APPLICATION OF LETHAL RATE VALUES TO PASTEURIZATION PROCESSES OF SAUSAGES

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Under practical conditions pasteurization of sausages is usually performed according to experience. This is, however, unsatisfactory as it often results in underheated or overheated products. In both cases the quality of the products and the economy are affected.

In the canning industry evaluation of thermal processes has been used for a long time. Different procedures for evaluation have been developed since Bigelow et al (1) presented their general method. This method has been modified by Ball (2), by Schultz and Olson (3) and by Toggert and Farrow (4). A further version of the general method has been presented by Patashnik (5) and by Takács et al (6). These methods have, however, been primarily developed for sterilizing temperatures and have to be modified for evaluating pasteurization processes-.

The aim of this work has been to find a simple method for evaluating pasteurization processes of sausages.

Test cultures

The test strains had previously been isolated from different meat products (pasteurized sausages, canned ham) and belonged to the enterococcus group. They survived normal pasteurization.

The strains were subcultured into nutrient broth and incubated at 37°C for 24 hours. Before running a test the culture was kept in the refrigerator for a least one day in order to "age" the cells.

Determination of thermal reduction time

The equipment used corresponded essentially to the tube method proposed by Bigelow and Esty (7). The tubes were of stainless steel (1.1 mm walls) with an internal diameter of 5.8 mm. After sterilization of the heating menstruum, which consisted of a meat emulsion of the same composition as the sausage (10% protein, 60% water, 2% NaCl, 26% fat) the menstruum was inoculated with a known number of test organisms of a selected strain. About 1/3 of each test tube was filled with the inoculatedmenstruum, stoppered at both ends and finally immersed into a thermostatically controlled water bath.

The water level in the bath was maintained at 2-3 cm above the level of the menstruum in the tubes. At regular intervals the tubes were transferred to an iced water bath for cooling. Finally the number of surviving bacteria was determined by the plate count method.

The data obtained were used to plat survivor curves and to calculate decimal reduction time values (D-values) for various temperatures from 63° to 70°C.

By using the tube method to determine D-values it was possible to measure the death rate of bacteria by a simple manner, still using an authentic substrate. The effect of the

chemical environment on the heat resistance of bacterial cells has been demonstrated by several authors (8,9) and therefore need not be discussed here.

Because of the heating and cooling lags, small deviations from the straight-line shape of the survivor curve occured. The observed deviations were greater for heat sensitive strains than for heat resistant strains at the same temperature. In order to attain reasonable accuracy the thermal resistance tests were run at temperatures where heating and cooling lags did not seem to have any measurable effect on the results.

A typical survivor curve for a Streptococcus faecium strain is shown in figure 1.

Thermal death time curves. D-Values measured at different temperatures were used to plot thermal death time curves. Finally z-values were determined graphically as described by Stumbo (10).

Heat penetration curves. The time-temperature relationchips at a point at or near the geometrical center of the sausages during the thermal process were measured using an YSI- telethermometer. From the data obtained heat penetration curves were plotted as shown in figure 2.

Calculating lethal rate. Lethal rates were calculated according to the following equation presented by Ball (2).

$$L = \log^{-1} \frac{T - Tr}{z}$$

which may also be written as

$$L = 10^{\frac{T-Tr}{z}}$$

inwhich T = any lethal temperature
Tr= reference temperature
z = z-value of the test organism.

Lethal rate tables for z-values relevant to vegetative cells and pasteurization temperatures have, as for as we know, not been published before. We have calculated lethal rate valued for z-values between 1.11°C (34°F) and 6.67°C (44°F) and lethal temperatures from 50°C (122.0°F) to 75.0°C (167°F), based on the reference temperature 65°C (149°F).

Our values are presented in table 1.

Evaluation of typical pasteurization processes

For evaluating pasteurizing processes we chose the method proposed by Patashnik (5) and by Takács et al (6). This method has the advantage of being simple, accurate and readily applicable to different pasteurizing processes.

To illustrate the calculating procedure the pasteurizing process shown in figure 3 will be evaluated.

In the example chosen temperature readings were taken every minute during the process. All data needed are presented in table 2. Lethal rate values necessary were taken from table 1.

A suitable sxheme for calculation is presented in table 2.

In column 1 of table 2 process times in minutes are entered. In column 2 the corresponding temperatures (center temperature) expressed in degrees Celsius are entered. Finally in column 3 the lethality corresponding to each temperature is written.

To calculate the total process value all lethality values in column 3 are summarized and entered into column 4. As the equal-time-intervals had been 1 minute no multiplication is needed to find the total process value (5).

In the same way different parts of the process (heating period, cooling period) may be calculated independent of each other. Pasteurizing meat emulsions in a laboratory pasteurizer to different F_o-values calculated by the method described have shown that the method can be used to compare different pasteurizing processes of sausage.

Later on the method will be used to establish pasteurization standards for different types of pasteurized meat products.

References

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Table 1 : Lethal rate values for pasteurizing temperatures and z-values corresponding to vegetative cells.
Reference temperature 65°C (149°F)

Temperature	Z-values °C (°F)										
°C (°F)	1,11 (34)	1,67 (35)	2,22 (36)	2,78 (37)	3,33 (38)	3,89 (39)	4,44 (40)	5,00 (41)	5,56 (42)	6,11 (43)	6,67 (44)
50,0 (122,0)	0,1606	0,1692	0,1773	0,1863	0,1957	0,2031	0,2113	0,2195	0,2276	0,2355	0,2434
50,5 (122,9)	0,1707	0,1795	0,1883	0,1970	0,2056	0,2141	0,2226	0,2309	0,2391	0,2472	0,2551
51,0 (123,8)	0,1814	0,1905	0,1995	0,2084	0,2172	0,2258	0,2344	0,2428	0,2512	0,2594	0,2674
51,5 (124,7)	0,1928	0,2021	0,2113	0,2204	0,2293	0,2382	0,2469	0,2554	0,2639	0,2722	0,2803
52,0 (125,6)	0,2050	0,2145	0,2238	0,2331	0,2422	0,2512	0,2600	0,2687	0,2772	0,2856	0,2939
52,5 (126,5)	0,2179	0,2275	0,2371	0,2465	0,2558	0,2649	0,2738	0,2826	0,2912	0,2997	0,3080
53,0 (127,4)	0,2315	0,2414	0,2512	0,2607	0,2701	0,2793	0,2884	0,2973	0,3060	0,3145	0,3229
53,5 (128,3)	0,2461	0,2562	0,2660	0,2757	0,2852	0,2946	0,3037	0,3127	0,3214	0,3300	0,3385
54,0 (129,2)	0,2616	0,2718	0,2818	0,2916	0,3012	0,3106	0,3199	0,3289	0,3377	0,3463	0,3548
54,5 (130,1)	0,2780	0,2884	0,2985	0,3084	0,3181	0,3276	0,3369	0,3459	0,3548	0,3634	0,3719
55,0 (131,0)	0,2955	0,3059	0,3162	0,3262	0,3359	0,3455	0,3548	0,3638	0,3727	0,3814	0,3898
55,5 (131,9)	0,3140	0,3246	0,3349	0,3450	0,3548	0,3643	0,3736	0,3827	0,3916	0,4002	0,4086
56,0 (132,8)	0,3338	0,3444	0,3548	0,3648	0,3747	0,3842	0,3935	0,4026	0,4114	0,4200	0,4283
56,5 (133,7)	0,3548	0,3654	0,3758	0,3859	0,3957	0,4052	0,4144	0,4234	0,4322	0,4407	0,4490
57,0 (134,6)	0,3771	0,3877	0,3981	0,4081	0,4178	0,4273	0,4365	0,4454	0,4540	0,4625	0,4706
57,5 (135,5)	0,4008	0,4114	0,4216	0,4316	0,4413	0,4506	0,4597	0,4685	0,4770	0,4853	0,4933
58,0 (136,4)	0,4260	0,4365	0,4466	0,4565	0,4660	0,4752	0,4841	0,4928	0,5011	0,5093	0,5171
58,5 (137,3)	0,4527	0,4631	0,4731	0,4828	0,4921	0,5011	0,5099	0,5183	0,5265	0,5344	0,5421
59,0 (138,2)	0,4812	0,4913	0,5011	0,5106	0,5197	0,5285	0,5370	0,5452	0,5531	0,5608	0,5682
59,5 (139,1)	0,5114	0,5213	0,5308	0,5400	0,5488	0,5573	0,5655	0,5735	0,5811	0,5885	0,5956
60,0 (140,0)	0,5436	0,5531	0,5623	0,5711	0,5796	0,5878	0,5956	0,6032	0,6105	0,6175	0,6243
60,5 (140,9)	0,5777	0,5869	0,5956	0,6040	0,6121	0,6198	0,6273	0,6345	0,6414	0,6480	0,6544
61,0 (141,8)	0,6140	0,6227	0,6309	0,6388	0,6464	0,6537	0,6606	0,6674	0,6738	0,6800	0,6860
61,5 (142,7)	0,6526	0,6606	0,6683	0,6756	0,6826	0,6893	0,6958	0,7020	0,7079	0,7136	0,7191
62,0 (143,6)	0,6937	0,7009	0,7079	0,7145	0,7209	0,7270	0,7328	0,7384	0,7437	0,7488	0,7538
62,5 (144,5)	0,7373	0,7437	0,7498	0,7557	0,7613	0,7666	0,7717	0,7766	0,7813	0,7858	0,7901
63,0 (145,4)	0,7836	0,7891	0,7943	0,7992	0,8040	0,8085	0,8128	0,8169	0,8208	0,8246	0,8282
63,5 (146,3)	0,8328	0,9372	0,8413	0,8453	0,8490	0,8526	0,8560	0,8593	0,8624	0,8653	0,8682
64,0 (147,2)	0,8852	0,8883	0,8912	0,8940	0,8966	0,8991	0,9015	0,9038	0,9060	0,9081	0,9101
64,5 (148,1)	0,9408	0,9425	0,9440	0,9455	0,9469	0,9482	0,9495	0,9507	0,9518	0,9529	0,9539
65,0 (149,0)	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
65,5 (149,9)	1,0628	1,0609	1,0592	1,0576	1,0560	1,0545	1,0531	1,0518	1,0505	1,0493	1,0482
66,0 (150,8)	1,1296	1,1257	1,1220	1,1185	1,1152	1,1121	1,1091	1,1063	1,1037	1,1011	1,0987
66,5 (151,7)	1,2006	1,1943	1,1885	1,1829	1,1777	1,1728	1,1681	1,1637	1,1595	1,1555	1,1517
67,0 (152,6)	1,2760	1,2672	1,2589	1,2511	1,2437	1,2368	1,2302	1,2240	1,2181	1,2126	1,2073
67,5 (153,5)	1,3562	1,3445	1,3335	1,3231	1,3134	1,3043	1,2956	1,2875	1,2798	1,2724	1,2655
68,0 (154,4)	1,4415	1,4265	1,4125	1,3994	1,3870	1,3755	1,3645	1,3542	1,3445	1,3353	1,3265
68,5 (155,3)	1,5321	1,5135	1,4962	1,4800	1,4648	1,4505	1,4371	1,4244	1,4125	1,4012	1,3905
69,0 (156,2)	1,6284	1,6058	1,5848	1,5652	1,5469	1,5297	1,5135	1,4983	1,4839	1,4704	1,4575
69,5 (157,1)	1,7307	1,7038	1,6788	1,6554	1,6336	1,6132	1,5940	1,5760	1,5590	1,5430	1,5278
70,0 (158,0)	1,8395	1,8077	1,7782	1,7508	1,7252	1,7012	1,6788	1,6577	1,6378	1,6192	1,6015
70,5 (158,9)	1,9551	1,9180	1,8836	1,8516	1,8219	1,7940	1,7680	1,7436	1,7207	1,6991	1,6788
71,0 (159,8)	2,0780	2,0350	1,9952	1,9583	1,9240	1,8920	1,8620	1,8340	1,8077	1,7830	1,7597
71,5 (160,7)	2,2086	2,1591	2,1134	2,0711	2,0318	1,9952	1,9611	1,9291	1,8992	1,8710	1,8446
72,0 (161,6)	2,3474	2,2908	2,2387	2,1904	2,1457	2,1041	2,0653	2,0291	1,9952	1,9634	1,9335
72,5 (162,5)	2,4949	2,4306	2,3713	2,3166	2,2660	2,2189	2,1752	2,1343	2,0961	2,0604	2,0268
73,0 (163,4)	2,6517	2,5788	2,5118	2,4501	2,3930	2,3400	2,2908	2,2450	2,2022	2,1621	2,1245
73,5 (164,3)	2,8183	2,7361	2,6607	2,5912	2,5271	2,4677	2,4126	2,3614	2,3135	2,2688	2,2270
74,0 (165,2)	2,9955	2,9030	2,8183	2,7405	2,6687	2,6024	2,5409	2,4838	2,4306	2,3809	2,3344
74,5 (166,1)	3,1837	3,0801	2,9853	2,8984	2,8183	2,7444	2,6760	2,6126	2,5535	2,4984	2,4470
75,0 (167,0)	3,3838	3,2680	3,1622	3,0653	2,9763	2,8942	2,8183	2,7480	2,6826	2,6218	2,5650

Table 2 : Process value calculation of a commercial pasteurization process of sausages.
z-value : 3.89° resp. 39°F

(1) Processing time in min.	(2) Temp. °C	(3) Lethality	(4) F_o
1	51,4	0,2382	Heating period
2	52,1	0,2512	
3	52,8	0,2793	
4	53,5	0,2946	
5	54,2	0,3106	
6	55,1	0,3455	
7	56,0	0,3842	
8	56,9	0,4273	
9	57,8	0,4752	
10	58,6	0,5011	
11	59,4	0,5573	
12	60,2	0,5878	
13	60,9	0,6537	
14	61,6	0,6893	
15	62,2	0,7270	
16	62,8	0,8085	
17	63,4	0,8526	
18	63,9	0,8991	
19	64,5	0,9482	
20	65,0	1,0000	
21	65,5	1,0545	
22	66,0	1,1121	
23	66,5	1,1728	
24	66,9	1,2368	
25	67,4	1,3043	
26	67,8	1,3755	
27	68,1	1,3755	
28	68,5	1,4505	
29	68,8	1,5297	
30	69,2	1,5297	
31	69,5	1,6132	
32	69,9	1,7012	
33	70,2	1,7012	
34	70,5	1,7940	
35	70,8	1,8920	
36	71,0	1,8920	
37	71,3	1,9952	
38	71,4	1,9952	
39	71,5	1,9952	
40	71,6	1,9952	
41	71,7	1,9952	44,9417
42	71,4	1,9952	Cooling period
43	71,2	1,8920	
44	70,9	1,8920	
45	70,6	1,7940	
46	69,4	1,6132	
47	68,2	1,3755	
48	66,9	1,2368	
49	65,7	1,0545	
50	63,9	0,8991	
51	62,1	0,7270	
52	60,3	0,6198	
53	58,5	0,5011	
54	56,6	0,4052	
55	54,7	0,3276	
56	52,8	0,2793	
57	50,9	0,2258	16.8381
		Total lethality : (process value)	61.7820

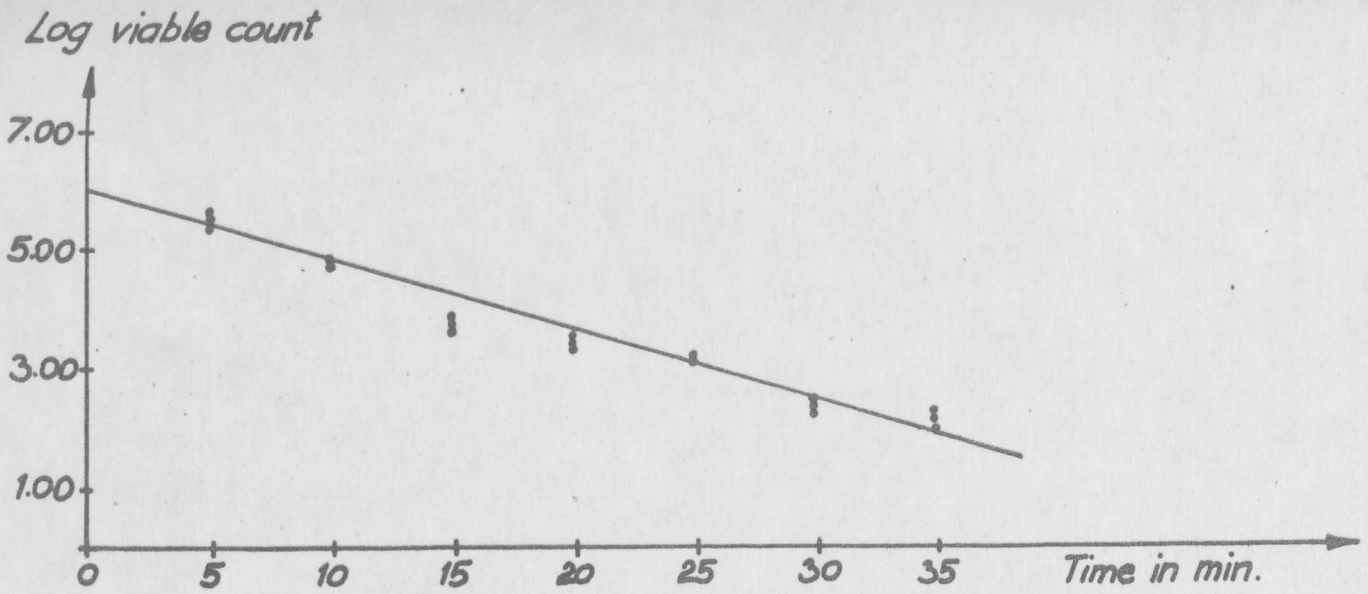

Figure 1. Survivor curve for a strain of Streptococcus faecium in meat emulsion at 70°C D= 9.1 min

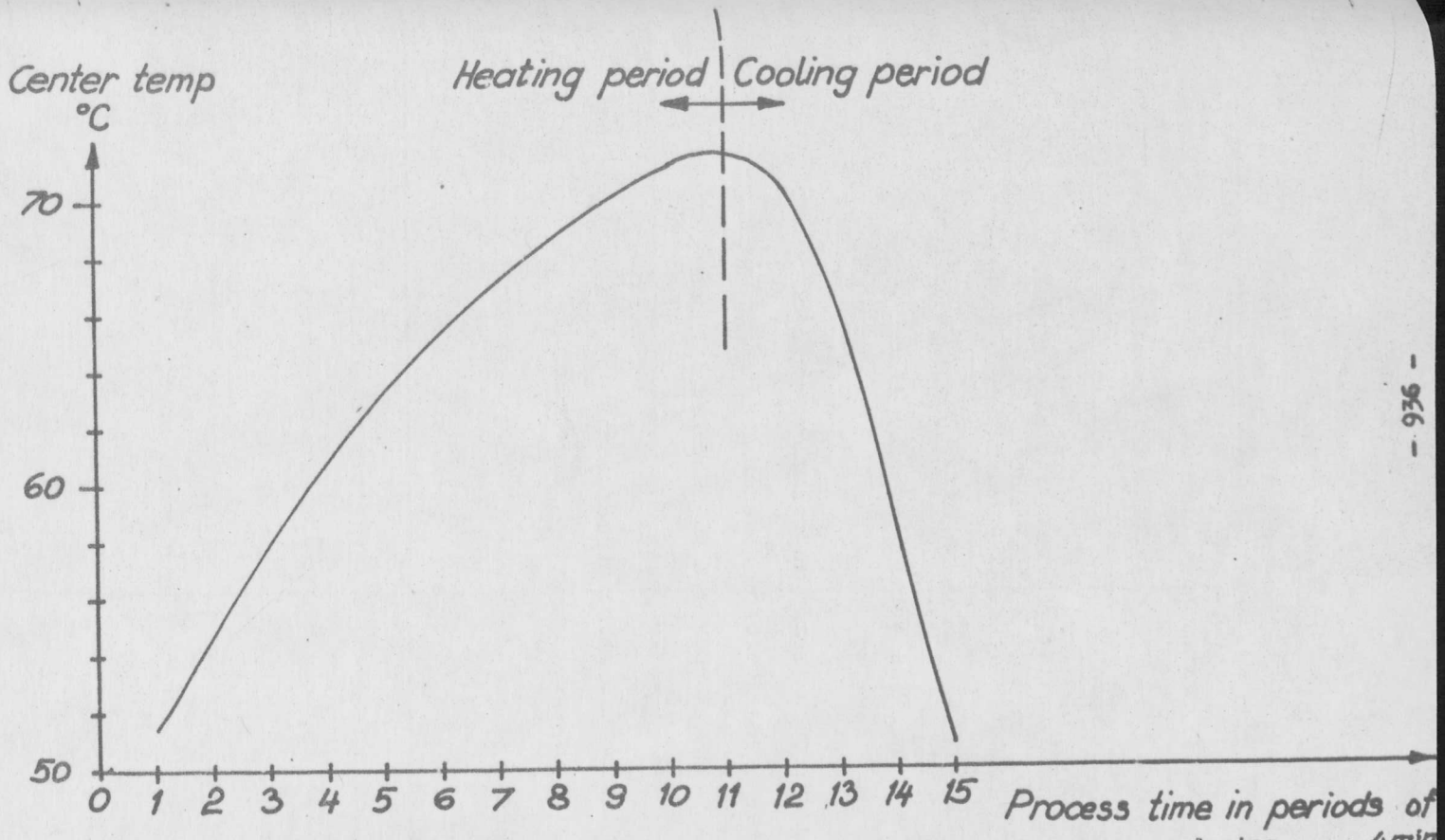

Fig.2 Time - temperature relationship at the geometrical center of a sausage during pasteurization.