Lethality Treatment Determination

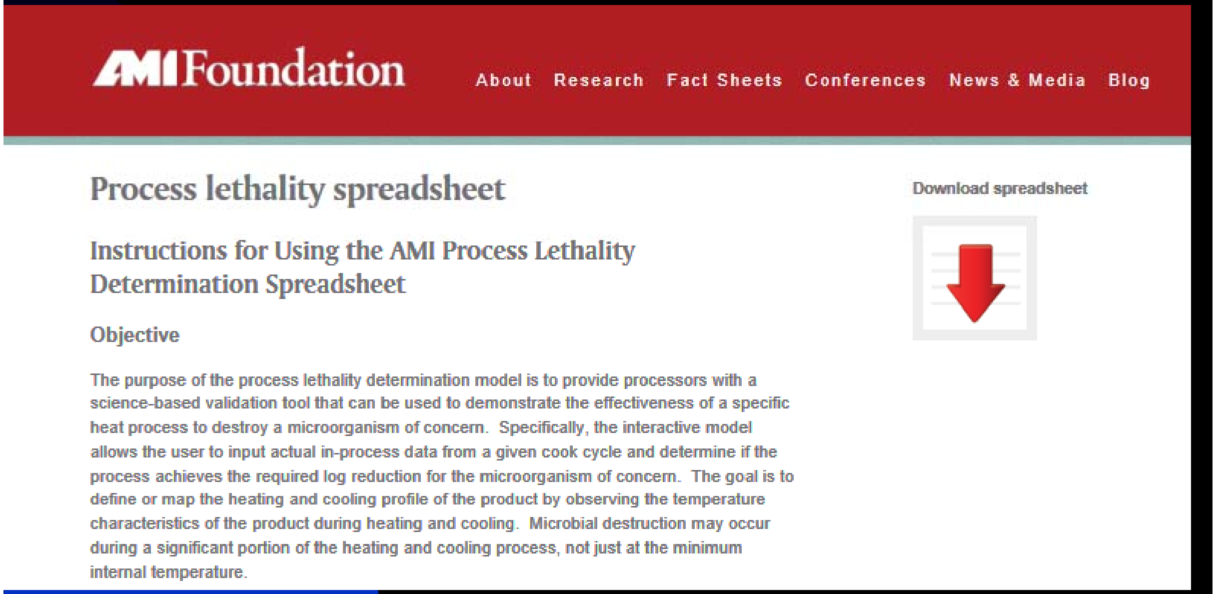
Calculating Thermal Inactivation of Pathogens

Andrew Milkowski, Ph.D.

Food Research Institute
University of Wisconsin - Madison

AMI Foundation

http://www.amif.org/process-lethality/



Process lethality spreadsheet

Instructions for Using the AMI Process Lethality Determination Spreadsheet

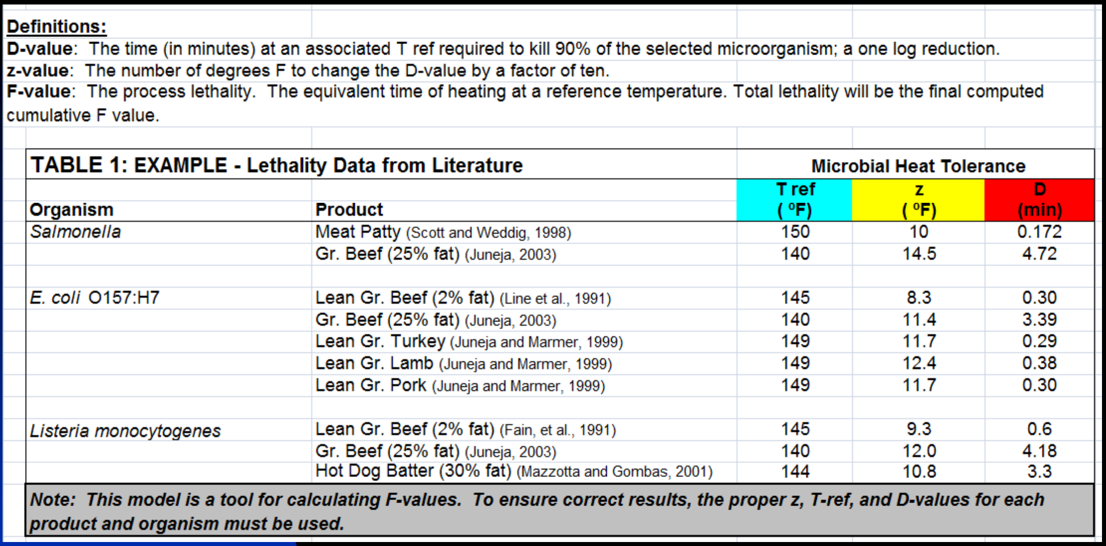
Objective

The purpose of the process lethality determination model is to provide processors with a science-based validation tool that can be used to demonstrate the effectiveness of a specific heat process to destroy a microorganism of concern. Specifically, the interactive model allows the user to input actual in-process data from a given cook cycle and determine if the process achieves the required log reduction for the microorganism of concern. The goal is to define or map the heating and cooling profile of the product by observing the temperature characteristics of the product during heating and cooling. Microbial destruction may occur during a significant portion of the heating and cooling process, not just at the minimum internal temperature.

American Meat Institute
1150 Connecticut Avenue, NW 12th Floor · Washington, DC 20036
202-587-4200 (main) · 202-587-4300 (fax)

How to use the AMI Spreadsheet

1. **Select a D, T_{ref} and z value for your product.**
   - **Decide on the pathogen**
     - **For multiple pathogens use the most thermally resistant (largest D close to finished internal temp**
   - **Use a published value for a product that is closest in type and composition to your situation**
   - **Hierarchy of importance**
     1. **Cured vs uncured**
     2. **Fat level**
     3. **Species**
     4. **Whole vs ground vs emulsified**
2. **Enter data from values recorded in the process**
   - **Use core temperature or the coldest point in the product**
   - **20 points is sufficient <u>IF</u> enough of the data is in the region above 120F (at least 10 data points)**
   - **May or may not use the cooling part of the process**
3. **Samples are provided by AMI**



<u>Definitions:</u>
D-value: The time (in minutes) at an associated T ref required to kill 90% of the selected microorganism; a one log reduction.
z-value: The number of degrees F to change the D-value by a factor of ten.
F-value: The process lethality. The equivalent time of heating at a reference temperature. Total lethality will be the final computed cumulative F value.

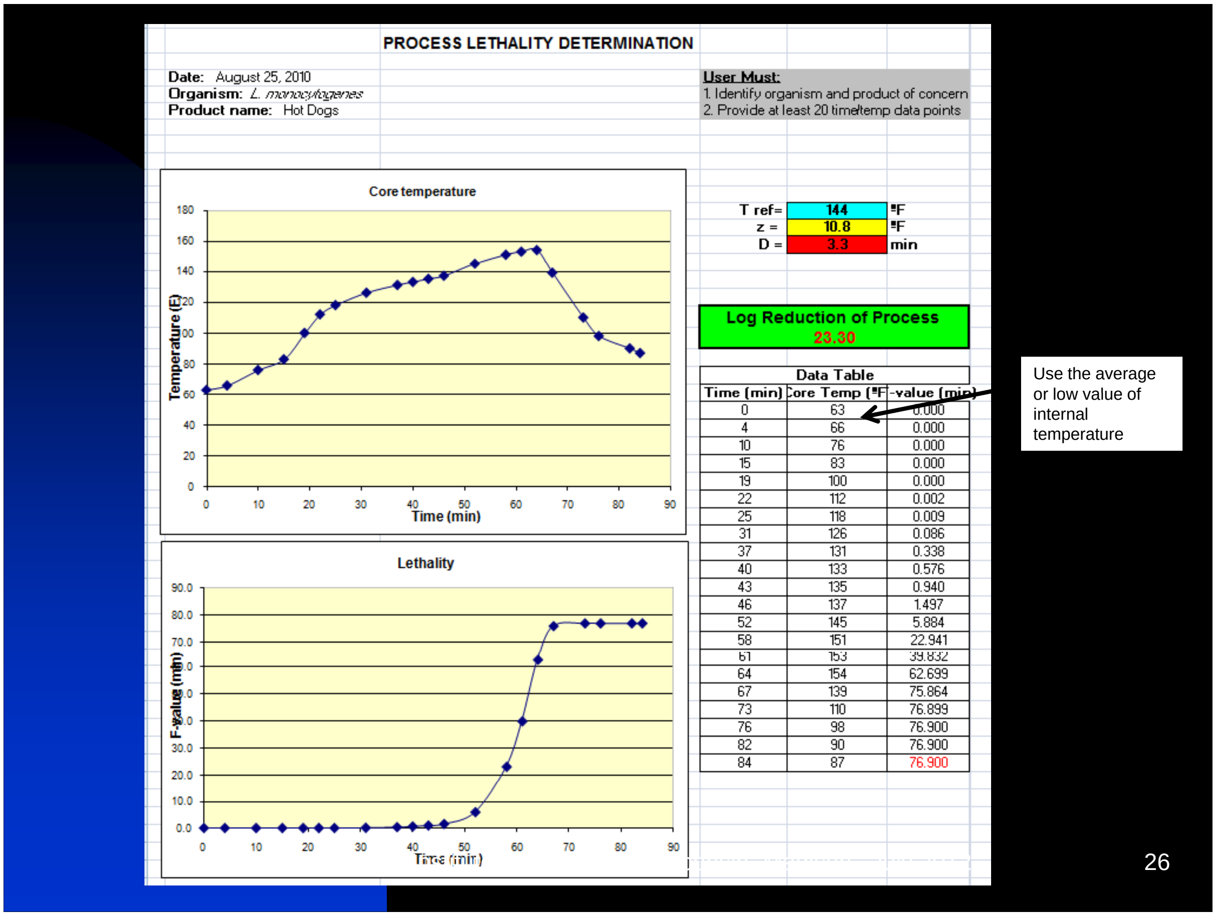
TABLE 1: EXAMPLE - Lethality Data from Literature

		Microbial Heat Tolerance		
Organism	**Product**	**T ref (°F)**	**z (°F)**	**D (min)**
Salmonella	Meat Patty (Scott and Weddig, 1998)	150	10	0.172
	Gr. Beef (25% fat) (Juneja, 2003)	140	14.5	4.72
E. coli O157:H7	Lean Gr. Beef (2% fat) (Line et al., 1991)	145	8.3	0.30
	Gr. Beef (25% fat) (Juneja, 2003)	140	11.4	3.39
	Lean Gr. Turkey (Juneja and Marmer, 1999)	149	11.7	0.29
	Lean Gr. Lamb (Juneja and Marmer, 1999)	149	12.4	0.38
	Lean Gr. Pork (Juneja and Marmer, 1999)	149	11.7	0.30
Listeria monocytogenes	Lean Gr. Beef (2% fat) (Fain, et al., 1991)	145	9.3	0.6
	Gr. Beef (25% fat) (Juneja, 2003)	140	12.0	4.18
	Hot Dog Batter (30% fat) (Mazzotta and Gombas, 2001)	144	10.8	3.3

Note: This model is a tool for calculating F-values. To ensure correct results, the proper z, T-ref, and D-values for each product and organism must be used.

Other values can be found in the handout references

- But be careful on converting units for z values (don't incorporate the 32^{o} offset between F and C)



PROCESS LETHALITY DETERMINATION

Date: August 25, 2010
Organism: *L. monocytogenes*
Product name: Hot Dogs

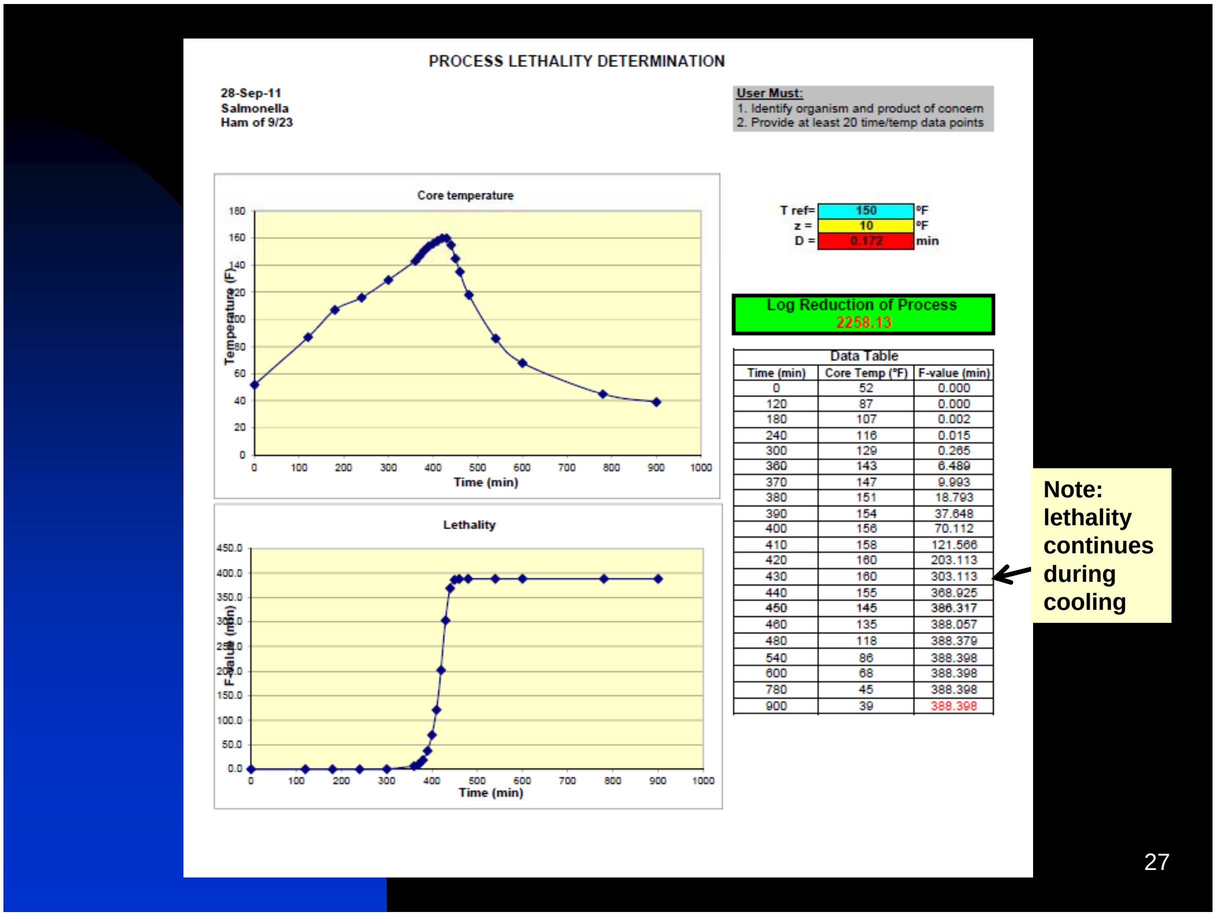
User Must:
1. Identify organism and product of concern
2. Provide at least 20 time/temp data points

T ref= 144 °F
z = 10.8 °F
D = 3.3 min

Log Reduction of Process
23.30

Data Table		
Time (min)	Core Temp (°F	-value (min)
0	63	0.000
4	66	0.000
10	76	0.000
15	83	0.000
19	100	0.000
22	112	0.002
25	118	0.009
31	126	0.086
37	131	0.338
40	133	0.576
43	135	0.940
46	137	1.497
52	145	5.884
58	151	22.941
61	153	39.832
64	154	62.699
67	139	75.864
73	110	76.899
76	98	76.900
82	90	76.900
84	87	76.900

Use the average or low value of internal temperature



PROCESS LETHALITY DETERMINATION

28-Sep-11
Salmonella
Ham of 9/23

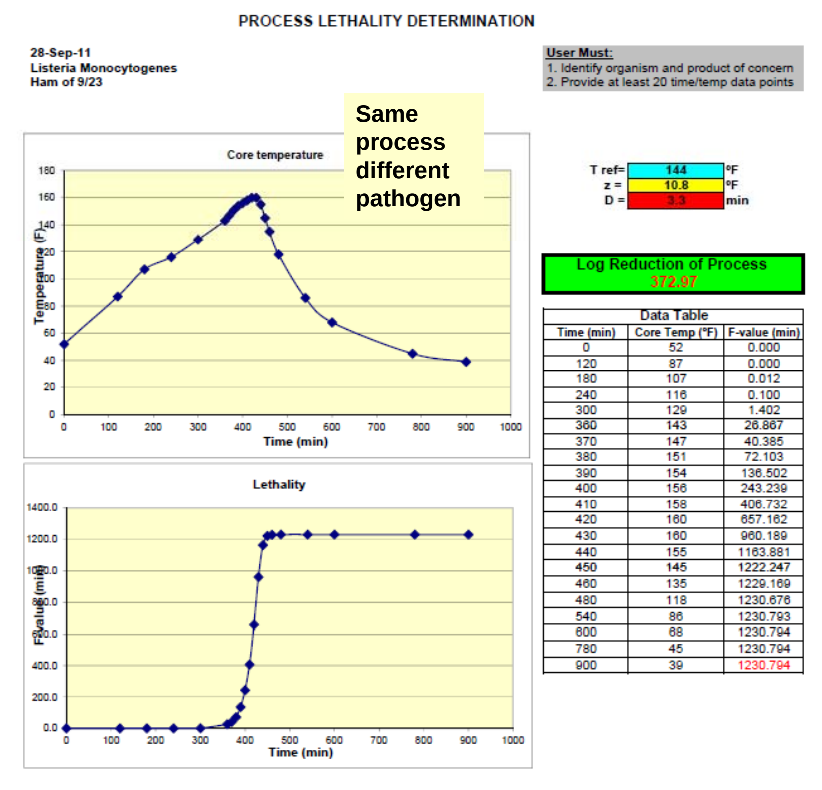
User Must:
1. Identify organism and product of concern
2. Provide at least 20 time/temp data points

T ref= 150 °F
z = 10 °F
D = 0.172 min

Log Reduction of Process
2258.13

Data Table		
Time (min)	Core Temp (°F)	F-value (min)
0	52	0.000
120	87	0.000
180	107	0.002
240	116	0.015
300	129	0.265
360	143	6.489
370	147	9.993
380	151	18.793
390	154	37.648
400	156	70.112
410	158	121.566
420	160	203.113
430	160	303.113
440	155	368.925
450	145	386.317
460	135	388.057
480	118	388.379
540	86	388.398
600	68	388.398
780	45	388.398
900	39	388.398

Note: lethality continues during cooling



PROCESS LETHALITY DETERMINATION

28-Sep-11
Listeria Monocytogenes
Ham of 9/23

User Must:
1. Identify organism and product of concern
2. Provide at least 20 time/temp data points

Same process different pathogen

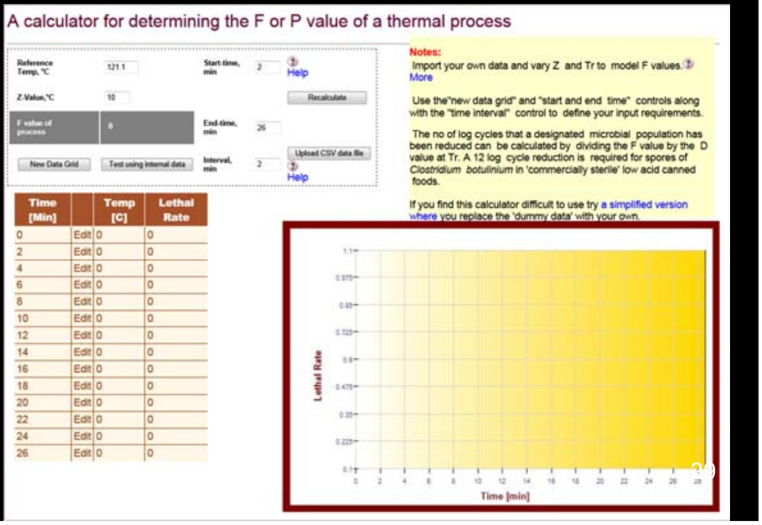
T ref= 144 °F
z = 10.8 °F
D = 3.3 min

Log Reduction of Process
372.97

Data Table		
Time (min)	Core Temp (°F)	F-value (min)
0	52	0.000
120	87	0.000
180	107	0.012
240	116	0.100
300	129	1.402
360	143	26.867
370	147	40.385
380	151	72.103
390	154	136.502
400	156	243.239
410	158	406.732
420	160	657.162
430	160	960.189
440	155	1163.881
450	145	1222.247
460	135	1229.169
480	118	1230.676
540	86	1230.793
600	68	1230.794
780	45	1230.794
900	39	1230.794

Another Web Site Based Lethality Calculator

- Mullan, W.M.A. (2007). Calculator for determining the F value of a thermal process. [On-line]. Available from: http://www.dairyscience.info/index.php/thermal-processing/134-f-value-thermal-process.html . Accessed: 13 July, 2012.



A calculator for determining the F or P value of a thermal process

Reference Temp, °C: 121.1
Z-Value,°C: 10
F value of process: 0
Start-time, min: 2
End-time, min: 26
Interval, min: 2

Notes:
Import your own data and vary Z and Tr to model F values. More

Use the"new data grid" and "start and end time" controls along with the "time interval" control to define your input requirements.

The no of log cycles that a designated microbial population has been reduced can be calculated by dividing the F value by the D value at Tr. A 12 log cycle reduction is required for spores of *Clostridium botulinium* in 'commercially sterile' low acid canned foods.

If you find this calculator difficult to use try a simplified version where you replace the 'dummy data' with your own.

Time [Min]		Temp [C]	Lethal Rate
0	Edit	0	0
2	Edit	0	0
4	Edit	0	0
6	Edit	0	0
8	Edit	0	0
10	Edit	0	0
12	Edit	0	0
14	Edit	0	0
16	Edit	0	0
18	Edit	0	0
20	Edit	0	0
22	Edit	0	0
24	Edit	0	0
26	Edit	0	0

Another Web Site Based Lethality Calculator

- Combase Predictor
  - www.combase.cc
  - Requires registration
  - Limited temperature ranges, all in ^{o}C
  - Time in hours

○ Growth model ● Thermal inactivation model ○ Non thermal survival model

Temperature: ○ Static ● Changing

Water Activity: ● NaCl ○ Aw

Observation Duration: Time(h) 30

Input your temperature profile in the textbox

The temperature inputs must be within the range [54.5-64.5]

```
0     54.5
.015  55
.025  56
.026  57
.030  58
```

Escherichia coli

Relative decrease <=?	Phys.state [0-1] Help	T (°C) [54.5-64.5]	pH [4.2-8]	NaCl (%) [0.0-8.4]
	0.229925		6.5	2.5

Max.rate (log.conc/h):

D value (minutes):

Predictions

time(h)	Temp.(C)	conc.(Log10 cells/g)
0.00	54.50	0.00
0.30	54.51	-0.61
0.61	54.52	-1.44
0.91	54.53	-2.32
1.21	54.54	-3.20
1.52	54.55	-4.10
1.82	54.56	-4.99
2.12	54.57	-5.89
2.42	54.58	-6.80
2.73	54.59	-7.71
3.03	54.60	-8.62
3.33	54.61	-9.54

Food Research Institute,
University of Wisconsin- Madison,
July 2012

Process lethality spreadsheet

Download spreadsheet

(/wp-content/uploads/Process-Lethality-Spreadsheet-August-2010.xls)

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Objective

The purpose of the process lethality determination model is to provide processors with a science-based validation tool that can be used to demonstrate the effectiveness of a specific heat process to destroy a microorganism of concern. Specifically, the interactive model allows the user to input actual in-process data from a given cook cycle and determine if the process achieves the required log reduction for the microorganism of concern. The goal is to define or map the heating and cooling profile of the product by observing the temperature characteristics of the product during heating and cooling. Microbial destruction may occur during a significant portion of the heating and cooling process, not just at the minimum internal temperature.

Definitions

- Thermal Death Time: This is the time in minutes, necessary to kill a given number of organisms at a specified temperature.
- T ref: The reference temperature used when establishing the D- and z-values.
- D-Value: This indicates time in minutes at a constant temperature, that is necessary to destroy 90% or 1 log of the organism present at a given reference temperature. A D-value at one temperature, along with a z-value, is used to define the heat resistance of a microorganism.
- z-Value: This is the temperature increase required to reduce the thermal death time by a factor of 10. It is the number of degrees between a 10-fold change (or log cycle) in a microorganism's heat resistance. The z-value is considered a constant for a given microorganism strain in a given product.
- F-Value: This is the process lethality or the time in minutes, at a specific temperature required to destroy a certain number of viable cells.

You must provide the following

- Identify microorganism and meat and/or poultry product of concern.
- Provide at least 20 time/core product temperatures that represents the products heating and cooling process.

Instructions:

1. By using the table that contains the lethality data from literature, we have selected the microorganism and product of concern. For example, let's say our organism of concern is*L. monocytogenes*, and our product is a hot dog. Identify the corresponding T ref (144 F), z-value (10.8 F), and D-value (3.3 min) provided in the table. These values should be obtained from your own companies challenge study data, from scientific literature, or other reliable sources. These values need to be relevant and appropriate for the type of product and the organism of concern. The table provides some example values from scientific literature that apply to certain products, but you need to justify your choice or provide more relevant values for your specific product and process.
2. Once the T ref (144 F), z-value (10.8 F), and D value (3.3 min) have been identified, enter them into the appropriate labeled cells below the table that contains the lethality data from literature.

3. The data table below these three values gives an example of what some time/temperature data points may look like. Time must be recorded in increasing minutes (0, 10 min, 20 min, 30 min) as each temperature value is recorded. The temperature must be the core product temperature that identifies the coolest spot in the product and the product should be in the coolest zone in the cooking chamber. It is suggested that at least 20 data points be entered into the data table. The values that you enter should be a time-temperature map of the product as it heats and cools.
4. Once the table has been completed, the F-value, or process lethality, will be calculated at each data point and a cumulative F-value will be given as the very last number in the right hand column of the data table (76.90 min). This number adds up the lethality values for each time interval and calculates an approximation of the area under the lethal rate curve. This value will be referred to as the “computed cumulative F value” or the “cumulative process lethality”. In the given example, the calculation results in an equivalent lethality at 144 F of 76.90 minutes. Clear the values in the first two columns and enter your own continuous process time and core product temperature (°F) in the appropriate columns.
5. After the data has been entered, a core temperature and a lethality curve are produced. The first graph shows a plot of the core product time/temperature relationship and the second graph shows a plot of the data converted to lethal rates or the cumulative F-value. In the example, because 144°F is the selected reference temperature, the area under the curve represents the total lethal effect of the process equivalent to 144 F. In this example, the lethality of the process is 76.90 minutes. This represents an “equivalent” time.
6. The total log reduction of the process is automatically determined by dividing the cumulative F-value (76.90) by the D-value (3.3) that was entered into the appropriate labeled cell. The resulting value equals the total log reduction of the process (23.30).
7. By using these estimates, you or a process authority should determine if the process meets regulatory requirements as safe. Additional documents, such as Appendix A (http://www.fsis.usda.gov/oa/fr/95033F-a.htm), which discuss desired log reductions should also be considered when evaluating a lethality process.

Summary

This spreadsheet is to be used as a tool to determine if a specific cooking process has provided sufficient time and temperature to achieve a required log reduction for a given microorganism. If the appropriate log reduction is achieved for the process and organism of concern, the data and graphs provided in the spreadsheet may be used as a component of the HACCP validation materials. If the cooking process does not result in the appropriate log reduction, the cooking process needs to be re-evaluated and additional time and or temperature may need to be applied to the process.

Please direct all questions to the AMIF staff at 202-587-4200.

References

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Compatibility

The process lethality determination spreadsheet model is compatible with either Microsoft Excel version 5.0 (the version of Excel that is packaged with Microsoft Office 95) or Microsoft Excel 97 (the version that is packaged with Microsoft Office 97). Microsoft Excel version 5.0 and Microsoft Excel 97 will work regardless if the operating system is Windows 95, Windows 98 or Windows NT.

FOOD RESEARCH INSTITUTE
University of Wisconsin-Madison

D-Value References

Compiled by M. E. Doyle
Food Research Institute, University of Wisconsin–Madison
Supplement to the FRI Webinar “Calculating Thermal Inactivation of Pathogens”
July 2012, updated Sept. 2012

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