USDA-ARS | U.S. Wheat and Barley Scab Initiative

FY21 Performance Progress Report

Due date: July 26, 2022

Cover Page

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Phone:	701-231-8474
Fiscal Year:	2021
USDA-ARS Agreement ID:	59-0206-0-130
USDA-ARS Agreement Title:	Essential Oil Nanoemulsion to Control of Mycotoxin Production in Cereals
FY20 USDA-ARS Award Amount:	$58,749
Recipient Organization:	North Dakota State University Department of Plant Sciences NDSU Depart. #7670, PO Box 6050 Fargo, ND 58108
DUNS Number:	80-388-2299
EIN:	45-6002439
Recipient Identifying Number or Account Number, if any:	FAR0031915
Project/Grant Period:	6/1/21 - 5/31/23
Reporting Period End Date:	5/31/2022

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
FST-R	Essential Oil Nanoemulsion to Control of Mycotoxin Production in Cereals	$58,749
	FY21 Total ARS Award Amount	$58,749

I am submitting this report as an: ☒ Annual Report ☒ Final Report

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.

Jaijai Rao _____ 05/24/2022

Principal Investigator Signature Date Report Submitted

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‡ BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
EC-HQ – Executive Committee-Headquarters
FST-R – Food Safety & Toxicology (Research)
FST-S – Food Safety & Toxicology (Service)
GDER – Gene Discovery & Engineering Resistance
HWW-CP – Hard Winter Wheat Coordinated Project
MGMT – FHB Management
MGMT-IM – FHB Management – Integrated Management Coordinated Project
PBG – Pathogen Biology & Genetics
TSCI – Transformational Science
VDHR – Variety Development & Uniform Nurseries
NWW –Northern Soft Winter Wheat Region
SPR – Spring Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: Essential Oil Nanoemulsion to Control of Mycotoxin Production in Cereals

1. **What are the major goals and objectives of the research project?**
   Goal one: Preparation, Characterization of essential oil nanoemulsions and their major chemical compounds nanoemulsions
   Goal two: Antifungal and antimycotoxigenic mechanisms of action (MOA) of essential oil nanoemulsions
   Goal three: Application of essential oil nanoemulsions for reducing Fusarium Infection and DON production during micro malting processing
2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   a) What were the major activities?

   Majority activities in goal one:
   - The chemical composition of essential oils (thyme oil, clove leaf, bud and hop oil) have been characterized using Gas chromatography–mass spectrometry (GC-MS).
   - A number of physically stable 5 wt% of essential oil-in-water nanoemulsions including thyme oil and their constituents, clove leaf, clove bud, hop essential oil have been fabricated using high energy method.
   - The physiochemical properties of nanoemulsions have been characterized including particle size, particle size distribution and long term stability of nanoemulsion.

   Majority activities in goal two:
   - The antifungal activity of essential oil-in-water nanoemulsions have been evaluated in terms of inhibition of mycelial growth and spore germination
   - The influence of essential oil nanoemulsions on outer cell membrane compositions (total lipid content, chitin content) and permeability and integrity of cytoplasmic membrane were evaluated using fluorescence-based assay (confocal laser scanning microscopy).
   - The mycotoxin inhibitory activity of essential oil-in-water nanoemulsions have been evaluated in rice culture
   - The method for evaluating mycotoxin inhibitory activity of essential oil-in-water nanoemulsions in Trichothecene biosynthesis induction (TBI) medium has been established.

   Majority activities in goal three:
   - Application of clove oil nanoemulsions for reducing Fusarium Infection and DON production during micro malting processing using Fusarium-infected barley (Variety: Stellar- ND) at the North Dakota State University trial
   - Application of hop oil nanoemulsion for reducing Fusarium Infection and DON production during micro malting processing using naturally fusarium infected six row barley (Variety: Pinnacle).

   b) What were the significant results?

   - By blending 30 wt% of essential oil with 70 wt% of corn oil in oil phase (5 wt%), clove thyme oil-in-water nanoemulsion, bud oil (CBO)-in-water nanoemulsion, clove leaf

oil (CLO)-in-water nanoemulsion and hop oil-in-water nanoemulsion showed highly physical stable with the mean particle size < 200 nm.

- The concentration of major chemical constituents in essential oil such as eugenol and caryophyllene in nanoemulsion maintained constant during storage time.
- The antifungal activities of essential oil nanoemulsions against two *Fusarium graminearum* isolates were strongly dependent on the essential oil concentrations. In general, the order of antifungal activity from the strongest to weakest is thyme oil, clove leaf oil, clove bud oil and hop oil.
- The antifungal activity of essential oils has been elucidated including alternating the total lipid content in outer cell membrane, decreasing chitin in outer cell membrane and damaging the cytoplasmic membrane as evidenced by confocal laser scanning microscopy (CLSM).
- In terms of antimycotoxigenic mechanisms of action (MOA) of thyme oil, thyme oil significantly ($p<0.05$) up-regulated the expression of the most genes studied (Tri3, Tri4, and Tri5) in two isolates, while thymol that is the major chemical constitutes in thyme oil did not up-regulate any gene expression.

c) List key outcomes or other achievements.

- Two manuscripts have been submitted to the journal, and another two manuscripts will be submitted by end of this year.

3. What opportunities for training and professional development has the project provided?

Two PhD students and one part-time researcher have been trained by this project.

4. How have the results been disseminated to communities of interest?

Results have been presented in several conferences as listed below:

- Haiyang Jiang, **Jiajia Rao***. Antifungal activity of hop essential oil against Fusarium species and their mycotoxin production. 2022 Institute of Food Technologists (IFT) Annual Meeting, July 10–13, Chicago, USA.
- Haiyang Jiang, **Jiajia Rao*.** Antifungal and mycotoxin inhibitory activity of hop extracts. 2021 National Fusarium Head Blight Forum, December 6-7, 2021 Virtual.
- **Jiajia Rao.** Essential oil based nanoemulsions as antifungal agents in food processing. 2021 National Fusarium Head Blight Forum, December 6-7, 2021 Virtual (***Invited talk***).
- Haiyang Jiang, **Jiajia Rao***. Chemical composition, antifungal and mycotoxin inhibitory activities of essential oil nanoemulsions from leaves and buds of clove. 2021 Institute of Food Technologists (IFT) Annual Meeting, July 18–21, Virtual.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY21 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period?

☒ Yes, I've included the citation reference in listing(s) below.
☐ No, I have nothing to report.

Journal publications as a result of FY21 grant award

List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.

Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published [include DOI#]; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

- Haiyang Jiang, Shaobin Zhong, Paul Schwarz, Bingcan Chen, Jiajia Rao. Chemical composition of essential oils from leaf and bud of clove and their impact on the antifungal and mycotoxin inhibitory activities of clove oil-in-water nanoemulsions. *Industrial Crops and Products* (accepted); acknowledgment of federal support - yes
- Haiyang Jiang, Shaobin Zhong, Paul Schwarz, Bingcan Chen, Jiajia Rao. Antifungal and mycotoxin inhibitory activity of nanoencapsulated hop essential oil and their mode of action. Food Control (*submitted*); acknowledgment of federal support - yes

Books or other non-periodical, one-time publications as a result of FY21 grant award

Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.

Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

N/A

Other publications, conference papers and presentations as a result of FY21 grant award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.

- Haiyang Jiang, Jiajia Rao. Antifungal activity of hop essential oil against Fusarium species and their mycotoxin production. 2022 Institute of Food Technologists (IFT) Annual Meeting, July 10–13, Chicago, USA.
- Haiyang Jiang, Jiajia Rao. (2021). Antifungal and mycotoxin inhibitory activity of hop extracts. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf
- Jiajia Rao. (2021). Essential oil based nanoemulsions as antifungal agents in food processing. *Proceedings of the 2021 National Fusarium Head Blight Forum;* Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf
- Haiyang Jiang, Jiajia Rao. Chemical composition, antifungal and mycotoxin inhibitory activities of essential oil nanoemulsions from leaves and buds of clove. 2021 Institute of Food Technologists (IFT) Annual Meeting, July 18–21, Virtual.