**U. S. Food and Drug Administration**
**Center for Food Safety and Applied Nutrition**
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# Kinetics of Microbial Inactivation for Alternative Food Processing Technologies

# Research Needs

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**All Technologies**

- Evaluate the adequacy of the linear first-order survivor curve model. Although there is evidence of various types of deviations from this historical model, a universally accepted alternative has not evolved. Future research on an appropriate model(s) would be beneficial to all preservation technologies.

- Establish experimental protocol for obtaining statistically reliable kinetic parameters to describe survivor curves for microbial populations exposed to various alternative technologies, especially pulsed electric fields, pulsed light, oscillating magnetic fields and X-rays. For example, PEF studies should incorporate multiple levels of electric field intensity, as well as test the potential for synergy with temperature.

- Identify differences of inactivation action/mechanism(s) among alternative technologies. For example, pulsed light and ultraviolet light, ohmic and microwave, PEF and thermal, and so on.

- Determine the synergism or antagonism of one alternative process used with another and their combined effect on microbial inactivation efficiency.

- Determine potential formation of unpalatable and toxic by-products of processing with alternative technologies.

- Develop methods for measuring and monitoring temperatures or other treatment actions within individual, large, solid particulates.

- Identify new or changing critical process factors and their effect on microbial inactivation.

- Investigate the influence of pressure on reduction of microbial populations using the proper experimental design (statistically valid, collection of data at different pressures and control of temperature and product), so that z(P) and/or activation volumes (V) are quantified. Synergistic effects among pressure, temperature, and other measurable variables also should be evaluated.

**Pulsed Electric Fields**

- Develop reliable kinetic parameters for the microbial inactivation models using PEF for the microbial population of interest in food safety. Develop and evaluate the subsequent kinetic models.

- Determine mechanisms of microbial and enzyme inactivation by PEF.

- Identify the pathogens of concern most resistant to PEF.

- Identify surrogate microorganisms for these pathogens.

- Develop validation methods to ensure microbiological effectiveness of PEF.

- Conduct studies to optimize critical process factors identified with PEF.

- Design PEF treatment chambers for uniformity and processing capacity.

- Develop PEF electrode materials for longer operation time and lower metal migration.

- Design, evaluate and reduce costs of process systems.

**Ohmic and Inductive Heating**

- Investigate more fully the combined influence of temperature and electric fields on the inactivation kinetics of key pathogenic microorganisms.

- Develop the knowledge base to assess the impact of deviations for specific designs of ohmic heaters, including improved models for ohmic processes.

**Microwave**

- Determine the effects of food formulation on heating patterns and assess their impact on overall process effectiveness.

- Determine the effects of equipment design factors, including frequency (for example, 915 MHz is sometimes proposed instead of the commonly used 2450 MHz for better uniformity of heating).

- Develop variable frequency ovens and assess their usefulness in food applications for improved uniformity of heating.

- Understand the factors affecting heating patterns, including qualitative changes occurring with frequency changes.

- Develop ways to monitor and real-time adjust for process deviations in microwave and radio frequency processing.

**Pulsed Light**

- Determine the suitability of the technology for solid foods and non-clear liquids where penetration depth is critical.

- Quantitatively determine the resistance of common pathogens or surrogate organisms to pulsed light treatments.

- Understand the differences between this technology and that of the more conventional UV (254 nm) light treatment.

- Determine the mechanisms of microbial inactivation to determine whether they are significantly different from those proposed for UV light.

- Understand the mechanism and quantification of the benefit attributed to the pulse effect.

**Ultrasound**

- Determine the effect of ultrasound on microbial inactivation efficiency when used with other processing technologies (high pressure, heat or others).

- Identify the mechanisms of microbial inactivation when used in combination with other technologies.

- Identify the critical process factors when ultrasound is used in hurdle technology.

- Evaluate the influence of the food properties, such as viscosity and size of particulates, on microbial inactivation.

**High Voltage Arc Discharge**

- Determine how delivery of highly reactive ozone and UV radiation by electric arc discharge inactivates microorganisms.

- Quantify the inactivation kinetics and mechanisms.

- Identify process by-products generated during the submerged arc discharge process due to the highly reactive nature of ozone and UV irradiation.

- Define maximum allowable dose similar to food irradiation.

**Oscillating Magnetic Fields**

- Establish the effects of magnetic fields on microbial inactivation.
- Elucidate the destruction kinetics of magnetic fields.
- Determine the mechanism of action of magnetic fields.
- Determine critical process factors and effects on microbial inactivation.
- Validate the process and evaluate the need for indicator organisms.
- Identify process deviations and determine ways to address them.

**Ultraviolet Light**

- Quantitatively determine the effects of individual parameters, such as suspended and dissolved solid concentration, on the effectiveness of the treatment.

**High Pressure**

- Conduct additional modeling research, using data generated by multiple-cell pressure units that allow for similar come-up times. Although HPP-derived semi-logarithmic survival curves appear nonlinear (for example, sigmoidal or biphasic), in HPP predictive microbiology, a logarithmic order of reduction is normally assumed. This assumption carries the danger of underestimating the subpopulation of pressure-resistant organisms.
- Investigate the influence of pressure on reduction of microbial populations using the proper experimental design (statistically valid, collection of data at different pressures and control of temperature and product), so that kinetic parameters are quantified. In this way, critical process factors can be evaluated for survival of pathogens or surrogates in a statistical manner. Accurate predictions could be used to develop HACCP plans.
- Evaluate synergistic effects among pressure, temperature and other variables.

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