

CE Grant Annual Progress Report 2016

-USDA AFRI 2016-68003-24840-

Confidential and Internal Report

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Overview

The Center of Excellence for Food Safety Technologies using Microwave Energy funded by the USDA-AFRI is wrapping up a year of work towards the project's goals. The report below outlines the accomplishments and future plans of each of the Principal Investigators on the project. The following report gives an update of the center's activities from March 15, 2016 through November 15th, 2016.

Review of Objectives

Objective 1: Conduct engineering studies to optimize design and assist in scaling-up of MW assisted pasteurization (MAPS) and sterilization (MATS) systems.

Objective 2: Develop and validate MAPS processes for selected food products for FDA FSMA compliance and develop protocols for regulatory filing.

Objective 3: Evaluate, improve and maximize the quality of MAPS and MATS processed foods.

Objective 4: Design and develop polymeric packages for MAPS and MATS processed foods.

Objective 5: Conduct accelerated storage and sensory studies for MAPS and MATS processed foods.

Objective 6: Conduct economic analysis to assess the costs and benefits of adopting MAPS technology by food processing companies.

Objective 7: Study energy and water usage in MATS and MAPS operations, evaluate environmental impact.

Objective 8: Assist food processing companies to develop food formulations for MAPS and MATS processing, develop and validate processes, and file for FDA and USDA FSIS acceptance.

Objective 9: Disseminate knowledge via short-courses, certificate programs, and web based media.

Objective 10: Prepare the next generation of leaders trained in food safety technologies and implementation.

Research Updates

Dr. Tang – Washington State University

Metal Carrier Design (Objectives 1 & 3)

New carrier designs using stainless steel have been developed and patented to support industrial scale-up of both microwave assisted pasteurization systems (MAPS) and microwave assisted sterilization (MATS) systems. The new carriers are robust, easy to clean, and provide flexibility to process individual and institutional size trays and pouches. Our engineers spent six months conducting over 100 experiments with the pilot scale MAPS system to prove the concept and improve engineering details (through five different prototype versions) to reach the final designs.

The new metal food package carrier (Fig. 1) designs are based on the combination of Faraday Cage and WSU Single-Mode Cavity. The metal patterns allow 915 MHz microwave energy to more uniformly distribute to the food packages. When the metal carriers move through the single-mode cavity filled with water, microwave coupling is very efficient.

The Faraday-Tang Cage carrier as shown below distributes microwave energy around the cage's exterior; it partially cancels out electric charges or radiation within the cage's interior. The carriers can be loaded and unloaded with robotic arms in industrial operations.



Figure 1 - New metal carrier filled with 10-oz model food trays

Figure 2 shows the microwave heating uniformity, as indicated by our new chemical marker system (to be discussed later), inside 10.5-oz food packages. The uniformity was

improved compared to that of Figure 3 in food packages processed on the carrier without metal pattern. The heating patterns are further validated with computer simulation.

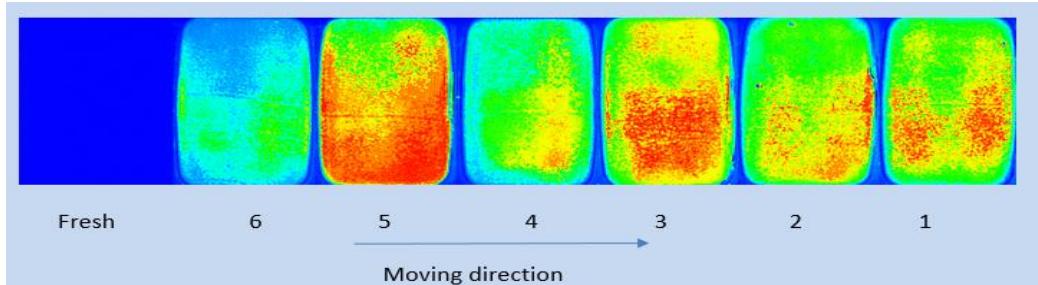


Figure 2 - Heating pattern in 10.5-oz potato/gel trays on metal carrier (with metal shield)

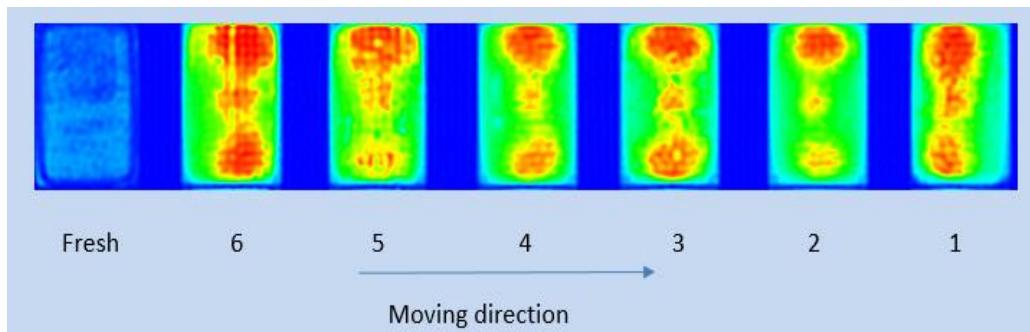


Figure 3 - Heating pattern in potato/gel trays on metal carrier (without metal pattern) processed in MAPS for comparison

Temperature measurement tests were conducted with the new metal carrier. Figure 4 shows temperature profiles measured at the locations of cold and hot spots in 10.5-oz mashed potato gel model food trays. The uniformity of microwave heating in 10.5-oz tray was improved with the new metal carrier as indicated by the small difference between temperatures at the cold and hot spots.

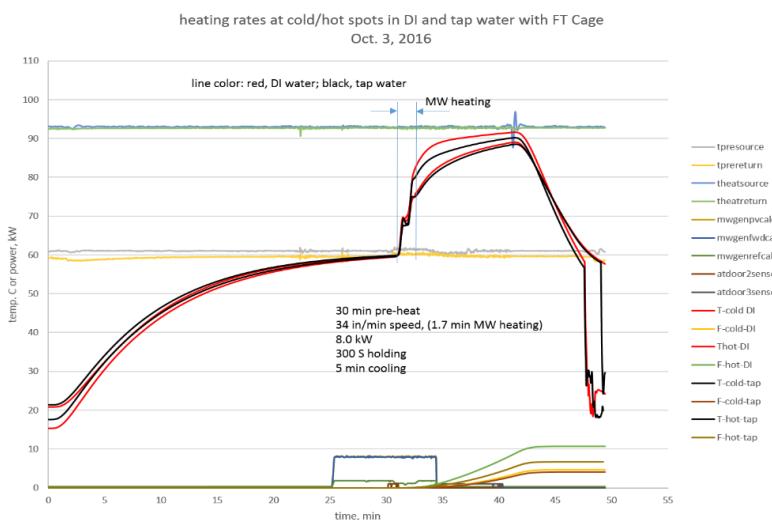


Figure 4 - Heating rates at cold/hot spots inside 10.5-oz model food trays

Tests were also conducted with 8-oz pouches with a new metal pouch carrier (Fig. 5). Positive testing results were achieved with the new metal pouch carrier (Figs. 6 & 7).



Figure 5 - New metal carrier filled with 8-oz model food pouches

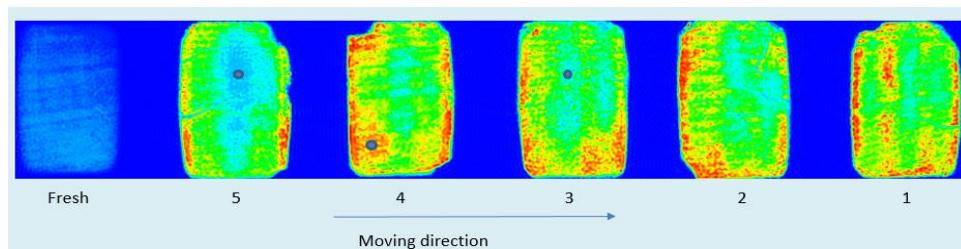


Figure 6 - Heating pattern in 8-oz potato/gel pouches on metal carrier (with metal shield)

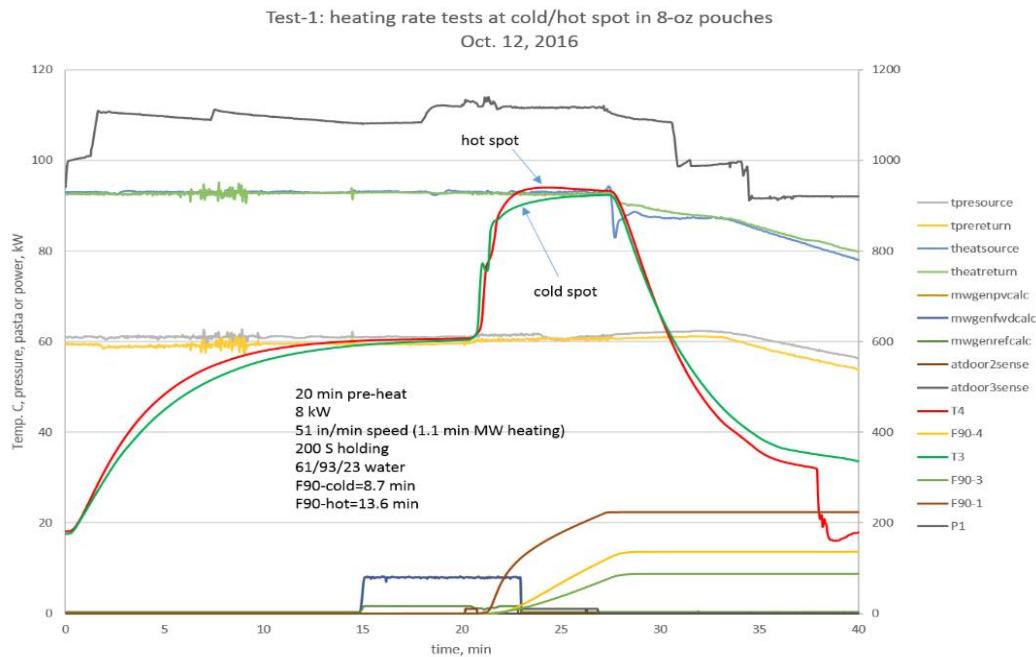


Figure 7 - Temperature profiles at location of cold and hot spots in 8-oz pouches

Patent Filings (Objective 1 & 3)

To protect the intellectual property of the research, WSU has filed, or in the process of filing, patent protection for MAPS in the United States as well as 11 other countries, including the European Union as shown below.

Table 1 - Status of Patent filing for MAPS and MATS

Date	Country	Number	Status
8/11/2016	United States	15234,926	Filed
11/6/2016	China	137,009,637	Filed
	Europe	-	In Preparation
	India	-	In Preparation
	South Korea	-	In Preparation
	Australia	2,015,256,068	Filed
11/6/2016	Canada	2,947,053	Filed
11/6/2016	Israel	248,663	Filed
11/6/2016	Japan	-	Filed
11/6/2016	Mexico	MX/a/2016/013842	Filed
11/6/2016	Thailand	1601006460	Filed
11/6/2016	Brazil	BR 11 2016 025733-2	Published

Dr. Tang, the WSU Engineering team, and the WSU Office of Commercialization had weekly conference calls with 915 Labs, and hosted two meetings in Pullman, WA to share the latest engineering results for incorporation of the design into commercial microwave systems. 915 Labs has recently agreed to adopt two major suggestions (e.g., using lower microwave power in a continuous mode and metal carrier designs) from WSU that were successfully proof tested in the MATS-B unit of Ameriqual Foods. The two design improvements will greatly increase energy efficiency and food quality as compared to their early designs.

Redesign of WSU MAPS System (Objective 1)

As stated in the proposal, the WSU engineering team is in the process of redesigning the microwave pasteurization system. Two single-mode cavities, one tee waveguide, eight elbow waveguides and one 5 kW generator will be added into current MAP system in order to closely simulate industrial processes. After updating, the MAP system will have four WSU Single-Mode Cavities and two 915 MHz microwave generators. We have acquired a new 915 MHz generator, waveguides, and other parts. Assembly and testing will be completed by March 2017. Multi-metal shielded food carriers can be loaded into the pre-heating section. The system assembly and testing will be completed by March 2017.

Developing New Model Food Systems (Objective 3)

We have developed and are assessing new model foods as effective and convenient tools to quantify quality changes from microwave pasteurization for the purpose of process optimization for safe ready-to-eat meals. This work has been completed by a PhD. Student, Ellen Bornhorst, which has led to four manuscripts (one accepted, three in submission). Our team will use the new model system to optimize MAPS processing parameters to produce optimal food quality. Ms. Bornhorst has also successfully defended her thesis in November 2016, and has been offered a position with USDA ARS in Beltsville, MD to continue food safety research.

Improve Computer Simulation Models (Objective 1)

Computer simulation models were also developed to study the influence of metal carriers on heating uniformity in single and multi-compartment trays. The model has been validated by a PhD. student Deepali Jain.

Supporting Other PI's Activities (Objectives 3 & 4)

Members of Tang's laboratory developed two recipes, developed processes for two seafood products and shipped samples to the US Army Natick Soldier Center for sensory tests (see report from Tom Yang).

They also developed processes and conducted MATS runs for packaging evaluations by Dr. Sablani's team and for sensory tests for Dr. Ross' team.

Outreach (Objective 2 & 9)

Dr. Tang delivered invited presentations on MAPS and MATS at the Conference of Food Engineering (September 2016, Columbus Ohio), Institute for Thermal Processing Authority Workshop (September 2016, Columbus Ohio), 3rd Global Congress on Microwave Energy Applications (July 2016, Cartagena, Spain), and 11th HACCP Conference (November 2016, Las Vegas). His graduate students made 6 presentations at the 2016 Annual meetings of IFT, IAFP, and IMPI.

The team worked with the Seafood Products Association (SPA, Seattle) as consultant regarding good manufacturing practices, process development, microbial safety, filing documents for FDA approval, and providing facilities for training industrial and regulatory personnel continues in the form of regular communication and attendance at knowledge dissemination events. Collaboration with Seafood Consulting Services/SPA is heavily reliant on work with FDA regulatory filing. This work will intensify as a result of the success of other project goals, and therefore are not likely to occur until years three and four.

Recruiting PhD students (Objective 10)

Two new PhD students (Qu Zhi and Yoon-Ki Hong) were recruited and joined the team in August 2016 to work on this project.

[Dr. Sablani – Washington State University](#)

Dr. Sablani recruited three doctoral students (1) Juhi Patel, (2) Chandrashekhar Sonar, and (3) Saleh Al-Ghamdi. The students started their program in the fall of 2016. Currently, the students are doing course work relevant to their academic program and polymeric packaging research. They are getting hands-on experience in analytical techniques for characterization of polymeric material, measurement of food quality attributes, sensory analysis, and shelf-life studies. Students have broadly identified their research topics related to packaging for MATS and MAPS processed products (objective 10).

Collaborating polymer companies including Kuraray America Inc., Printpack, Bemis, and Toppan have been engaged in the initial discussion of design and development of gas barrier packaging for MATS and MAPS products (objective 4).

Potential recipes for shelf-life studies of MATS processed were discussed with US Army Natick (objective 5).

[Dr. Ross – Washington State University](#)

In the School of Food Science at WSU, since March, personnel have been added to the grant in support of objective 3. A PhD student, Sasha Barnett, started with the grant in August 2016. Sasha brings a background in nutrition and research design. Her primary objective is to understand functional and chemical properties of salt in processed foods, including microwave processed foods, with the objective of developing reduced salt foods (objective 3a). In addition, one post-doctoral associate, Dr. Charles Diako, and one 1 PhD student, Ben Bernhard, have also been added to the grant. Dr. Charles Diako brings a background in food analytical chemistry and nutrient analysis while Ben Bernhard brings expertise in sensory and instrumental evaluation of texture in food. Both individuals will address objective 3b and 3c, which includes the analyses of chemical and physical attributes of MATS and MAPS processed food products (objective 10).

In addition to securing the necessary personnel, we have: 1) prepared a research proposal, including a literature review, outlining the approach that we will use to address objective 3, specifically the distribution and perception of salt in processed foods, 2) developed methodologies that will be employed by this grant, including sensory methods, analytical chemistry methods (including nutrient analysis) and textural analysis methods, 3) participated in bi-monthly grant conference calls to update the group on research progress (objective 3).

[Dr. Gallardo – Washington State University](#)

A comprehensive literature review on ready to eat meals was completed. The literature review involved three branches of applied economics research, (i) studies describing the demand for ready to eat meals including the sociodemographic profile of ready to eat meals consumers, (ii) studies centering on non-conventional retail distribution of ready to eat meals, such as online

demand for food, this also included the sociodemographic profile of the online food buyer, (iii) approaches/methodology to describe demand for novel foods (objective 6).

An online pilot survey was conducted to elicit WTP values for ready to eat meals. The purpose of the pilot survey was to develop a proof of concept tool that could be used in a future massive survey targeting consumers. A total of 75 participants responded to the proof of concept survey. Questions elicited purchasing patterns, sociodemographic background and the discrete choice experiment, the tool to estimate the WTP. Pictures of vegetables processed by MAPS and retort were included in the discrete choice scenarios. Our preliminary estimations indicated that participants were willing to pay a price premium of \$3.71/10-oz box of ready to eat vegetables prepared via MAPS compared to retort technology. If prices for retort processed vegetables were sold at \$4.49 and MAPS processed vegetables at \$8.20/10-oz box (a \$3.71/10-oz price premium) the market share for vegetables processed via either technology, will be 50%. Any price over \$8.20/10-oz box for MAPS processed vegetables, will decrease the market share for vegetables processed under this technology (objective 6).

[Dr. D'Souza - University of Tennessee](#)

The paperwork for the subcontract to UT took additional time and so funding was not available until late summer of 2016. Attempts at graduate student recruitment are on-going. In addition, literature searches to determine appropriate bacterial surrogates with suitable heat inactivation parameters comparable to the heat inactivation of hepatitis A virus are being initiated. Industrial commercial sources of bacterial surrogates are also being sought and non-disclosure agreements may be initiated in the next few months/semester (objective 2).

[Dr. Gray - North Carolina State University](#)

In addition to the formally stated objectives listed above, our proposal is committed to engage in a systematic and multi-disciplinary program of performance evaluation. Consistent with the evaluation plan and logic model included in the proposal, the first phase of this evaluation effort has been focusing on monitoring and formative evaluation. Dr. Gray, our evaluation specialist, has been participating in all team meetings and conference calls and has been using program records and observation to track whether key activities and interventions are implemented as intended. Consistent with the "improvement evaluation" strategy we proposed he has also provided feedback on achievement of various objectives. Recent feedback has focused on the plans and strategy for our kick-off meeting and formation of our MW Industry Alliance. The purview of his efforts will include: various management activities designed to promote collaboration and interaction with stakeholders, scientific/technical (objectives 1-5) and technology transfer and education (objectives 8-10).

[Tom Yang - US Army Natick Soldier Center](#)

Sensory Evaluation at Military Base (Objective 3 & 5)

In addition to in-house sensory tests, in 2016, we initiated a technical demonstration of MAPS samples at Camp Edwards in Barnstable, MA. Camp Edwards is a United States military training installation which is located in western [Barnstable County, Massachusetts](#). It forms the largest part of [Joint Base Cape Cod](#), which also includes [Otis Air National Guard Base](#) and [Coast Guard Air Station Cape Cod](#). Samples tested were Salmon with Asparagus & Tomatoes and Shrimp-Broccoli-Pasta in Alfredo Sauce which were prepared and processed by Washington State University. The acceptance (in Table 2), though acceptable, was lower than the similar evaluation conducted earlier at Natick Labs (see figs 9 and 10). A major lesson learned from this preliminary trial with a large test population: 1) the evaluation at Camp Edwards was conducted after soldiers had a fish dinner, 2) the large variations resulted from non-seafood tasters to seafood favorables (depicted by min- to max- range of 1 to 9) which skewed the test scores with large variance (~4 on a scale of 9). However, perfect scores of 9 from several soldiers who participated in the trial were observed. Should the test be conducted at more regular training condition, the acceptance would have been much higher.



Figure 8 - Soldiers tasting MAPS samples at Camp Edwards

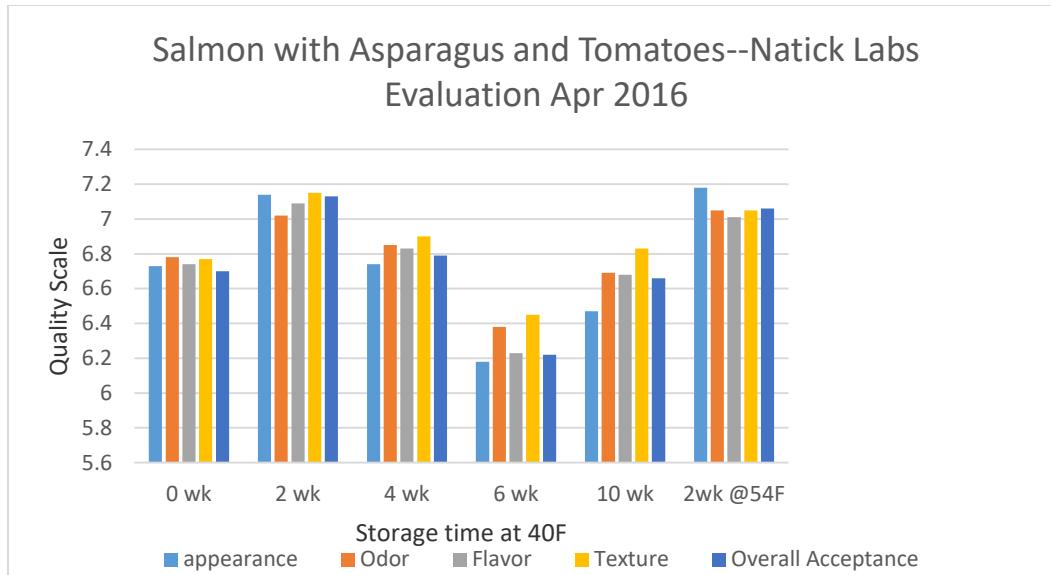


Figure 9 - US Army Natick Internal Panel Test Results for MAPS Product Over 10 Weeks Shelf-Life

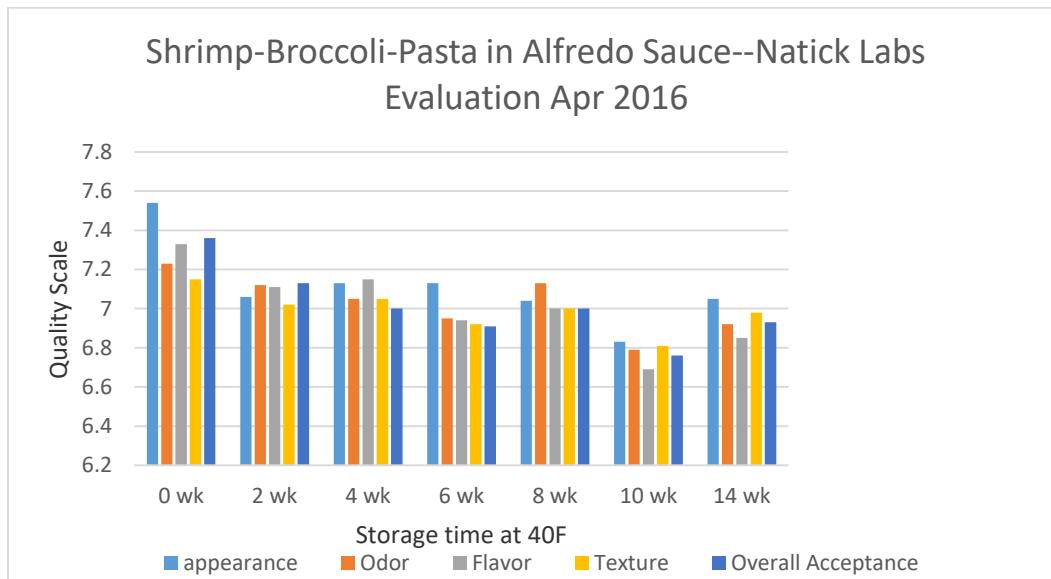


Figure 10 - Natick Soldier Center Internal Sensory Panel Results for a MAPS products over 14 week shelf-life.

Hedonic:	(1) Dislike Extremely (2) Dislike Very Much (3) Dislike Moderately (4) Dislike Slightly (5) Neither Like nor Dislike (6) Like Slightly (7) Like Moderately (8) Like Very Much (9) Like Extremely	No significant difference ($p > 0.05$)
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Table 2 - Camp Edwards Evaluation Results

Sample Description	Valid N	Mean	Median	Min	Max	Std Dev	CI	Std Err	Variance
Salmon and Pasta	101	5.76	6	1	9	2.05	0.4	.20	4.20
Shrimp and Pasta	98	5.77	6	1	9	1.99	0.4	.20	3.98

Enhance Collaboration and Technology Transfer (Objectives 8 & 9)

US Army Natick scientists had frequent communications with 915 Labs and WSU to develop a very aggressive road map of the MATS pilot and production systems for the global market. Natick will meet with Australian Defense Department in Dec 2016 to establish collaboration of implementing MATS processing for Australian military and industry.

Publications and News

The center has been gaining extensive news coverage since acceptance of the grant. All news items are listed on the center's website [\[https://labs.wsu.edu/coe/newspublicationslinks/\]](https://labs.wsu.edu/coe/newspublicationslinks/) and are updated on a continual basis. News directly concerning our center as well as industry relevant news is posted on the page. Some of the most recent news items are listed below.

- Higgins, Kevin T. "Novel Technologies Provide Options to Conventional Pasteurization, Sterilization and Drying." *Food Processing*. 23 Aug. 2016. Web. [\[http://www.foodprocessing.com/articles/2016/technologies-pasteurization-sterilization-drying/?show=all\]](http://www.foodprocessing.com/articles/2016/technologies-pasteurization-sterilization-drying/?show=all)
- Kantor, Sylvia. "Investment in Novel Technologies Advances Food Safety, Quality." *United States Department of Agriculture - National Institute of Food and Agriculture*. 8 July 2016. Web. [\[https://nifa.usda.gov/blog/investment-novel-technologies-advances-food-safety-quality\]](https://nifa.usda.gov/blog/investment-novel-technologies-advances-food-safety-quality)
- Tang, Juming. "Feeling the Heat." International Innovation. 16 June 2016. Web. [\[http://www.internationalinnovation.com/feeling-the-heat/\]](http://www.internationalinnovation.com/feeling-the-heat/)
- Weaver, Matthew. "WSU Establishes Food Processing Center." Capital Press. 19 Apr. 2016. Web. [\[http://www.capitalpress.com/Research/20160419/wsu-establishes-food-processing-center#.V9BQUo172uQ.wordpress\]](http://www.capitalpress.com/Research/20160419/wsu-establishes-food-processing-center#.V9BQUo172uQ.wordpress)
- Rounce, Kevin. "WSU Center of Excellence." Washington Ag Network. 14 Apr. 2016. Web. [\[http://washingtonagnetwork.com/2016/04/14/wsu-center-excellence/\]](http://washingtonagnetwork.com/2016/04/14/wsu-center-excellence/)

A number of publications have resulted from the center's activities we well and are listed below:

- Sablani, S. and Tang, J. 2016. Packaging for Microwave Processes, In Encyclopedia of Agricultural, Food, and Biological Engineering, Second Edition DOI: 10.1081/E-EAFE2-120053752
- Bornhorst E.R., Tang, J., Sablani, S., Barbosa-Canovas, G.V. 2017. Development of model food systems for thermal pasteurization applications based on Maillard reaction products. *LWT-Food Science and Technology* 75:417-424.
- Cao, L., Rasco, B.A., Tang, J., Liu, L., Lai, K., Fan, Y. Huang, Y. 2016. Effect of freshness on the cook loss and shrinkage of grass carp (*Ctenopharyngodon idellus*) fillets following pasteurization. *International Journal of Food Properties* 19(10):2297-2306.
- Bhunia, K., Ovissipour, M., Rasco, B., Tang, J., Sablani, SS. 2016. Oxidation-reduction potential and lipid oxidation in ready-to-eat blue mussels in red sauce: criteria for package design. *J. of Food Science and Agriculture*.
- Bhunia, K., Sablani, S.S., Tang, J., Rasco, B., 2016. Non-invasive measurement of oxygen diffusion in model foods. *Food Research International* 89:161-168.
- Bhunia,K., Zhang, H., Liu, F., Rasco, B., Tang, J., Sablani, S.S. 2016. Morphological changes in multilayer polymeric films induced after microwave-assisted pasteurization. *Innovative Food Science & Emerging Technologies* 38:124-130. Presentation at IFT, 2016: by Juming Tang, Shyam Sablani, Doris D'Souza, Denis Gray, and Kevin Peterson
- D'Souza, D. H.* 2016. Heat Inactivation of Select Foodborne Pathogens: How Should We Select the Target Microbe? Proceedings IFT 2016, Chicago, IL, July 17, Invited Speaker. D'Souza, D. H.* 2016. Application of Cultivable Enteric Viral Surrogates to Determine Inactivation by Processing Approaches. Proceedings IFT 2016, Chicago, IL, July 17, Invited Speaker.
- Dr. Ross is currently finalizing a manuscript regarding salt detection and perception using both sensory methods and the electronic tongue for submission to the Journal of Food Science. (Ross)

Other Related Work

Industrial Alliances (Objective 8)

Juming Tang, Denis Gray, Kevin Petersen of 915 Labs and the other team members have had several discussions regarding the timing for an effective kick-off meeting and formation of the Microwave Industrial Alliance (MWIA). Tang and Petersen visited Amazon Fresh, Costco Headquarters, and several food companies on the west side of Washington state in May 2016. They also visited the Washington State University Cooperation Relationship Office in Seattle. We have tentatively decided to hold the meeting on March 15-16, 2017 in Seattle, WA. This will be a joint meeting (kick-off and formation of MWIA) to allow all principal investigators and

their graduate students/associates an opportunity to share research results as well as directly interact with food companies. A select group of industrial partners will be invited to learn about the latest MATS/MAPS updates, advancements, research findings, and refine the goals and develop structures for the MWIA. Development of materials to assess progress of these key components is underway.

Center Research Collaboration and Communication (Objective 9)

Collaboration among the center's Principal Investigators has been very steady since the grant's beginning. Bi-monthly meetings have been held every other month in which all PI's participate and discuss their respective lab's work, progress, bottlenecks, and future plans. In addition, a Center of Excellence website has been developed and launched to relay the center's ideas, goals, events, news, and information. It is continually updated with the latest news items and will serve as a central location for many research items. As relevant news and publications are written as a result of the center's activities, they will be posted on the site. The site also contains a secure section that is only open to the research members and serves as a location for collaboration and information sharing. The website is built so that it can be expanded on as the center grows in the future. The website can be found at: "<https://labs.wsu.edu/coe/>".

International Collaborations (Objective 9)

Massey University, in partnership with the New Zealand food industry, is prepared to establish a novel thermal food processing center based on MATS and MAPS

(<http://www.foodqualitynews.com/R-D/Massey-University-looks-at-novel-food-processing-technology>). Dr. Abby Thompson, Director of Riddet Innovation at Massey Institute of Food Science and Technology, visited Washington State University in September 2016 and initiated discussion for research collaboration on nutritional aspects of MATS and MAPS. Massey University hosted a workshop in October 2016 for 50 representatives of the New Zealand Food Industry to interact with 915 Labs in a discussion to acquire MATS and MAPS systems (<http://www.scoop.co.nz/stories/SC1610/S00026/massey-investigating-novel-food-technology.htm>).

The Australia Ministry of Defense allocated \$7.2 M in March 2016 to establish a demonstration and research center for MATS and MAPS. The center will be operated jointly between the Australia Defense Science and Technology Group (DSTG), the University of Tasmania, and CSIRO (<http://www.minister.defence.gov.au/2016/03/09/minister-for-defence-7-2m-for-new-food-processing-technology-in-tasmania/>). Representatives from DSTG, the University of Tasmania, and several leading Australia food companies participated in WSU boot-camps in 2016. WSU will host a team from the University of Tasmania on December 14-15, 2016 to discuss a joint research agreement.

We plan to collaborate closely with Massey University and University of Tasmania focusing on researching nutrition retention and consumer acceptance of MATS and MAPS processed ready-to-eat meals. We will invite their scientists and industrial partners to attend future Center and MWIA annual meetings.

Graduate Student Research (Objective 10)

Washington State University

The Graduate School of WSU has provided four Research Assistantships (RAs); one assistantship to each co-PD Tang, Sablani, Ross and Gallardo. In addition, the School of Food Science, the School of Economic Sciences and the Department of Biological Systems Engineering have supported four RAs. In total, 11 doctoral students have been recruited in year one, and are working on this project. Additional students are being supported through different funding sources. We plan to recruit additional 5-6 students in the coming years to work on this project.

Dr. Tang: Two new full-time students were recruited for the project. YoonKi Hong started work in August of 2016 and will focus PhD work on process simulation. Zhi Qu also started in August of 2016 as a PhD student and will focus work on food quality of MATS and MAPS processing. Three other students continued to work on the project: Ellen Bornhorst, Deepali Jain, and

Jungang Wang. Their research interest focus on model foods for quality evaluation, computer simulation, and food quality respectively. A final visiting scholar, Thammanoon Auksornsri, from Thailand has worked on the project looking into model food for thermal processing applications.

Dr. Sablani: Three new students began work on the project; Juhi Patel: package gas barrier properties and shelf-life of MATS and MAPS processed products, Chandrashekhar Sonar: time-temperature integrator for evaluation of food safety of MAPS products, and Saleh Al-Ghamdi: Polymeric packaging for MATS and MAPS processes.

Dr. Ross: Since March, one new PhD student has been recruited to work on this grant, Sasha Barnett. She started her PhD program in Food Science in August 2016. In preparation for her participation in this research project, Sasha attended the Microwave Processing boot-camp held at WSU in August 2016. Sasha's PhD research will focus on the question of salt in processed products (objective 3), with this research question being approached from both a food chemistry and sensory science perspective. Also on the project, are Dr. Charles Diako, a post-doctoral associate, and Ben Bernhard, a Food Science PhD student. Both individuals will work toward the achievement of objectives 3b and 3c, specifically the analyses of chemical and physical attributes of MATS and MAPS processed food products. The sensory facilities and food chemistry lab are well established and time has been spent further refining appropriate methods of analysis and ensuring that the appropriate infrastructure is present to support the research.

Dr. Gallardo: During the Summer 2016 – Juan Luo. She conducted most of the literature review. Juan did not continue because she was not admitted to the interdisciplinary program at the WSU graduate school. During the Fall 2016 – Two students were assigned to work for this project. Shuhong Zhang and Kara Grant. Shuhong had emotional and health issues that deterred her to make a significant contribution to the project. Kara conducted part of the literature review, focused on the approach. She designed and implemented the survey, tabulated data and ran the preliminary statistical analyses. Spring 2017 – A first year PhD student was recruited Qi Zhang. A third student is to-be-determined by the WSU SES graduate committee.

North Carolina State University

Dr. Gray: Efforts to recruit a part-time research assistant/post-doctoral student have begun. Expect to have student ready by beginning of year 2 when primary data collection will begin.

University of Tennessee

Dr. D'Souza: Student recruitment efforts are ongoing and will continue to develop in the upcoming year.

Plans for 2017

Dr. Tang - Washington State University

We will complete the assembly and testing of the improved MAP system at WSU, making it ready for demonstrations, boot-camp training, and product testing by May 2017. Finalization of computer simulation models for process development will be completed. WSU will also assist 915 Labs in the design of commercial MAPS for food companies and support the testing of food products by food companies and 915 Labs for demonstration. We will offer two boot-camps in 2017, will recruit two new PhD. students for this project, and initiate Microwave Industrial Alliance.

Dr. Sablani - Washington State University

Recruitment of one more student in the upcoming year. Design preliminary structures for tray and pouches and work with polymer companies for fabrication of novel structures and evaluate them with MATS and MAPS processes. Design and perform shelf-life and sensory studies to understand the influence of package gas barrier properties on the physical and chemical properties of packaged foods and lay the framework for design of time-temperature indicator for shelf-life determination of MAPS products.

Dr. Ross - Washington State University

For the upcoming year, we will work toward the achievement of objective 3. We will strive to answer the research questions posed in our research proposal, including the role of salt in processed foods and as well as evaluate the sensory, nutritional and physical properties associated with microwave processed foods. We will also continue to participate in the grant bi-monthly conference calls.

Dr. Gallardo - Washington State University

We plan to implement the pilot survey at the national level. In the survey we plan to include population segments in both urban and rural areas. We expect to obtain solid information on price premiums and potential market share for MAPS ready to eat meals.

A “field experimental study” will be executed in 2017 (exact date to-be-determined). In this study we will combine sensory taste testing with experimental auctions. That is, participants will have the opportunity to experience the MAPS food product and submit bids for it based on their preference. This will take place at the Food Innovation Center – Oregon State University, Portland, OR.

Dr. D'Souza- University of Tennessee, Knoxville

To continue our efforts in developing and validating MAPS processes to ensure food safety and inactivation of viral and bacterial pathogens, surrogate microorganisms that mimic the heat inactivation behavior of hepatitis A virus in foods will be sought. Their thermal inactivation

kinetics will be determined and applied to select food products. A graduate student and/or undergraduate help will be recruited and trained to meet this goals.

[Dr. Gray - North Carolina State University](#)

Consistent with our proposed strategy, the evaluation effort will begin to focus on output/outcome evaluation during years 2-4. Our efforts in these areas will use more structured and quantitative methods (*e.g.*, questionnaire, bibliometric and patent analyses) and will assess the extent to which the outcomes specified in our logic model have been produced. Primary data will be collected from significant stakeholder groups including firms participating in our MWIA. For instance, we will assess whether we have been able to increase FDA filings and acceptance, firms have installed MAPS systems in plants, gotten acceptance of developed packaging materials, followed through on use of new formulations or if individuals attending our courses or receiving our materials have gained new knowledge and/or changed their behavior (new product concepts or work with pilot facilities).

[Dr. Tom Yang - US Army Natick Soldier Center](#)

We plan to leverage Natick's own project accomplishment on MATS to improve the product quality, varieties, and nutritional enhancement. Will also collaborate with Mitsubishi Gas Company-USA and the Center of Excellence (Dr. Sablani) to explore the oxygen scavenging film/pouches to extend the shelf life of both MATS and MAPS products; specifically aiming at 3-year shelf stability of quality and nutrients.

Conclusions

For the first seven months of the project, the center has been very active in recruiting new members and students, acquiring equipment and instrument, clarifying and verifying principal instigator-specific goals and roles, in addition to conducting research activities proposed for year one. It is evident that within the first year of the grant, much has already been accomplished by all members of the group. This success will be followed through in the upcoming years of the project's lifespan.