



Research & Development Associates
Fall Forum

November 2009



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

New Technologies for
Shelf-stable Foods –
Successful Efforts of S&T
Consortia

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Senior Science Advisor
DoD Combat Feeding Program

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Advantages of Novel Preservation Technologies



- “Fresher” taste and texture
- Pasteurization with minimal chemical and physical changes; nonthermal HPP many commercial products
- Possible Sterilization by combination processes (Pressure + Heat) Note: Military shelf life - 6 mos at 38C & 3 yrs at 27C
- Improved nutrient content
- Maintain higher quality of extended shelf life
- New product categories – nutraceuticals/ use natural additives only for “clean labels”
- Rapid Volumetric Heating by Microwaves gives processed foods “freshly cooked” attributes – not “retort flavor” meat

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- 1) Initial Commercialization of HPP was for pasteurized products with enhanced sensory properties and more fresh-like character than thermally processed counterparts. Now a \$2 B market.
- 2) Food safety is a prime motivator, but added shelf life and processing efficiencies (seafood e.g.) may be a bonus.
- 3) First Filings under CFR for low-acid foods were made for mashed potatoes by a Pressure Assisted Thermal Process (PATS) in a retort pouch Sep. 2008 by the HPP DUST Consortium at NCFST, accepted Feb. 2009 and for MW sterilization in a single-serve polytray Oct. 2008 by the MW DUST Consortium at Washington State Univ.; 2nd revision Aug. 2009 accepted by FDA 7 Oct. 2009.

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<u>PROCESS</u>	<u>CAPABILITY</u>	<u>CONSTRAINT</u>
Microwave retort	Rapid heating of prepackaged solids; can also do in flow system mode	Uniformity/depth of penetration; Incompatible w/foil laminate packaging
RF	Rapid heating of packaged solids	Uniformity & compositional dependence; foil lid stock ok
High Pressure	Instant transmission in fluids & solids; Treat any food in flexible containers	Does not inactive spores except at high temp; Equipment capital cost

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Regulatory Criteria for Novel Processes



Regulatory Approval

- Refrigerated Foods for Pasteurization – GMP/HACCP
 - Target organisms for specific foods – USDA lead
- Acid & Acidified Foods – 21 CFR 114
- Low-acid Foods – 21 CFR-113
- Dairy & Egg Products – USDA & State Regulations

u Novel Thermal & Nonthermal Processes IFT Task Order to FDA

**U. S. Food and Drug Administration
Center for Food Safety and Applied Nutrition
June 2, 2000**

“Kinetics of Microbial Inactivation for Alternative Food Processing Technologies”

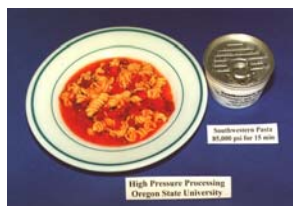
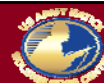
<http://vm.cfsan.fda.gov/~comm/ift-toc.html>

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High Pressure Processing of Low-acid Food FY00-08 DUST



Project Objective:
Optimize and validate
High Pressure
Processing to ensure
safety and nutritional
value of fresh-like
rations and commercial
items

**Partners – Hormel,
Unilever, Basic
American Foods,
ConAgra, Baxter ,
NCFST, Gen. Mills,
MARS/Masterfoods**

**Precursor - Oregon
State Univ. Acidified
Products
Demonstration
Contract 1999-2001**

**Avure
Technologies –
Prime Contractor**

**2002 IFT Industry
Achievement Award**

**2005 FLC Tech.
Transfer Award
Shared by C. P.
Dunne of Natick**



Demo Site – NCFST of IIT

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Pressure Assisted Thermal Sterilization (PATS) process



- Initial chamber temperatures between 60-90°C combined and pressures 500-800 MPa
- Internal **compression heating** can develop process temperatures of 80-130°C inside the product
- **Accelerated sterilization** due to pressure and temperature combination
- HPP DUST consortium filed PATS mashed potatoes with FDA in Sept 2008; accepted Feb. 2009

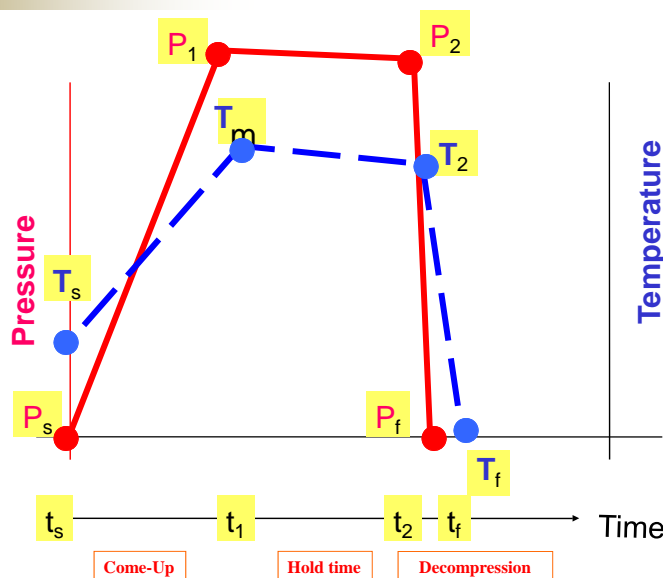
IMPROVED QUALITY

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HPP pressure/temp. cycle



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What we know now about HPP



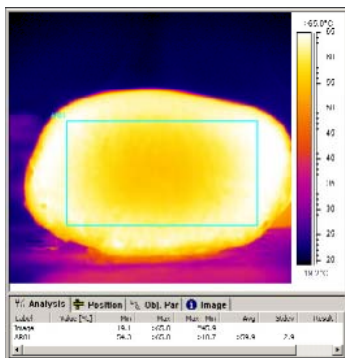
1. Increasing initial temperature for high pressure treatment will increase effectiveness for vegetative bacteria. Best above 40°C. Significant bacterial injury fraction.
2. Bacterial spores are not easily inactivated by high pressure, but shelf-stable processes can be applied with acid pH foods (demonstrated by Oregon State U. in '90s).
3. Combination preservation strategies, e.g. using temperature or additives in combination with HPP are needed to produce true shelf stable low- acid foods. First filing under CFR 114 was made in Sep. 2008 for Pressure Assisted Thermal Sterilization (PATS) of mashed potatoes by HPP DUST group with NCFST FCE #02930.
4. Surrogate organism spores now used to validate classic thermal retort processes are more sensitive to combinations of pressure and elevated temperatures than primary pathogen of concern – *Clostridium botulinum*; strains of that organism differ in sensitivity.

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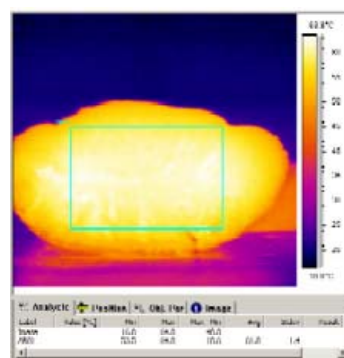
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Model HPP Compression Heating for Sterilization



Potato after pre-heat to 70°C in water bath



Potato after HPP at 688 MPa; T= 100°C



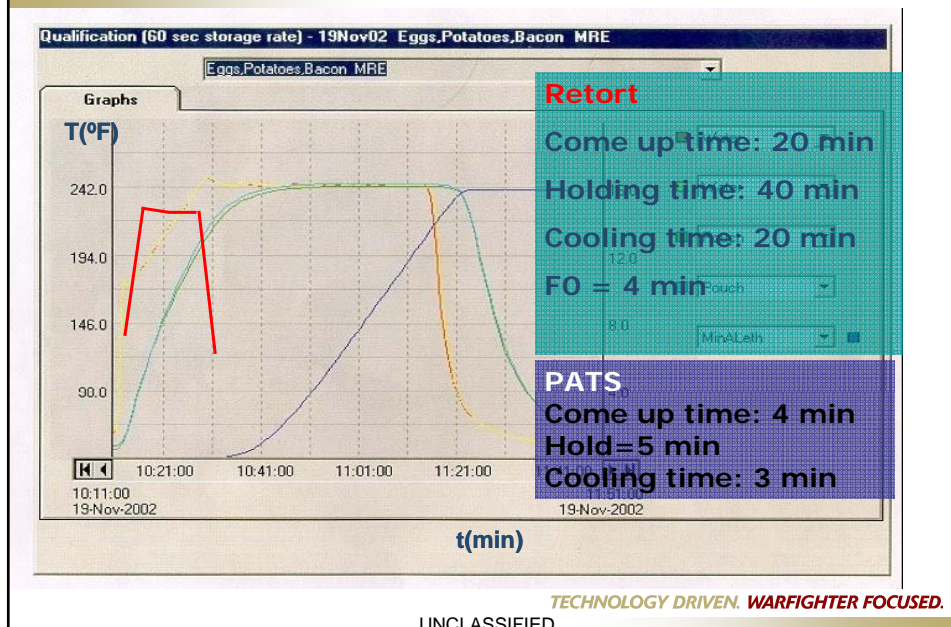
NCFST

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Process times: Retort vs. PATS



Critical Control Points PATS Sterilization



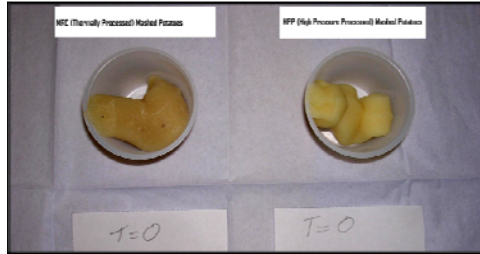
- Packaging Factors – MRE quad foil laminate pouch, dimensions - 4 ¾ in. X 7 ¼ in. , fill weight – max. 146.5 g, min. 135.5 g, head space < 1 cc.
- Formulation factor – Russet potatoes with defined preparation process and formula, known a_w
- Preheat to product temp. 90 °C,
- HPP applied pressure – 690 MPascals (100,000 psi)
- Holding time at pressure - 3min.
- Min. process temp. 121 °C
- Did inoculated pack bio-validation with 3-strain cocktail of pressure and temperature resistant strains of *C. botulinum*

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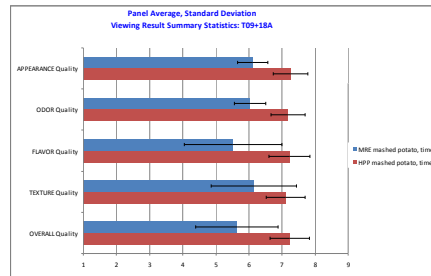


Initial Technical Sensory Panel PATS vs. MRE Mashed potatoes



**Ratings are on 9-point
Quality scale. N = 12-15**

**Mean quality scores:
MRE = 5.6
PATS = 7.2
Shown at IFT 2009
EXPO Innovation Award**



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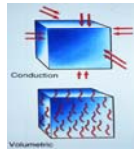
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Microwave Processing FY01 - 08 DUST Project at Wash. State Univ.



**Microwaves sharply
reduce process time**



**Project Objective: Develop an advanced
thermal processing technology to produce
high quality MRE™s**

Partners:
Kraft, Hormel, Rexham, Ferrite
Components, Graphic Packaging Co.,
Ocean Beauty Seafoods, MARS Foods US

**Kraft mac & cheese
processed by new and
old methods**



Microwave Sterilized
Wild Alaska Salmon

**A new thermal processing technology to bring quality meals
to our Warfighters in the 21st century**

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New 40 Tray Continuous MW Sterilizer at WSU



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Critical Control Points MW Sterilization



- Packaging Factors – tray dimensions, composition & orientation; fill weight – target 10.6 oz.
- Formulation factor – Instant mashed potato flakes, Max. salt 0.5% (determines heating rate)
- Belt Speed of MW processor – 2.1 ft/min (sets residence times)
- Minimum system pressure = 35 psig
- Preheat zone – initial product temp. 10 °C, time 40 min, final product temp. 75 °C
- MW Heating zone – time 5 min., final temp. 126 °C; Target $F_0 = 6$
- Reflected energy of 4 MW elements measured with directional couplers at > minimum target set for each zone
- Holding zone – time 5 min., water temp. 123 °C

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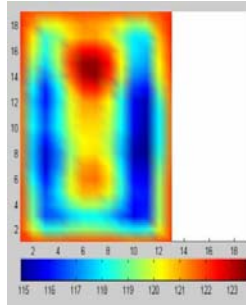
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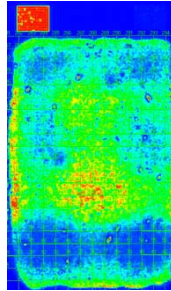
Critical Issue MW Sterilization
Stability of MW field and cold spot ID



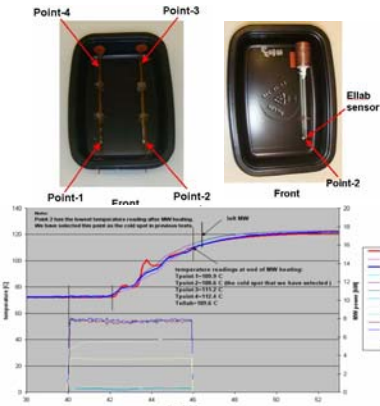
Computer Simulation
Heat transfer model



Chemical Marker
Vision System



Validate and Monitor Cold Spot In MW Sterilizer - F_0 with ELLAB data tracers

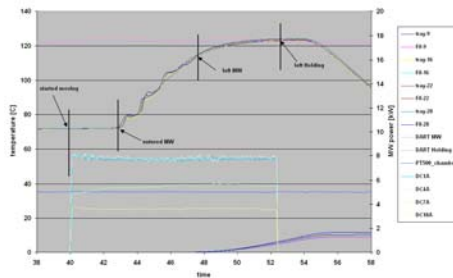


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WSU Testing of Mashed Potato Sterilization



Heat Penetration with
Ellab sensors



Inoculated pack study with
indicator spores PA 3679

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100 kW 915 MHz Cylindrical Heater
at YAMCO used in FDA filing



**Sweet Potato Puree Filing
Accepted - Now in production**



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100 kW 915 MHz UltrAseptics
system at NCSU



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2 month sensory shelf life test MW salsa con queso – 80 & 100 F



Ref. is Tostitos product in center

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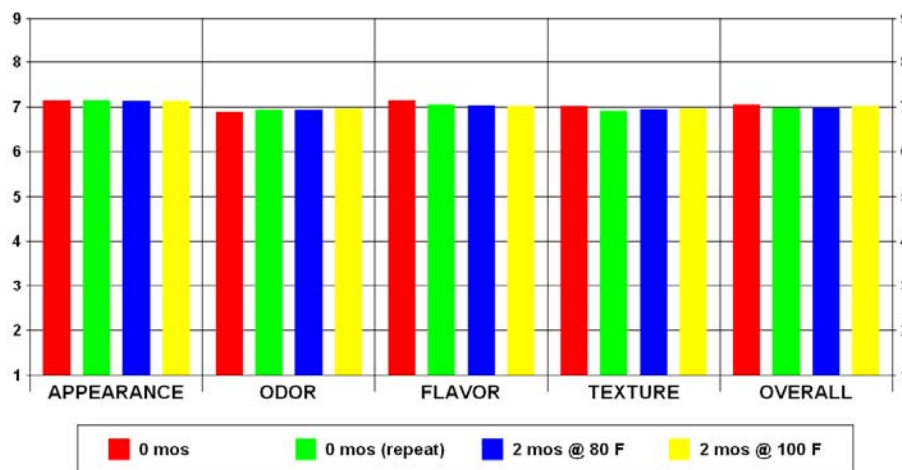
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Sensory: 9-pt Quality Ratings by Technical Panel



Continuous Flow Microwave Salsa Con Queso 0 months (initial) vs 2 months Storage



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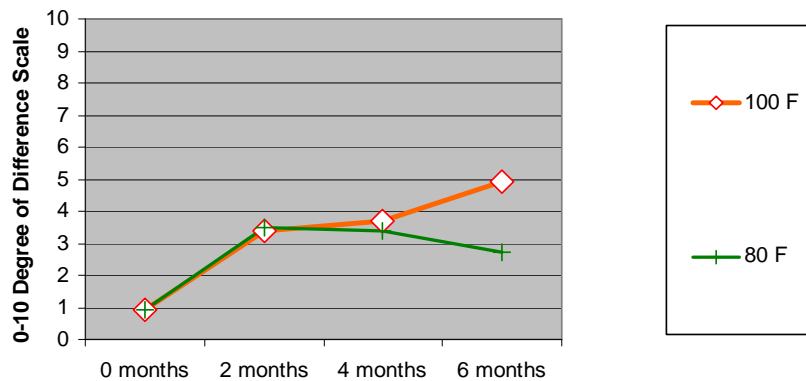
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Sensory Ratings: 6 months storage



**Degree of Difference from Reference, 6 months storage--
80 and 100 F (values >3-4 typically are noticed by
consumers)**



Note Reference Tostitos sample held at 40 F

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USDA CSREES Integrated Food Safety CAPPS Grant 2004-8 Demonstration Product Choices



- Ohio State University – Ohmic – chicken chow mein
 - PEF with Genesis Juice - apple juice
 - High Pressure Processing – ranch salad dressing in plastic bottles and pouches with Kraft
- North Carolina State Univ. – Continuous MW processing – first looked at sweet potato puree – helped get FDA acceptance of the process in June 08 at N. Carolina producer YAMCO, then did salsa con queso for CAPPS
- Washington State Univ. – Static MW sterilization – beef slices in gravy
- **USDA NRI grant award 2008 -10 to CAPPS for Quality of Foods Processed Using Selected Alternative Processing Technologies; diced tomatoes by 4 technologies**

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ISSUE – Adoption of New Processing Technologies



PROCESS Novelty

- Industry must weigh quality benefit vs. costs
- Sell Convenience & Quality
- Consumer acceptance
- “Fresh” Labeling issue with FDA; “natural” is alternative
- Safety must be a given

Determining Process Capability

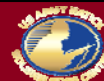
- Must optimize formulation and pre- processing steps
- Go beyond “ squeeze & taste”
- Reliability & Repeatability
- Regulatory Boundaries – easier first: Acid vs. Low-acid CFR 113/114 ; Refrigerated vs. Shelf Stable
- Meet shelf life goals with proper packaging
- HACCP / GMP for pasteurization

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Criteria for Success – Natick Tests



Sensory Acceptance

- Consumer acceptance - 9 point hedonics with suitable reference benchmarks – both fresh & commercial or military shelf stable
- Specific attribute trained panels - shelf- life monitoring

Chemical / Physical / Biochemical Stability

- Color and texture
- pH & enzymatic activity
- Sugar/organic acids / aldehyde profiles – HPLC
- Reaction products- pyroglutamate from glutamine,
 - Furals from sugars and ascorbate
- Nutrient content / nutritional analysis
- Phytochemicals content, e.g. phenolics

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Opportunity areas for High Pressure Processing or Microwave Sterilization



- Ready-to-eat or heat & serve meat/meal items
- Seafood – self shucking bonus with HPP
- Desserts, puddings, & dairy items
- Pastas with cheese or savory sauces
- Whole muscle meats, partially pre-cooked
- New market categories, e.g. avocado products and other “fresh” items with extended shelf life
- Functional foods
- Potatoes and other starches, esp. for breakfast – first target for PATS & MW sterilization was mashed potatoes

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Ultimate Consumer Testing



- Do annual field test with Warfighters comparing prototype new processed ration components integrated into meals with baseline of current MRE™s.
- Goal is to replace low preference items with better new ones in selections of 24 menus for next MRE™ procurement cycle
 - PATS Potatoes vs. current MRE™ retorted mashed potatoes done Aug. 2009
 - Preliminary results gave similar preference ratings – 6.2 on 9 pt.



* Photos from 2007 MRE™ field test, Ft. Bliss, TX

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R & D Needs for Optimization of MW & HP Processes



- 1) Address slow preheating step in pressure- assisted thermal sterilization (PATS) with MW preheating.
- 2) Need high barrier, non-foil packaging compatible with both MW and HPP processes.
- 3) Need improvements in both equipment and process monitoring devices to measure and record critical temperatures in cold spots of food packages in both MW and HPP vessels. Miniature, but very rugged shielded data loggers are a major research need. Some promising ones are being tested now.
- 4) To maintain the quality improvement from rapid MW or HPP processes, more rapid cooling at end of process cycle is desired.

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Novel Processes: Packaging Considerations Needed to Maintain Quality Advantages



- High Pressure – Almost any flexible container in batch mode. Flexible pouches make best use of volume of treatment chamber. Major advantage is scalability; actually can increase efficiency with bulk packs. Headspace air and potential delamination at high P&T are issues.
- Microwave batch sterilization processing can not have foil laminates. EVOH barrier material may serve here because of short time exposure at highest temps. Advanced Nanocomposite polymer films offer promise.
- Packaging configuration may effect process choice: MW alternative may be best in semi rigid polytray; HPP is better in pouches to get highest vessel loading capacity. HPP is easily scalable to institutional - sized pouches without extending processing time.

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Next Steps for Novel Sterilization



- High pressure sterilization consortium forming at NCFST
 - Will have upgrade of current 35 L system with next generation HP sterilizer built by Avure Technologies under contract with NSRDEC.
 - Will develop FDA filing protocols for more complex foods.
- MW Sterilization at Washington State Univ.
 - Will meet in Dec. 2009 to discuss with industrial partners formation of new consortium to replace sun setting MW DUST consortium
 - WSU working under contracts to NSRDEC and Print Pack to process in single serve pouches and to sterilize more heterogeneous foods and whole muscle meat and seafood.

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Acknowledgements



- Natick – Tom Yang, Richard Lopes, Douglas Grant (Summer HS Faculty), Melvin Carter, Linn Hallberg, Dr. Richard Beckwitt (Framingham State College faculty) and Alan Wright & NSC taste panel members
- Oregon State University – Dan Farkas & Marcia Walker (now at Avomex- Fresherized Foods)
- Avure Technologies – Ed Ting, Chris Baer, Curtis Anderson & Pat Adams
- North Carolina State Univ. – Josip Simunovic and Ken Swartzel
- WSU – Juming Tang, Gustavo Barbosa and Frank Younce
- Ohio State Univ. – Bala Balasubramaniam
- USDA Grants to CAPPs – Sudhir Sastry OSU Lead
- NCFST/IIT – Cindy Stewart, Eduardo Pazteca

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Process Authorities for Novel Sterilization



- High pressure PATS – Larry Keener
International Product Safety Consultants
Seattle, WA - LKEENER@aol.com
- Filing document was over 200 pages with data supporting each element of the PATS process.
- MW Sterilization – Kenny Lum
Seafood Products Association
Seattle, WA - www.spa-food.org
- Electronic filing with 5- page document first, followed by extensive data set. FDA treats as regular thermal process with burden of proof centering on process uniformity.

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www.orst.edu/dept/foodsci

Last workshop in Beijing China Oct. 14 -16, 2009
Next in Montreal, Canada Oct. 12-14, 2010



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