KINETICS OF SECONDARY MICROBIAL GROWTH DURING STORAGE OF SLICED LUNCHEON MEAT

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Background

Luncheon meat is usually sold in the form of slices wrapped in plastic vacuum bags. If a proper thermal processing has been applied, the primary product is sterile and thus it is the secondary microbial that contaminates the slice surface during slicing and packing, which determines its stability and edibility. The learning of kinetics of growth allows to select proper storing conditions and to determine a safe deadline for consumption. In the literature numerous models of mathematical prediction may be found, which describe growth of various pathogenic bacteria or their combinations at different conditions comprising storing temperature, salt concentration, water activity, pH, initial level of microbiological contamination, limit level of microbiological contamination, harmful to human health, etc. (Buchman 1993, Darey 1989 at 1994, McMeekin et all. 1993, Ross and McMeekin 1994, Walker and Jones 1994). In the Internet the „Pathogen Modeling Program" is available, comprising models of growth for numerous bacteria frequently appearing in foodstuffs, which takes into consideration their growth conditions. The practical usability of the existing predictive models is rather limited and a responsible manufacturer shall always prefer to determine shelf life for his products basing on experimental data. Therefore, there exists a keen need for a reasonably developed method of such research as well as for a scientific interpretation of its results.

Objectives

The aim of the studies was to examine a growth of pattern strains: Weisella viridescens ATCC 12706 and Escherichia coli NCTC 8196, placed on the surface of slices of luncheon meat in the form of the inoculum of a determined concentration, during storage in various temperatures.

Methods

The portions of the sliced luncheon meat, manufactured in the form of sterile preserves were the subject of the research. The product, after taking out from cans, was sliced and contaminated on their surfaces with the inoculum of Weisella viridescens and Escherichia coli bacteria of various initial numbers N_0 measured as a logarithm of the number of bacteria per one gram (CFU/g). The slices of luncheon meat, wrapped in the vacuum plastic bags were stored in the temperature of 2°C, 9 or 11°C and 20°C in the period of 1 to 4 weeks. In the determined intervals, i.e. after 1, 4, 7-8, 11-12 and 21-25 days the samples for microbiological tests were taken. The number of bacteria was determined with a plate method. The samples of the test with Weisella viridesceus strain were inoculated onto the plates with Mann, Rogosa, Sharp Agar (MRS) breeding-ground made by Merck Company, then incubated in the temperature of 30°C. The samples of the test with Escherichia coli strain were inoculated onto the plates with Plate Count Agar (PCA) breeding-ground made by Merck Company and then incubated in the temperature of 37°C. The tests were repeated twice using the luncheon meat of a similar salt contents 2% NaCl, but of different humidity 68% and 60% and different fat contents 10,5% and 20,0% and thus of a different brain concentration ranging from 2,9% (1st repetition) to 3,2% (2nd repetition).

Results and Discussion

The figures Nos. 1,2,3 and 4 present the dependence of the logarithm of the number of bacteria in one gram (CFU/g) N_t on the time t counted in days of sample storing, in the form of the points representing the results of experiments and the curve, which may be described with the following equation

$$N_t = N_{max}(1 - e^{-k(t+t0)}), \qquad (1)$$

where N_{max} – logarithm of the highest experienced number of bacteria (CFU/g), K – constant speed of growth of bacteria, t – time counted from the moment of sample contamination, t_0 – „initiation time" i.e. time necessary for development of the tested microorganism to the initial level of contamination $N_0=N_t$ for the time $t=0$. The equation (1) has been developed theoretically at the assumption that the kinetic process of the growth of microorganisms is the first order chemical reaction and that it passes according to the differential equation as follows

$$\frac{dN_\tau}{d\tau} = K(N_{max} - N_\tau), \qquad (2)$$

where τ – time counted from the beginning of the growth of bacteria.
The equation after integration shall read as follows

$$ln(N_{max} - N_\tau) = -K\tau + ln\, C, \qquad (3)$$

where $\ln C$ is an integration constant. If one determines the constant $\ln C$ at the boundary condition that for $\tau=0$ $N_\tau = 0$ he receives the equation as follows

$$N_\tau = N_{max}(1 - e^{-K\tau}), \qquad (4)$$

which, after substituting $\tau = t+t_0$ is converted into the formula (1).
The initial data and computed parameters of the equation (1) are given in the table.

The growth of bacteria depends, first of all, on temperature. For the temperature of 2°C E. coli did not show growth, on the contrary - during storing of the samples of luncheon meat a drop in the number of bacteria has been noticed. In the same temperature the number of W. viridescens has been growing but very slowly. In general, the impact of temperature on the growth of bacteria in the range between the minimum growth temperature and thermal death temperature may be described with the Arrhenius equation, but at the assumption of the variable energy activation.

The values of the energy of activation for the experimental data from the table 1 in Joules per kilomol (JkM^{-1}) has been calculated with the application of the equation given by Loncin 1976 as follows

$$\ln\frac{K}{K_w} = \frac{A}{R}\left(\frac{T_w - T}{T_w \times T}\right), \qquad (5)$$

where K_w is a pattern constant for the growth speed determined for the pattern temperature T_w, A – activation energy, R – gas constant. For W. viridescens ATCC 12706 they amount to:

in the first repetition

$5{,}9\cdot10^7$(T=20°C, Tw=11°C), $1{,}0\cdot10^8$(T=20°C, Tw=2°C) i $1{,}5\cdot10^8$ (T=11°C, Tw=2°C)

and in the second repetition,

$7{,}0\cdot10^7$(T=20°C,Tw=9°C), $1{,}2\cdot10^8$(T=20°C,Tw=2°C) i $1{,}8\cdot10^8$ (T=9°C, Tw=2°C)

For E. coli the values of the activation energy amount to $4{,}0\cdot10^7$(T=20°C, Tw=11°C) for the first repetition and to $4{,}1\cdot10^7$(T=20°C, Tw=9°C) for the second repetition. The values of the bacteria growth energy activation, as computed, are near or within the range from $3\cdot10^7$ to $1.2.10^8$ JkM^{-1} as given by Loncin 1976.

Table Initial data and parameters of the equation (1) describing the kinetics of the growth of test bacteria.

Test bacteria	E. coli NCTC 8196						W. viridescens ATCC 12706					
Repetition	1			2			1			2		
Temperature T (°C)	2	11	20	2	9	20	2	11	20	2	9	20
N_o (log (CFU/g))	4,08	4,08	4,08	3,61	3,61	3,61	3,08	3,08	3,08	4,28	4,28	4,28
N_{max} (log (CFU/g))	-	8,47	8,59	-	8,94	9,08	8,30	8,42	8,26	8,13	8,43	8,17
K (1/day)	-	0,44	0,74	-	0,36	0,70	0,09	0,67	1,43	0,12	0,92	2,80
t_0 (days)		1,51	1,09		2,40	0,79	7,30	1,03	0,23	6,05	0,84	0,09

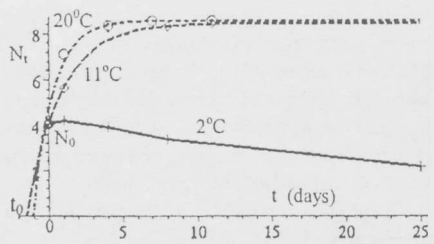

Fig. 1 E. coli / 1 repetition /

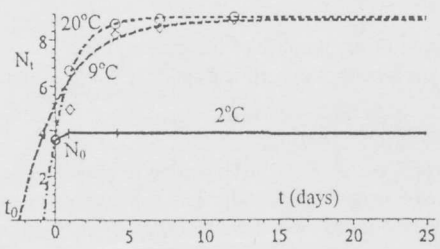

Fig. 2 E. coli / 2 repetition /

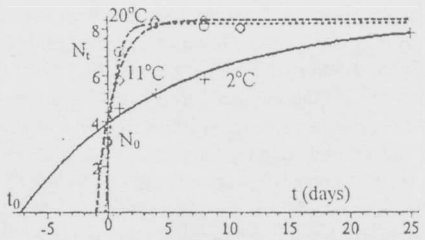

Fig. 3 W. viridescens / 1 repetition /

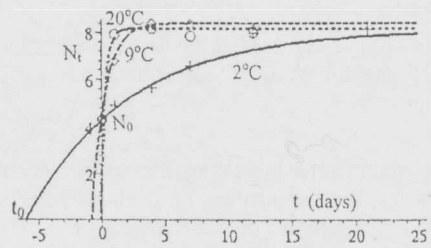

Fig. 4 W. viridescens / 2 repetition /

Conclusions

1. On the examples of the pattern E. coli and W. viridescens strains, the usability of the theoretically developed formula (1) for the description of the growth process of the bacteria transferred onto the surface on luncheon meat slices during storing, has been proved.
2. Presented formula (1) may consist a ground to prediction bacterial growth in cool storage packaged meat products and definition of a shelf-life period.

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