## Extension Fact Sheet

# Microwave Sterilization Technology


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## 1. How does microwave sterilization heats food?

Microwave sterilization is a thermal process [1]. It delivers energy to the food package under pressure and controlled temperature to achieve inactivation of bacteria harmful for humans.

Most processed foods today are heat treated to kill bacteria. Prolong exposure to high heat often diminishes product quality. Microwaves interact with polar water molecules and charged ions. The friction resulting from molecules aligning in rapidly alternating electromagnetic field generates the heat within food. Since the heat is produced directly in the food, the thermal processing time is sharply reduced. The color, texture and other sensory attributes of foods processed by microwave sterilization are often better compared with those of conventionally retorted foods while meeting microbial safety requirements. Currently, researchers are generating scientific and engineering information to support regulatory acceptance of microwave sterilization technology for industrial applications.

US Federal Communication Commission (FCC) allocates 915 MHz and 2450 MHz bands for industrial and domestic microwave heating applications. The microwave sterilization technology developed at Washington State University uses the combination of 915 MHz microwave and conventional heating to improve heating uniformity.

## 2. What are current industrial applications of microwave heating in North America?

A 300 kW MW oven with conveyor for continuous heating and drying applications.

Microwave ovens operating at 2450 MHz are common appliances in the households of USA and around the world. Hundreds of 2450 and 915 MHz systems between 10 to 200 kW heating capacities are used in the food industry for precooking bacons (e.g., used in Subways restaurants), tempering deep frozen meats when making meat patties, and precooking many other foods products [2, 3, 4, 5]. Commercial systems performing microwave pasteurization and/or sterilization of foods are currently available in Europe (e.g. TOP's Foods); however, the use of microwaves in USA to produce pre-packaged shelf stable foods is pending upon FDA acceptance.

The FDA acceptance has been recently granted for a sweet potato puree product sterilized using continuous flow microwave processing and aseptic packaging. This first industrial implementation of continuous flow microwave sterilization for low acid products has been implemented by Yamco in Snow Hill, NC.

## 3. What are the advantages of this technology and how does this technology benefit consumers?

There are a number of advantages of this novel and versatile food processing technology:

- A significant **reduction in the thermal processing time** while making food safe for consumption is the major advantage of microwave sterilization processing.

- The reduction in processing time results in more **fresh-like taste and texture**, and improves **visual appeal** of the food.
- The reduction of processing time may also potentially increase retention **of nutrients** in the thermally processed foods.
- **Instantaneous turn-on and off** of the process allows for a more precise process control, better energy usage, and cleaner working environment in food processing facilities.

- The use of post **packaging processing** could benefit manufactures in reducing spoilage, eliminating refrigeration costs, and provide safe foods for consumers.
- The microwave sterilization/pasteurization technology offers great opportunities for innovative **food companies** seeking to develop new food products which have not been possible due to limitation of severe heat in conventional retorting**.**

## 4. Can microwave sterilization be used for processing all foods?

Many heat sensitive products made by conventional thermal treatments often result in considerable changes in the quality of the food and make these products unacceptable for consumption. The shorter time and more uniform volumetric heating of microwave processing offers major advantages over conventional steam retorting in producing **a wide range** of high quality shelf-stable food products: liquid, semi-solid and solid. At Washington State University, products such as salmon fillets, macaroni and cheese, massed potato and beef in gravy have been processed with proven safety; see examples reported in Guan et al., 2003 [6] and Tang et al., 2008 [7]. Advantages of microwave processing for a certain food product will derive from the specific product properties, state, shape and thickness as well as the processing system design.

The 915 MHz Single-Mode Microwave Sterilization Technology developed at Washington State University can reduce the heating time of packaged foods to 1/4 to 1/10 of time required for conventional methods. The systems can be designed to work in batch or continuous mode. Compared with conventional food processing, microwave sterilization could potentially improve sensory, appearance and nutritional value [8].

Microwave sterilized salmon and rice

Conventionally processed (canned) salmon

At North Carolina State University, processes have been developed for sterilization of homogeneous [9] and particulate-containing [10] high and low acid food products. A wide variety of foods can benefit from this type of processing, provided they can be pumped and are receptive to microwave treatments.

The uniqueness of microwave sterilization technology is that it can be applied to both solid and liquid foods as well complete meals sealed in multi-compartment trays.

**As with every processing technology, there may be some food products that have better performance and greater consumer acceptance while using other processing technologies.**

## 5. Is food processed in microwave safe for consumers?

Yes, the food processed by this novel technology is safe for consumption. "Because the microwave energy is changed to heat as soon as it is absorbed by the food, it cannot make the food radioactive or contaminated. When the microwave energy is turned off and the food is removed from the oven, there is no residual radiation remaining in the food. In this regard, a microwave oven is much like an electric light that stops glowing when it is turned off." [11].

## 6. What is the shelf life of microwave sterilized product?

The shelf life of a product is determined by its microbiological safety and sensory attributes. In general, microwave sterilization can achieve the same reduction of bacterial population as conventional retorting. The microwave sterilization process awaits regulatory acceptance that will make sure that sterilization of food is complete. Products intended for microwave sterilization are usually packaged in plastic trays or pouches. The ability of plastics to withstand oxygen permeation will affect the organoleptic or sensory acceptance of the product during storage. Normal shelf life expectancy of microwave-sterilized products prepackaged in plastic containers or pouches is 2-3 years or longer. With innovative plastic technologies coming to the market, the new generations of plastics may increase the expected shelf life even longer.

## 7. Are microwave sterilized products commercially available?

Yes. In-package microwave sterilized products are currently available in Europe. Examples of microwave sterilized products include different pasta dishes, pasta sauces, rice dishes, main dishes etc.


*(http://www.topsfoods.com)*

## 8. How are microwave processed foods stored?

Microwave sterilized foods can be stored at ambient temperatures and re-heated in the common household microwave prior to consumption. These products do not require refrigeration thereby cutting down the cost for food processors and distributors, as well as saving valuable refrigerator/freezer space for consumers.

## 9. Is commercial scale equipment available?

To the best of our knowledge the commercial equipment for microwave sterilization is currently available in Europe (Belgium, Holland, and Italy). US manufacturers have several types of microwave heating systems for food tempering, de-freezing and baking, as well as pasteurization and drying of semi-liquid products. None of this equipment is designed for high temperature microwave sterilization. The scale-up pilot microwave sterilization systems for prepackaged foods are currently available at Washington State University and for pumpable foods at North Carolina State University. Industrial Microwave Systems in Morrisville, NC is the

supplier of commercial microwave processing equipment for continuous flow thermal processing (heating, drying, pasteurization and sterilization) of foods and biomaterials.

## 10. Is microwave sterilization equipment safe to operate and/or is it safe for environment?

Yes, with using approved equipment and following established relevant state regulations, the microwave equipment is safe to operate and is safe for environment. Microwaves are confined in metal enclosures. Typical examples are domestic microwave ovens. Both domestic microwave oven and industrial microwave system are designed to meet or exceed stringent requirements for microwave leakage (5mW/cm$^2$ measured 5 cm way from any part of the unit) [12].

## 11. How economical is microwave sterilization processing?

Conventional industrial heating method using steam or electric heaters may be more efficient compared to microwave heating in terms of converting the energy into a useful heat. It is difficult to estimate the total economical value for microwave sterilization technology when considering the complete chain from food product manufacturing, storage to distribution. But new values are added by using versatile novel technology that offers advantages over traditional processing such as:

- ability to heat solid, semi-solid and meal combination food products,
- more rapid heating and preservation of sensory and nutritional quality,
- possibility of ascetic packaging,
- high throughout of processed foods,
- possibility of incorporation of microwave processing equipment in the existing processing lines.

The continued growth in the production of microwave sterilized foods products in TOPS foods (Olen, Belgium) provides strong evidence in favor of the economic viability of the new technology.

## 12. What regulatory acceptance is required for commercializing a microwave sterilization processed product?

All new technologies to produce low acid (pH>4.6) shelf-stable foods require FDA acceptance to ensure that the processed foods are free from pathogenic bacteria.

The microwave sterilization consortium at Washington State University (http://www.microwaveheating.wsu.edu) is a fusion of food processing companies (Kraft Foods Global; Hormel Foods Corporation/Hormel Foods, LLC; Masterfoods USA, a division of Mars, Inc.; Ocean Beauty Seafood, Inc.), packaging and equipment companies (Rexam Containers, a division of Rexam Medical Packaging, Inc.; Graphic Packaging Company; The Ferrite Company) and the educational and government research institutions (Washington State University, Natick Army Center). The Consortium works under guidance of a technical consultant, the Seafood Products Association (Seattle, WA) towards FDA acceptance of the microwave sterilization process. Steps of the regulatory acceptance involve detection of cold spots in the food packages, temperature measurements and verification of desired microbiological lethality in the food products.

Continuous flow sterilization adds another dimension of complexity to process verification, especially for products containing discrete food particles, since microbial lethality occurs under the condition of constant product pumping through processing equipment. The first FDA acceptance for a microwave-sterilized low acid

product has been granted, and techniques have been developed and implemented for process and product safety validation of particle – containing products.

## 13. Are facilities available for product and process development before venturing into microwave sterilization processing?

There are several research facilities throughout the United States and Europe where food processors can evaluate microwave food processing technology. At Washington State University, pilot scale systems are available in the food processing pilot plant affiliated with the Department of Biological Systems Engineering and School of Food Science. Food processors that have signed a consortium agreement with Washington State University take advantage of the expertise of WSU faculty members and facilities to conduct confidential product evaluations for determining product physical and dielectrical properties, for predicting product behavior using developed computer simulation modeling packages, and for evaluating safety, quality, shelf life, and sensory attributes of the food product to obtain guidance on product development.

Continuous flow microwave processing and aseptic packaging equipment is available for testing by industrial users at the Department of Food, Bioprocessing and Nutrition Sciences at North Carolina State University in Raleigh, NC.

**Reference to commercial product or trade names is made with the understanding that no endorsement or discrimination by The Washington State University or by North Carolina State University is implied.**

**For additional information, contact:**


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Websites: http://www.oardc.ohio-state.edu/sastry/USDA_project.htm
http://www.microwaveheating.wsu.edu/
http://www.bsyse.wsu.edu/tang/
http://www.cals.ncsu.edu/food_science/PilotPlant/PilotPlantHomePage.htm
http://www.bsyse.wsu.edu/, http://sfs.wsu.edu,

Useful links: http://fst.osu.edu/CAPPS/index.html


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