

## MICROBIOLOGICAL PRESERVATION CHART FOR CONDIMENTS AND SAUCES WITH pH 4.2 and BELOW

The information contained in this chart is to be used as a guideline only. This chart is valid for products with a finished pH of 4.2 and below. If the product meets the definition of an acidified food, consult with a process authority. The use of the highest quality raw materials, adherence to good manufacturing practices and appropriate and effective sanitation programs and controls are critical to finished product integrity. Some products that may be covered by these guidelines include barbecue sauce, steak sauce, salsa and condiment sauces.

| pH   | Acetic Acid (Water Phase) |               | Temperature  | Time   | Sodium Benzoate   | Potassium Sorbate  | Comment   |
|--|---------------------------|---------------|--|--|---|--|---|
|  | Microbiostasis            | Microbiocidal |  |  |   |  |   |
| Refer to the attached chart for time and temperature guidelines. | ≥ 1.4%                    | > 2.0%        | Refer to the attached chart for time and temperature curves for the destruction of vegetative organisms. | Refer to the attached chart for time and temperature curves for the destruction of vegetative organisms. | <b>Microbiostasis</b><br>A) 0.05 - 0.1%. Inhibits growth of most yeasts and molds or bacteria (the undisassociated acid.)<br>B) 0.01 - 0.02%. Inhibits growth of most food poisoning and spore-forming bacteria (the undisassociated acid). | <b>Microbiostasis</b><br>0.1 – 0.3%. Inhibits growth of most catalase positive microbes such as yeasts, molds, bacteria (the undis-associated acid). | Careful attention must be given to the time and temperature at which a product is thermally processed to assure the safety of the food. Careful evaluation of sanitation practices, bioburden analysis, control of ingredients and the appropriate application of the information on this table and the accompanying thermal death curves will help assure product preservation and safety. |

Limitations - Thermal processing of these products is not required. The information contained herein is for post-control.

### References:

**pH**  
 National Canners Association  
 1968 Laboratory Manual for Food Canners and Processors  
 Refer to the tables below.

**Acetic Acid**  
 Smittle, Richard B., 1977. Journal of Food Protection, Vol. 40, No. 8. Pages 415-422  
 Smittle, Richard B., 2000. Journal of Food Protection, Vol. 63. Pages 1144-1153  
 ICMSF, 1980. Microbial Ecology of Foods, Volume 1, Factors Affecting Life and Death of Microorganisms. Page 132  
 Pitt, J.I., June 1974. Food Technology in Australia. Pages 238-241

**Temperature**  
 National Canners Association  
 1968 Laboratory Manual for Food Canners and Processors  
 Refer to the tables below.

**Time**  
 National Canners Association Research Laboratories  
 1968 Laboratory Manual for Food Canners and Processors

**Potassium Sorbate**  
 Block, Seymour, S., 1991. Disinfection, Sterilization, and Preservation, Fourth Edition. Page 811  
 ICMSF, 1980. Microbiological Ecology of Foods, Volume 1, Factors Affecting Life and Death of Microorganisms. Page 134

**Sodium Benzoate**  
 Block, Seymour, S., 1991. Disinfection, Sterilization, and Preservation, Fourth Edition. Page 809  
 ICMSF, 1980. Microbial Ecology of Foods, Volume 1, Factors Affecting Life and Death of Microorganisms. Page 133

**Thermal Process Requirements for Sauces with pH 3.9 or less**  
 $n = \text{Ref. Temp. (200 }^\circ\text{F)}$

$$F^{16} = 0.1 \text{ min}$$

F value (F)

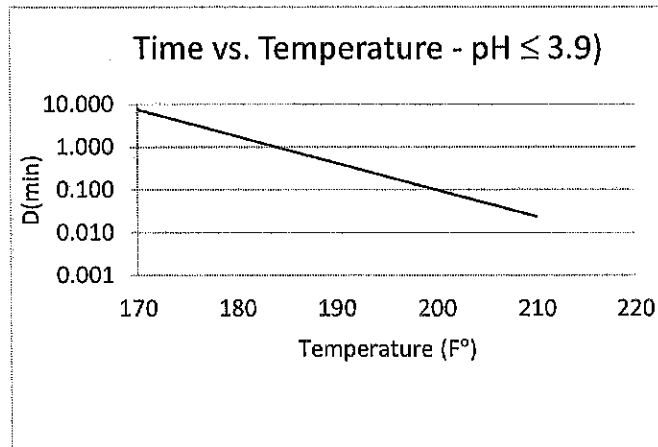
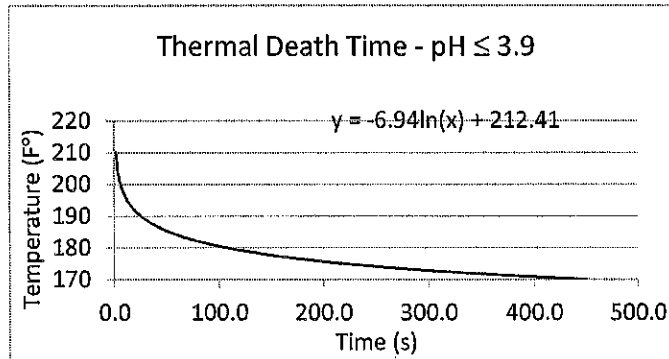
where  $T$  = Temperature of processing,  $t$  = heating time, and  $z$  = thermal resistance

$t$  = 6s  
 $T_{\text{ref}}$  = 200 °F  
 $z$  = 16 °F

$$F_n = t \times 10^{(T-n)/z}$$

$$F_n = 6 \times 10^{(200-n)/16}$$

| Temp. (°F) | Time (s) | Time (min) |
|------------|----------|------------|
| 170        | 449.9    | 7.498      |
| 171        | 389.6    | 6.493      |
| 172        | 337.4    | 5.623      |
| 173        | 292.2    | 4.870      |
| 174        | 253.0    | 4.217      |
| 175        | 219.1    | 3.652      |
| 176        | 189.7    | 3.162      |
| 177        | 164.3    | 2.738      |
| 178        | 142.3    | 2.372      |
| 179        | 123.2    | 2.053      |
| 180        | 106.7    | 1.778      |
| 181        | 92.4     | 1.540      |
| 182        | 80.0     | 1.333      |
| 183        | 69.3     | 1.155      |
| 184        | 60.0     | 1.000      |
| 185        | 52.0     | 0.867      |
| 186        | 45.0     | 0.750      |
| 187        | 39.0     | 0.650      |
| 188        | 33.7     | 0.562      |
| 189        | 29.2     | 0.487      |
| 190        | 25.3     | 0.422      |
| 191        | 21.9     | 0.365      |
| 192        | 19.0     | 0.317      |
| 193        | 16.4     | 0.273      |
| 194        | 14.2     | 0.237      |
| 195        | 12.3     | 0.205      |
| 196        | 10.7     | 0.178      |
| 197        | 9.2      | 0.153      |
| 198        | 8.0      | 0.133      |
| 199        | 6.9      | 0.115      |
| 200        | 6.0      | 0.100      |
| 201        | 5.2      | 0.087      |
| 202        | 4.5      | 0.075      |
| 203        | 3.9      | 0.065      |
| 204        | 3.4      | 0.057      |
| 205        | 2.9      | 0.048      |
| 206        | 2.5      | 0.042      |
| 207        | 2.2      | 0.037      |
| 208        | 1.9      | 0.032      |
| 209        | 1.6      | 0.027      |
| 210        | 1.4      | 0.023      |



National Canners Association  
 1968 Laboratory Manual for Food  
 Canners and Processors

**Thermal Process Requirements for Sauces with pH 3.9 - 4.1**  
 $n = \text{Ref. Temp. (200}^\circ\text{F)}$

$$F^{16} = 0.1 \text{ min}$$

F value (F)

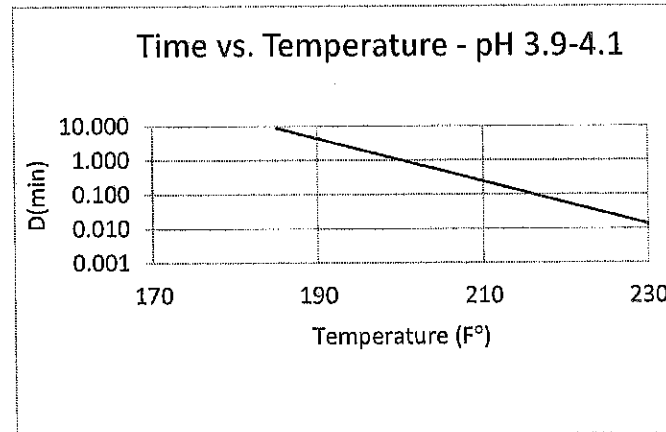
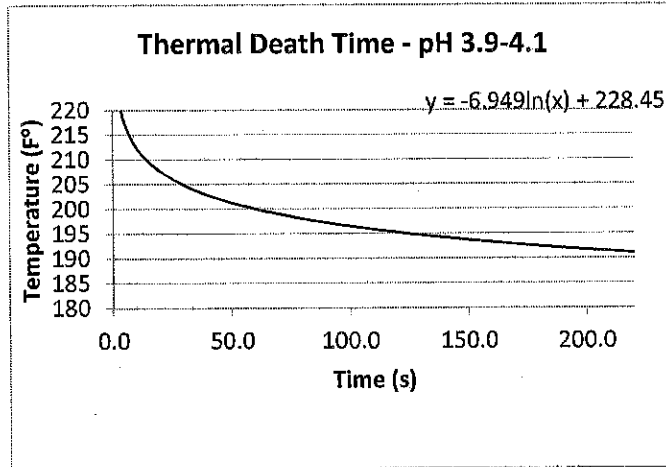
where T = Temperature of processing, t = heating time, and z = thermal resistance

t = 6s  
 $T_{\text{ref}} = 200^\circ\text{F}$   
 $z = 16^\circ\text{F}$

$$F_n = t \times 10^{(T-n)/z}$$

$$F_n = 6 \times 10^{(200-n)/16}$$

| Temp(F) | Time(s) | Time (min) |
|---------|---------|------------|
| 185     | 519.6   | 8.660      |
| 186     | 449.9   | 7.498      |
| 187     | 389.6   | 6.493      |
| 188     | 337.4   | 5.623      |
| 189     | 292.2   | 4.870      |
| 190     | 253.0   | 4.217      |
| 191     | 219.1   | 3.652      |
| 192     | 189.7   | 3.162      |
| 193     | 164.3   | 2.738      |
| 194     | 142.3   | 2.372      |
| 195     | 123.2   | 2.053      |
| 196     | 106.7   | 1.778      |
| 197     | 92.4    | 1.540      |
| 198     | 80.0    | 1.333      |
| 199     | 69.3    | 1.155      |
| 200     | 60.0    | 1.000      |
| 201     | 52.0    | 0.867      |
| 202     | 45.0    | 0.750      |
| 203     | 39.0    | 0.650      |
| 204     | 33.7    | 0.562      |
| 205     | 29.2    | 0.487      |
| 206     | 25.3    | 0.422      |
| 207     | 21.9    | 0.365      |
| 208     | 19.0    | 0.317      |
| 209     | 16.4    | 0.273      |
| 210     | 14.2    | 0.237      |
| 211     | 12.3    | 0.205      |
| 212     | 10.7    | 0.178      |
| 213     | 9.2     | 0.153      |
| 214     | 8.0     | 0.133      |
| 215     | 6.9     | 0.115      |
| 216     | 6.0     | 0.100      |
| 217     | 5.2     | 0.087      |
| 218     | 4.5     | 0.075      |
| 219     | 3.9     | 0.065      |
| 220     | 3.4     | 0.057      |
| 221     | 2.9     | 0.048      |
| 222     | 2.5     | 0.042      |
| 223     | 2.2     | 0.037      |
| 224     | 1.9     | 0.032      |
| 225     | 1.6     | 0.027      |
| 226     | 1.4     | 0.023      |
| 227     | 1.2     | 0.020      |
| 228     | 1.1     | 0.018      |
| 229     | 0.9     | 0.015      |
| 230     | 0.8     | 0.013      |



National Canners Association  
 1968 Laboratory Manual for Food  
 Canners and Processors

**Thermal Process Requirements for Sauces with pH 4.1 - 4.2**  
 $n = \text{Ref. Temp. (200}^\circ\text{F)}$

$F^{16} = 0.1 \text{ min}$   
 200

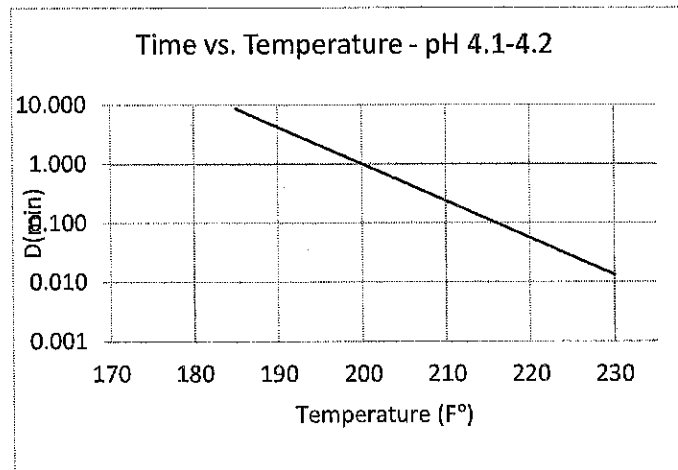
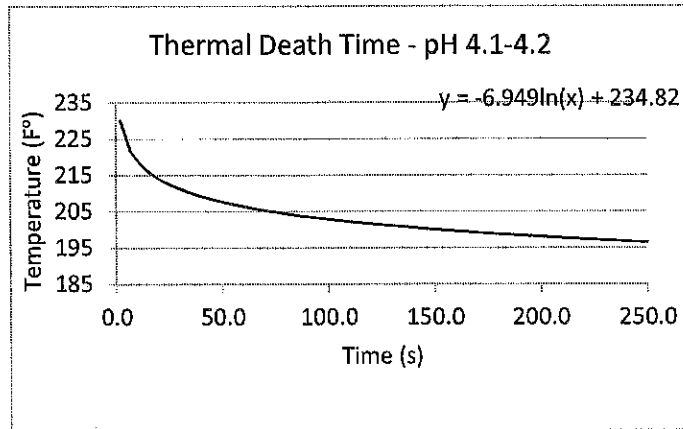
F value (F)

where T = Temperature of processing, t = heating time, and z = thermal resistance

t = 150s  
 $T_{ref} = 200^\circ\text{F}$   
 z = 16°F

$F_n = t \times 10^{(T-n)/z}$   
 $F_n = 6 \times 10^{(200-n)/16}$

| Temp (F) | Time (s) | Time (min) |
|----------|----------|------------|
| 185      | 1298.9   | 21.648     |
| 186      | 1124.8   | 18.747     |
| 187      | 974.1    | 16.235     |
| 188      | 843.5    | 14.058     |
| 189      | 730.5    | 12.175     |
| 190      | 632.5    | 10.542     |
| 191      | 547.8    | 9.130      |
| 192      | 474.3    | 7.905      |
| 193      | 410.8    | 6.847      |
| 194      | 355.7    | 5.928      |
| 195      | 308.0    | 5.133      |
| 196      | 266.7    | 4.445      |
| 197      | 231.0    | 3.850      |
| 198      | 200.0    | 3.333      |
| 199      | 173.2    | 2.887      |
| 200      | 150.0    | 2.500      |
| 201      | 129.9    | 2.165      |
| 202      | 112.5    | 1.875      |
| 203      | 97.4     | 1.623      |
| 204      | 84.4     | 1.407      |
| 205      | 73.0     | 1.217      |
| 206      | 63.3     | 1.055      |
| 207      | 54.8     | 0.913      |
| 208      | 47.4     | 0.790      |
| 209      | 41.1     | 0.685      |
| 210      | 35.6     | 0.593      |
| 211      | 30.8     | 0.513      |
| 212      | 26.7     | 0.445      |
| 213      | 23.1     | 0.385      |
| 214      | 20.0     | 0.333      |
| 215      | 17.3     | 0.288      |
| 216      | 15.0     | 0.250      |
| 217      | 13.0     | 0.217      |
| 218      | 11.2     | 0.187      |
| 219      | 9.7      | 0.162      |
| 220      | 8.4      | 0.140      |
| 221      | 7.3      | 0.122      |
| 222      | 6.3      | 0.105      |
| 223      | 5.5      | 0.092      |
| 224      | 4.7      | 0.078      |
| 225      | 4.1      | 0.068      |
| 226      | 3.6      | 0.060      |
| 227      | 3.1      | 0.052      |
| 228      | 2.7      | 0.045      |
| 229      | 2.3      | 0.038      |
| 230      | 2        | 0.033      |



National Canners Association  
 1968 Laboratory Manual for Food  
 Canners and Processors