u-can-u-pick

Project Title	Farm to School "Back at the Table" Conference and Tour			
Recipient Organization Name:	Oklahoma Department of Agriculture, Food and Forestry			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Cheri Long			
Phone:	405-249-9234			
Email:	cheri.long@ag.ok.gov			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Due to Covid-19 restrictions, the Farm to School "Back at the Table" Conference became a combined effort of Farm to School and Cooking For Kids at Oklahoma State University. The in person conference was planned but due to the covid restrictions it was evident that in person was not going to happen. The conference then became an online, virtual event. The content of the conference changed a little bit because of intended participants not being available. So we went with a school garden focus. Still focusing on specialty crops but in the school garden setting. This event was offered in April 2021 and took place on three Thursdays for one hour each session. The first session we offered these topics: Global Gardens Virtual Tour and Q&A, Procurement as it pertains to using school garden produce in cafeterias, Funding & Resource Opportunities. The second session topics were: School Garden Champion Interview (Oktaha & Maple School) discussing how they started the gardens and how they use them now. We also included a Food Demo with Chef Bill Harris with Cooking for Kids. He demonstrated how to use specialty crops in recipes for the school cafeterias. The third session topic was: Garden Skills in the Greenhouse Learning Center. This was a joint effort of OSU extension and Farm to School. Josh Campbell, OSU Extension shared on how to build school garden beds and Shelley Mitchell, Associate Extension Specialist, OSU Extension demonstrated hands-on experience on teaching in the school garden along with how to plant specific things in the school garden using raised beds, buckets, and other containers. Great alternative to what was originally proposed.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Objective 1 - Educate and train school food service personnel about procurement procedures for Farm to School	X	
2	Objective 2 - Educate and train school food service personnel about the Department of Defense "Fresh" program, as well as, how to use procurement dollars to purchase specialty crops through this program.	X	
3	Objective 3 - Educate and train school food service personnel about "Fresh, Fruits and Vegetable" program through the Department of Health and how to use procurement dollars to purchase specialty crops through this program.	X	
4	Objective 4 - Provide resources to use in the cafeteria to promote eating healthy.	X	
5	Objective 5 - Take the conference participants on a one day traveling workshop to tour specialty crop producers in Oklahoma in order for them to connect with growers.		X

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	The Back at the Table Conference was held virtually for the second scheduled conference. We had to modify content a little because we partnered with OSU and their conference content was school gardens. We chose to partner with OSU because of COVID and there were no available venues due to COVID.	Objectives 1-3
2	The speakers/presenters were local including Farm to School, Oklahoma Dept. of Education Child Nutrition and Junior Master Gardeners with OSU Extension and our Local Chef Bill Harris.	Objectives 1-3
3	The conference was held as a webinar over 3 weeks time. This included the tours. They were virtual as well. The tours included a Global Garden in Tulsa and 2 school gardens, one in the Maple Public School System and Oktaha Public School System.	Objective 5
4	Each participant received the Tasteful Harvest Poster set and a Cookbook.	Objective 4

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	The original plan was to have the conference in September but, COVID had all venues shut down and inaccessible. Farm to School partnered with Oklahoma State University and was set and ready then COVID numbers increased so we had to come up with another plan.	The plan that finally came about so we could accomplish our goals was to set up the conference as a webinar format. April was the month chosen and we spread out the content over 3 weeks. Each webinar session was on a Thursday afternoon for 1 hour. April 8th, April 15th, and April 22nd.
2	With the change in content and format we knew our numbers would be down from the 100 projection but this was out of necessity.	Our numbers actually were more than our projected number so we were pleased. There were 183 online for the 3 day webinar set up.

LESSONS LEARNED

We have learned out of necessity that things can be done although modified but they can be done on a virtual platform. Not the best but we made it work.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

We have carried out and implemented the same type of training at other Farm to School meetings, trainings in connection with OSDE Child Nutrition.

BENEFICIARIES

Number of project beneficiaries: 183

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☑ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 3, Indicator 2a.	A survey was sent to the 183 individuals that participated in the trainings with 5 questions relating to food procurement with a minimum of 85% of the responses to each question strongly agreeing they gained knowledge

DATA COLLECTION

A online survey was taken after the series. The questions meet all 5 of the objectives in the grant.

1. As a result of this webinar series, I know more about procurement procedures for Farm to School.

2. As a result of this webinar series, I know more about the DoD "Fresh" program and how to use procurement dollars to purchase specialty crops through this program.
3. As a result of this webinar series, I know more about the "Fresh, Fruits and Vegetable" program through the Department of Health and how to use procurement dollars to purchase specialty crops through the program.
4. As a result of this webinar series, I have or will have, or know where to find resources, to use in the cafeteria to promote eating healthy.
5. As a result of this webinar series, I have made connections, or know how to make connections, with growers as a result of the virtual tours of specialty crops producers in Oklahoma.

Each questions responses were: Strongly agree, agree, neutral, disagree and strongly disagree.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$0.00	$0.00
Fringe Benefits	$0.00	$0.00
Travel	$1,500.00	$2,000.00
Equipment	$0.00	$0.00
Supplies	$764.00	$386.42
Contractual	$5,200.00	$5,564.25
Other	$3,500.00	$3,124.20
Direct Costs Sub-Total	$10,964.00	$11,074.87
Indirect Costs	$0.00	$0.00
Total Federal Costs	$10,964.00	$11,074.87

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Tasteful Harvest Resources

Recipient Organization Name:	Oklahoma Department of Agriculture, Food and Forestry			
Period of Performance:	**Start Date:**	9/28/2018	**End Date:**	9/27/2021
Recipient's Project Contact				
Name:	Cheri Long			
Phone:	405-249-9234			
Email:	cheri.long@ag.ok.gov			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

12 posters entitled Tasteful Harvest Poster Set, promoting or showcasing 12 specialty crops grown in Oklahoma, which include, Asparagus, Broccoli, Carrots, Cucumbers, and more were created. The posters include facts about each crop and a variety of pictures of them. These will be used in classrooms and cafeterias around the state of Oklahoma. With the posters, there are Connection pages for classroom teachers, cafeterias, and families that promote the specialty crops using recipes, lessons and activities, taste tests.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Increase exposure of vegetable subgroups that meet meal pattern requirements.	X	
2	Increase awareness of Oklahoma's seasonality and availability.	X	
3	Increase nutrition education and knowledge utilized in the classroom, school cafeteria and local communities	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	The Tasteful Harvest Posters have been given to child nutrition directors and food service personnel as well as classroom educators throughout the state.	Objectives 1-3
2	The Tasteful Harvest Cookbook was completed and also been given out across the state.	Objective 1-3
3	Trainings have taken place during the spring and summer and the posters and	Objectives 1-3

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	cookbooks have been given to the participants.	

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Covid-19 has still been a little bit of a hindrance but, not completely. These resources are still continuing to be sent out or given out.	We have put digital copies of the posters on the website along with the Connection Pages for easy download and added a request for posters. This has been a huge help in getting these out to schools.
2	The cookbook is a huge hit but has not been put on the Farm to School website for folks to request copies.	The digital files have been requested to send to the website coordinator to get up on the website.
3	Since Covid 19 has been an ongoing issue, the number of conference, trainings and events have been smaller than first anticipated.	Continuing to mail out the resources and encourage participation as much as possible.
4	Due to Covid 19 and the schools being virtual or closed to the public, Farm to School staff has not been able to get into the schools to do taste tests or surveys with the students.	Farm to School has been connecting with child nutrition folks to possibly increase fresh vegetables and fruits on the trays.

LESSONS LEARNED

Make sure all digital files are available and ready to go up on the website all at the same time.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Farm to School has been and will continue to train educators and child nutrition leaders across the state in Pk-12 grade sites and show them successful ways to use the Tasteful Harvest resources. Farm to School staff will continue to work with schools and early childhood sites to get in the sites to do surveys and taste tests as allowed.

BENEFICIARIES

Number of project beneficiaries:.....1,500

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
☑ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption

☑ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access

☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources

☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems

☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 2, Indicator 1.b	Due to Covid restrictions posters have been requested and sent out as well as the cookbook. Based on the downloads of posters as well as the connection pages reported, approximately 3,000-4,000 students have been reached but, none has reported back on the intention to eat more specialty crops.
2	Outcome 2, Indicator 2.b	With schools closed, doing virtual learning and implementing strict visitor policies ODAFF's F2S staff was not able to travel to schools or child education centers to work with the education staff. This negatively impacted our ability to accomplish Outcome 2, Indicator 2.b
3	Outcome 3, Indicator 2.a.	ODAFF staff has been limited on their ability to meet with school nutrition staff therefore we did not meet our goal of reaching 500 individuals. Of those that we have 40 have responded that they gained knowledge on both access and how to prepare, purchase and process the specialty crops in their schools.

DATA COLLECTION

Due to Covid 19 restrictions there has not been additional data collected other than the request for resources to be sent out and resources downloaded from the website.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$0.00	$0.00
Fringe Benefits	$0.00	$0.00
Travel	$0.00	$0.00
Equipment	$0.00	$0.00
Supplies	$0.00	$0.00
Contractual	$0.00	$0.00
Other	$17,000.00	$13,974.38
Direct Costs Sub-Total	$17,000.00	$13,974.38
Indirect Costs	$0.00	$0.00
Total Federal Costs	$17,000.00	$13,974.38

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

Tasteful Harvest Resources - https://okfarmtoschool.com/tasteful-harvest-resources/