

Project/Activity Number: NC-1023

Project/Activity Title: Engineering for Food Safety and Quality

Period Covered: October 2018 to September 2019

Date of This Report: December 21, 2019

Annual Meeting Date(s): October 20-22, 2019

Annual Meeting Location: Las Cruces, NM

Participants: 29

Barbara Chamberlin; Efren Delgado; Akinbode Adedeji; Gail Bornhorst; Rohan Tikekar; Pamela Martinez; Kelly Dick; Ilce Medina; Ashim Datta; Mukund Karwe; Fanbin Kong; Jiajia Chen; Sudhir Sastry, VM Balasubramaniam; Yanyun Zhao; Lester A. Wilson; Fanbin Kong, Swamy Anantheswaran; Youngsoo Lee; Richard Hartel; Kirk Dolan; Dennis Heldman, Ozan Ciftci, Yi-Cheng Wang, Kasiviswanathan Muthukumarappan, Sam Chang, Pawan Takhar, Roger Ruan, Rohan Tikekar, David Jackson.

Annual Meeting Summary

The annual meeting was held at the Encanta Hotel. The opening mixer was held on the evening of October 20 at the hotel lobby followed by dinner. The main event started on October 21. Dr. Hongda Chen provided the "Washington update" as a webinar. Barbara Chamberlain, one of the hosts, gave introductions and overview of the meeting agenda. David Jackson went over requirements and dates for the rewrite. Lester Wilson gave a summary of the Steering Committee Report. Ad hoc committee reports were given. Station reports commenced with youngest members going first. A new format of "max 5 minutes, 5 slides" organized by objective was used for Station Reports. Led by Gail Bornhorst, all members chose one of the working groups during lunch to decide on the text for each objective. In the afternoon, groups continued to work on the objectives. Gail Bornhorst announced future NC-1023 meetings as 2020 at U. IL and 2021 either MS or MI. Ozan Cifti was elected new secretary. Sudhir Sastry gave information on Conference of Food Engineering Meeting in Raleigh, NC, Sep. 13-16, 2020. NMSU gave tours of Food Processing Lab and Learning Games Lab and Innovative Media Research & Extension. Evening dinner. Dean Flores and President gave a welcome talk. On October 22, Head of experiment station at NMSU gave an overview of food and agricultural economy of New Mexico. Gail Bornhorst gave an overview of the Steering Committee report and upcoming deadlines. Word changes in the objectives were announced. Various ideas for outreach and extension advertising our NC-1023 group activities were discussed. The meeting concluded at 12:30 pm on October 22, 2019. Detailed minutes are available upon request.

Accomplishments

The project has four objectives. The text of the four objectives was updated during the 2019 meeting. Individual stations have continued to work on each of the four objectives and detailed accomplishments of individual stations are available upon request. In this report, we showcase collaborative accomplishments in each of the objectives.

1. Characterize multi-scale physical, chemical and biological properties of food, biological and engineered materials

Tennessee and Iowa station collaborated on dairy polar lipids recovery from waste streams and characterization of compositional and oxidative properties

Tennessee, Nebraska, and Missouri stations collaborated on soybean oil composition and physical and rheological characterization

California collaborated with Idaho, Washington, Georgia, Utah, Wisconsin, and Missouri stations to characterize the rheological properties of a tomato-based salad dressing

Georgia and Missouri stations collaborated to characterize the behavior of nanocellulose during digestion and the health effects

Georgia and Nebraska stations collaborated to compare different methods in measuring dielectric properties of low moisture foods

Kentucky and Virginia stations collaborated on spent grain value addition, and submitted joint USDA proposal.

Oregon collaborated with Indiana, Iowa, Michigan, Mississippi, Nebraska, and Virginia stations to compare the effect of different extraction methods on phenolics and anthocyanin contents from red wine grape pomace.

Illinois and Indiana stations collaborated to measure viscoelastic properties of cricket protein gels.

Illinois and Washington stations are beginning a collaboration to measure moisture/oxygen permeability of microcapsules processed with 3-fluid nozzle in spray drying.

Washington and Illinois stations collaborated to measure thermal properties of potatoes for utilization in Hybrid Mixture Based Theory Model.

Michigan and Indiana stations collaborated in a joint company to design a rapid test instrument to rapidly estimate thermal properties of foods up to 140 °C.

Minnesota and California stations collaborated with Almond Board of California to analyze physiochemical, chemical, microbiological properties including toxic pesticide residues, etc. using NMR, MRI, and LC-MS

Minnesota collaborated with Food Companies and Kathiravan Krishnamurthy of Illinois Institute of Technology to develop catalytic intense pulsed light and microwave based processing technologies for pasteurization of powdered and particulate foods

Minnesota station collaborated with industry and Virginia station on functional component extraction from barley malt rootlets

2. Develop new and sustainable technologies to transform raw materials into safe, high quality, health enhanced and value added foods through processing, packaging and preservation

Georgia and Washington stations collaborated to develop Radio Frequency pasteurization of food powders

Nebraska, Oregon, Iowa, Michigan, Indiana, Mississippi and Virginia stations collaborated to extract grape pomace using supercritical carbon dioxide and subcritical water as part of Extraction of Bioactive Compounds committee.

Arkansas, Nebraska, Georgia, New Mexico and Arkansas stations collaborated to prepare an NSF Engineering Research Center (ERC) proposal on Advanced Food Engineering.

New York and Ohio stations are collaborating on a project that evaluates the microbial safety of dry plant environments by developing improved cleaning and sanitation technologies.

South Dakota and Nebraska stations are developing a sustainable extrusion process for retaining/enhancing the nutritional and physical characteristics of quinoa and millets.

South Dakota and Iowa stations are investigating the effect of high voltage atmospheric cold plasma on *E. coli* K-12 in apple juice.

Oregon, Washington and Nebraska stations are investigating radio frequency dielectric heating for drying and pasteurizing Oregon hazelnuts.

Michigan is leading a collaboration with Washington, Arkansas, Georgia, North Carolina, IIT and FDA on improving development, implementation, and validation of low-moisture pasteurization technologies and processes (USDA NIFA AFRI CAP project).

Michigan, Nebraska, Virginia, Oregon, Maine, Purdue, Iowa, and Mississippi stations have a collaborative project of Extraction of Bioactive compounds from grape pomace, with the aim to evaluate the effect of different food technologies in the extraction of phenolic compounds.

Dr. Medina-Meza, is collaborating with Dr. Ozan Cifti (Nebraska) in a study to evaluate the impact of CO₂ supercritical extraction on phytochemicals from quinoa.

Minnesota, Washington, Mississippi and California stations collaborated on food waste reduction and utilization process development.

3. Develop mathematical models to understand, predict and optimize for safe and improved quality of foods, and to enhance consumer health

Tennessee collaborated with Nebraska station to model radio frequency heating of egg white powder continuously moving on a conveyor belt (See <https://doi.org/10.1016/j.jfoodeng.2019.05.029>)

Arkansas collaborated with Michigan, Illinois, and Washington stations to develop inactivation kinetics models for Salmonella and *E. faecium* in various low-moisture foods.

Pennsylvania collaborated with the Illinois station on “Modeling of Heat Transfer During Hot Water Sanitization of A Commercial Mushroom Disc Slicer.”

Ohio and Illinois stations collaborated in using COMSOL to model the diffusion of anthocyanins from alginate-pectin hydrogel.

Illinois and Washington stations collaborated to model fluid, heat and solute transport in foods subjected to freeze-thaw cycles

Pennsylvania and Illinois collaborated to estimate the heat transfer coefficient in a mushroom slicer using Computational Fluid Dynamics.

Michigan station is collaborating with FDA, Kansas, and Georgia stations in developing and testing novel Salmonella inactivation models for validating baking and other temperature/moisture-dynamic processes.

Michigan and Indiana stations are working to determine design factors for the Washington station cell for estimating inactivation parameters in low-moisture foods.

Michigan and Indiana jointly provided food safety modeling assistance to a large food company. The company wrote a letter of support to fund 3 years of a ½-time Ph.D. for a USDA NIFA grant that was jointly submitted.

4. Disseminate knowledge developed through research and novel pedagogical methods to enhance student and other stakeholder learning and practice

California and New York stations collaborated on using teaching modules for thermal processing in Food Science Courses, and co-moderated a session on education at the IFT2019 Annual Meeting.

A industry-university collaborative group (Idaho, California, Ohio, Washington, Pepsico, Unilever, McCormick, and ConAgra , U. Salerno-Italy) organized by the Society of Food Engineering (SoFE) surveyed stakeholders to determine educational needs to convert engineers hired by industry into food engineers, and determined gaps.

Six editors representing Ohio, Oregon, and Washington stations, USDA ARS, Natick Labs, and the food industry are co-editing 2nd edition of Nonthermal Processing Technologies for Food.

New York station collaborated with California, Georgia, Illinois, Michigan, Wisconsin, and other stations to implement teaching modules that enhance learning using a simulation-based approach.

Impacts

1. Developed new mechanistic models to understand various processes critical for food safety, processing and quality
2. Initiated a multi-institutional research program to evaluate physical properties of foods.
3. Developed and optimized several new technologies (e.g. light, high pressure, plasma, pulsed electric field, ultrasound, and microwave and other thermal processes) to enhance the safety of various food products
4. Invented, designed and developed new devices to measure engineering properties of foods.
5. Several new pedagogical techniques were formulated and implemented to enhance student learning of food safety and engineering principles

Publications

A complete list of research publications from NC-1023 members is available upon request. Here, we highlight publications that resulted from collaborative activities between members.

1. Tan J, Martini S, Wang Y, Kong F, Hartel RW, Barbosa-Cánovas G, Vardhanabhtutig B, Bornhorst G, Keppler S, Joyner H. 2019. Inter-Laboratory Measurement of Rheological Properties of Tomato Salad Dressing. *Journal of Food Science*. <https://doi.org/10.1111/1750-3841.14828>
2. Tan Y, da Silva T, Martini S, Joyner H. 2019. Numerical Modeling of Wear Behavior of Solid Fats. *Journal of Food Engineering* 260:12-21.
3. Tan J, Martini S, Wang Y, Kong, F, Hartel R, Barbosa-Cánovas G, Vardhanabhuti B, Bornhorst G, Keppler S, Joyner H. 2019. Interlaboratory Measurement of Rheological Properties of Tomato Salad Dressing. *J Food Sci* <https://doi.org/10.1111/1750-3841.14828>
4. Vogel, P., Bayon de Noyer, S., Park, H., Nguyen, H., Hou, L., Changa, T., Ciftci, O., Wang, T., Cahoon, E., Clemente, T. 2019. Expression of the Arabidopsis WRINKLED 1 transcription factor leads to higher accumulation of palmitate in soybean seed. *Plant Biotechnology Journal*. 1-11. doi: 10.1111/pbi.13061.
5. Fei, T., Walker, J.A., Vickerman, K.L., Stanley, L.M., Jarboe, D., Wang, T. 2018. Synthesis and characterization of soybean oil-based waxes and their application as paraffin substitute for corrugated coating, *Journal of Industrial and Engineering Chemistry*. 58: 113-122.
6. Leite, T.S., Sastry, S.K., and Cristianini, M. 2018. Effect of concentration and consistency on the electrical conductivity of carboxymethyl cellulose solutions. *Journal of Food Process Engineering*. 41(8):e12883.
7. Simpson, R., Nuñez, H., Jacques, A., Ramirez, C., Quiroz, N., Moreno, J., and Sastry. S.K. 2018. Application of a moderate electric field for the potential acceleration of the salting process of

Atlantic salmon (*Salmo salar*). *J. Food Process Eng.* <https://doi.org/10.1111/jfpe.12846>

8. Zhong, S., Vendrell-Pacheco, M., Heskitt, B., Chitchumroonchokchai, C., Failla, M., Sastry, S.K., Francis, D., Martín-Belloso, O., Elez-Martinez, P., and Kopec, R. 2019. The Effect of Novel Processing Technologies on the Bioaccessibility and Caco-2 Cell Uptake of Carotenoids from Tomato and Kale-based Juices. *Journal of Agricultural and Food Chemistry* (accepted for publication).
9. Tan J, Martini S, Wang Y, Kong F, Hartel R, Barbosa-Cánovas G, Vardhanabhuti B, Bornhorst G, Keppler S, Joyner H. Interlaboratory Measurement of Rheological Properties of Tomato Salad Dressing. *Journal of food science*. 2019 Oct 7.
10. Ozturk S, Liu S, Xu J, Tang J, Chen J, Singh RK, Kong F. Inactivation of *Salmonella* Enteritidis and *Enterococcus faecium* NRRL B-2354 in corn flour by radio frequency heating with subsequent freezing. *LWT*. 2019 Aug 1;111:782-9.
11. Balasubramaniam, V.M., Nitin, N., Kathiravan Krishnamurthy, A. Sulaiman. 2019. Putting pressure on food. *Chemical Engineering Progress*. 115 (5), 56-60
12. Kshirod K. Dash, V. M. Balasubramaniam, Shreya Kamat. 2019. High pressure assisted osmotic dehydrated ginger slices. *Journal of Food Engineering*, 247, 19-29
13. Zulkurnain, Musfirah; Balasubramaniam, V.M.; Maleky, Farnaz. 2019. Effects of Lipid Solid Mass Fraction and Non-Lipid Solids on Crystallization Behaviors of Model Fats under High Pressure. *Molecules* 2019, 24(15), 2853
14. Muramatsu, Y., Dolan, K.D., Mishra, D.K., 2019. Factors influencing estimation of thermal inactivation parameters in low-moisture foods using a test cell. *Journal of Food Engineering* 262, 100-108.

Conference presentations

1. Tan J, Kong, F, Hartel R, Martini S, Barbaosa-Cánovas G, Vardhanabhuti B, Bornhorst G, Joyner H. Inter- and Intra-Lab Factors in Characterization of Salad Dressing Rheological Properties. Conference of Food Engineering. 2018. Minneapolis, MN. Wang, T., Fei, Tao. 2018. Developing vegetable oil based wax coating alternatives. 2018 AOCS Annual Meeting and Expo, May 6-9 Minneapolis, MN.
2. Ahmad N, D'Souza RC, Hildebrandt I, Thippareddi H, Marks B, Ryser E. 2018. Validation of *Enterococcus faecium* NRRL B-2354 as a surrogate for thermal inactivation of *Salmonella* in date paste. Abstract P2-87. Presented at the Annual Meeting of the International Association for Food Protection. Salt Lake City, UT. July 8-11, 2018.
3. Ahmad N, Oztabak C, Marks B, Ryser E. 2018 Effect of talc on thermal resistance of *Enterococcus faecium* NRRL B-2354 in almond meal at a water activity of 0.45. Abstract P2-88. Presented at the Annual Meeting of the International Association for Food Protection. Salt Lake City, UT. July 8-11, 2018.
4. Consideration of Validation of Thermal Processes Used in the Manufacture of Low Moisture Foods. Industry mini-workshop. Process Expo U. Chicago, IL. Sep 19, 2017. (30+ attendees)
5. Safety of Low Moisture Foods: Product and Process Factors Affecting Pathogen Survival and Resistance. In Low Moisture Foods from Ingredients to Finished Products: Food Materials Science Fundamentals, Challenges, and Opportunities. IFT 2-day Workshop. July 14-15, 2018. Chicago, IL. (50+ attendees)
6. Safety of Low Moisture Foods: Validating Pathogen Lethality for Low-Moisture Food Processes. In Low Moisture Foods from Ingredients to Finished Products: Food Materials Science Fundamentals, Challenges, and Opportunities. IFT 2-day Workshop. July 14-15, 2018. Chicago, IL. (50+ attendees)

7. Low Moisture (Low Water Activity) Foods: Microbiological Safety and Current Regulatory Requirements. IAFP Webinar. Sep 27, 2018. (603 registrants; 351 live attendees)

Collaborative grants

While individual members of the project have been awarded several competitive grants in 2018-2019, in this section we highlight new and ongoing research and education grants awarded to collaborative projects between member stations.

1. United States Department of Agriculture, National Institute of Food and Agriculture (USDA NIFA), Award No. 2015-68003-23415. \$4.7 million. Enhancing Low-Moisture Food Safety by Improving Development and Implementation of Pasteurization Technologies (Michigan State University, Washington State University, University of Nebraska, Illinois Institute of Technology, University of Georgia, North Carolina State University).
2. Zhao, Y., Tang, J. Enhancing productivity and safety of Oregon hazelnuts through technology innovation, ODA Specialty Crop Grant, \$169,791, 04/19-09/21
3. Further develop scalable process for phospholipid-enriched and high-value dairy co-products, from Midwest Dairy Association, T. Wang, S. Clark \$91,377, 2019-2021
4. Fanbin Kong as PI (UGA) and Mengshi Lin as Co-PI (U Missouri) received grants from USDA-NIFA for the project "Effect of Nanocellulose and Food Matrix on Mucosal Structure, Nutrient Absorption and Colonic Fermentation". Funding amount: \$465,000. Project duration: September 2019-AUGUST 2022.
5. Zhong, Qixin, and Drake, MaryAnne at NC station, "Derivatized skim milk powder for use as functional ingredients in transparent beverages," funded for \$470,000.
6. Development and Implementation of Innovative Food Safety Training Tools for the Production and Distribution of Microgreens, USDA Food Safety Outreach, 9/1/2019-8/31/2022 (Collaboration with the University of Arkansas)
7. "Don't Wash my Chicken?! Developing Food Safety Education Messages to Address Consumer Barriers to Adopting Safe Food Handling Practices," USDA-NIFA AFRI, 07/01/2019- 06/30/2021 (Collaboration with Drexel University)