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High-pressure processing variably affects similar microorganisms

1 April 2003

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Any sanitary process designed to control a species needs to consider variations in properties within that species.

As described in this column in the February 2003 *Global Aquaculture Advocate*, high hydrostatic pressure (HHP) processing can improve the shelf life, quality, and safety of fish and fishery products. Among other impacts, high pressures either destroy or inactivate harmful microbial cells in the fish products through a combination of physiological and biochemical effects on the microorganisms. Microorganisms' responses to HHP, however, vary significantly.

Microorganisms that share the same scientific name can have significantly different biochemical and physical properties. Unlike many other forms of life, microorganisms only have to share a few biochemical and morphological properties to be classified as identical. Consequently, many

microorganisms with the same scientific name can have disparate responses when exposed to similar environmental effects. Any processes or procedures designed to control a single microorganism must consider the variations in properties that can occur within that species.

Effects of pressure on *Listeria monocytogenes*

Substantial differences among various *L. monocytogenes* isolates have been reported in scientific literature. Table 1 provides an example of the magnitude of microbial inactivation that has been reported within two isolates, one obtained from a microbial collection and the other isolated from a food product.

With five minutes of HHP processing at 375 million pascals (MPa), one strain was reduced by a factor of 10, while the other was reduced by a factor of 1,000. The magnitude after 20 minutes of pressurization illustrated an even greater difference in pressure rsistance between the strains. One strain was reduced by a factor of 100, while the other was reduced by a factor of 10 million. A processor developing a process to reduce *L. monocytogenes* by 5 $logs_{10}$ could have a process as short as five minutes or longer than 30 minutes, depending on the pressure tolerance of the specific strain of microorganism encountered.

Table 1. Destruction of two strains of *L. monocytogenes* at 375 MPa.

Treatment Time (min)	Strain 1 (Log_{10} Number of Organisms Destroyed)	Strain 2 (Log_{10} Number of Organisms Destroyed)
5	10^1	10^3
10	10^1	10^5
15	10^2	10^6
20	10^2	10^7
25	10^3	10^7
30	10^3	10^7

Table 1. Destruction of two strains of *L. monocytogenes* at 375 MPa.

A second study utilizing various pressures and three strains of *L. monocytogenes* clearly demonstrated the lethal effect of increasing pressure on cells (Table 2). However, a significant difference in pressure resistance was again observed among the three strains.

The time required for microorganism inactivation or death was significantly reduced by increasing the hydrostatic pressures applied. A processor producing a ready-to-eat product and employing reasonable sanitary practices should not have a *L. monocytogenes* population greater than 1,000 per grams in the final product. Therefore, a listericidal HHP process could be less than 10 minutes at 450 MPa, while at 300 Mpa, the process would exceed 30 minutes.

Table 2. Destruction of *L. monocytogenes* strains at varied pressures.

Treatment Time (min)	Pressure 300 MPa			375 MPa			450 MPa		
	1	2	3	1	2	3	1	2	3
	(Log_{10} Number of Organisms Destroyed)								
5	0	0	0	0	0	10^3	$10^{1.5}$	$10^{2.5}$	10^7
10	0	0	0	0	$10^{2.5}$	10^5	10^4	10^5	ND
15	0	0	10	$10^{1.5}$	10^4	10^6	$10^{5.5}$	10^5	
20	0	0	$10^{1.5}$	$10^{1.5}$	$10^{4.5}$	10^7	10^7	10^5	
25	0	0	10^2	$10^{2.5}$	$10^{4.5}$	10^7	10^7	10^5	
30	0	0	10^3	10^3	$10^{4.5}$	10^7	ND	10^5	

ND = not detected

Effects of pressure in different food products

In addition to differences between stains and pressures, the environment in which the microorganisms are contained during pressurization is important. Some products provide a sparing effect on microorganisms, while others increase their vulnerability. Table 3 demonstrates the survival of one strain of *L. mo*nocytogenes in two different food products at 375 MPa.

Table 3. Destruction of *L. monocytogenes* at 375 MPa in two food products.

Treatment Time (min)	Product 1 (Log_{10} Number of Organisms Destroyed)	Product 2 (Log_{10} Number of Organisms Destroyed)
5	10^1	10^3
10	$10^{1.5}$	10^5
15	10^2	$10^{5.5}$
20	$10^{2.5}$	10^6
25	10^3	$10^{7.5}$
30	$10^{3.5}$	$10^{7.5}$

These figures clearly showed that if complete or partial destruction of *L. monocytogenes* in a food product is desired, research must determine if more than one strain is present and how readily the various strains succumb to pressurization in that food product. Unfortunately, the information obtained on the destruction or inactivation of a microorganism in one food product cannot be readily transferred to another product.

Effects of pressurization ramp on microorganism inactivation

One strain of *L. innocua* was used as a surrogate microorganism in a study where slow pressurization with rapid depressurization was tested against a process with rapid pressurization and slow depressurization. The test was conducted over a range of 400 to 600 Mpa, with holding times ranging 0.5 to five minutes. Results of the study indicated there was no difference in inactivation of the microorganisms between the two techniques.

Conclusion

When developing a process, the services of a food microbiologist and statistician could prove to be most useful. Since the United States Food and Drug Administration has established a zero defect action level for *L. monocytogenes* in cooked, ready-to-eat products, processors cannot afford to establish treatment processes that do not perform as intended.

Variables to be considered in developing a listericidal process based on high hydrostatic pressure technology should include the variations in the various *L. monocytogenes* serovars, magnitude of the reduction required, food product being processed, and intended use of the product. Finally, the sanitary operations of the processing facilities are most important.

A facility that employs acceptable sanitary practices may require a 3 $\log_{10}$ reduction, while one with marginal sanitary practices may need a 5 $\log_{10}$ reduction. The process time required to achieve the two log difference could be significant. Longer process times can result in major increases in capital investments and production costs.

(Editor's Note: This article was originally published in the April 2003 print edition of the Global Aquaculture Advocate*.)*

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