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DETERMINATION OF POWER–TIME CURVES OF STAPHYLOCOCCUS AUREUS GROWTH AND STUDY OF PROMOTER ACTION OF A GINSENG

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Abstract

The power *vs.* time curves of *Staphylococcus aureus* were determined by using a 2277 Thermal Activity Monitor (Sweden). By means of a new model of microorganism growth, the growth rate constants at different concentrations of ginseng and the minimum concentration were calculated from these curves.

Keywords: ginseng, growth rate constant, microcalorimetric method, minimum concentration, power *vs.* time curve, promoter action, *Staphylococcus aureus*

Introduction

An account was earlier published [1] of the optimum concentration of a synthetic medicine with fungistatic action. The power *vs.* time curves of bacterial growth were determined under inhibitory conditions. These curves yield considerable information on the process of growth of microorganisms, e.g. the optimum growth temperature [2, 3], a new experimental mode [4], the optimum concentration of a synthetic medicine with fungistatic action [5] and the kinetic parameters [6]. In general, the metabolisms of bacteria are very complicated, but only some such processes have been studied.

In the present paper, the power *vs.* time curves were determined and the promoter action of ginseng at different concentrations was studied. The growth rate constant and the minimum concentration in the promoter action of ginseng were calculated.

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Experimental

Instrument

A new type of heat-flow microcalorimeter, the 2277 thermal activity monitor (Thermo Metric AB, Sweden), was used in the flow-through mode in this experiment. The sample was pumped through the flow cell by a 2132 microperspex peristaltic pump. This system is very sensitive, the detection limit being 1.5×10^{-7} W, while the baseline stability (over a period of 24 h) is 2×10^{-7} W, the range of working temperature is 10–80°C and the working temperature can be maintained constant within $\pm2\times10^{-4}$ °C.

Method

The complete cleaning and sterilization procedure for the flow tubing was as follows: sterilized distilled water, 0.1 mol L^{-1} HCl, 0.1 mol L^{-1} NaOH, and ethanol solution (75%) were pumped through the system for 30 min each at a flow rate of 30 ml h^{-1}; finally, sterilized distilled water was pumped through the system for 30 min at a flow rate of 10 ml h^{-1}, and the baseline was determined. When a stable baseline had been obtained, the bacterial sample, medium and ginseng in different volumes were pumped into the flow cell system and the monitor began to record the power *vs.* time curves of continuous growth for *Staphylococcus aureus*. When the recording pen had returned to the baseline and became stabilized, the process of bacterial growth was complete.

Materials

Staphylococcus aureus was employed as microorganisms.

A soluble medium (*pH* 7.2–7.4) was used, containing 1 g NaCl, 2 g peptone and 1 g beef extract in each 200 ml.

The soluble medium contained ginseng in different concentrations 64.3 g of natural complete fourth-year ginseng was decocted for 30 min and filtered to give 42 ml of medicine solution with a concentration of 1.531 g ginseng/ml medicine solution. Different volumes were added to the soluble medium.

Establishment of new experimental model of bacterial growth

Metabolic bacterial processes were determined under isothermal and isochoric conditions, where the supply of nutrient matter and oxygen was limited. In the presence of ginseng, the growth process of *Staphylococcus aureus* is inhibited. It was earlier found [7] that the exponential mode could not be used to simulate this process.

In the growth phase, the number of bacteria is in accordance with the following law:

$$dN(t)/dt = \mu N(t) - \beta N^2(t) \quad (1)$$

where μ is the growth rate constant, β is the deceleration rate constant, and $N(t)$ is the number of bacteria at time t.

If the bacterial growth power is P_o, then

$$P(t) = P_o N(t) \quad (2)$$

and accordingly

$$dP(t)/dt = \mu P(t) - (\beta/P_o)P^2(t) \quad (3)$$

The integral of (3) is given by

$$P^{-1}(t) = (P_o^{-1} - \beta/\mu P_o)e^{-\mu t} + \beta/\mu P_o$$
$$\text{or } P^{-1}(t) = ae^{-\mu t} + b \quad (4)$$

where $a=P_o^{-1}-(\beta/\mu P_o)$ and $b=\beta/\mu P_o$

Experimental results and calculation of growth rate constant and minimum concentration

The power *vs.* time curves for *Staphylococcus aureus* were determined at 37°C and different concentrations of ginseng (Fig. 1). From the growth curves and the $P(t)$ and t data (Table 1), the growth rate constant (μ) and deceleration rate constant (β) can be calculated.

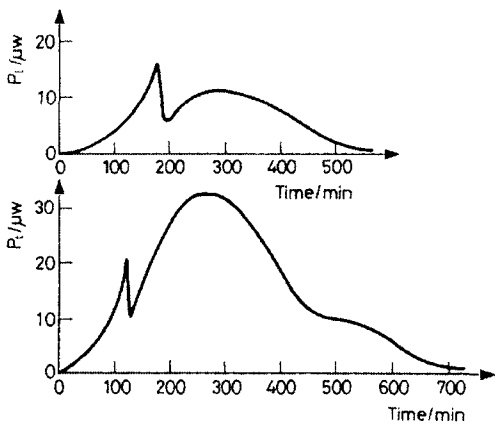

Fig. 1 Power *vs.* time curves: a) *Staphylococcus aureus* in the absence of ginseng; b) *Staphylococcus aureus* with 0.03734 g ml^{-1} ginseng

When the concentration of ginseng with promoter action is 0.03734 g ml^{-1}, the corresponding nonlinear equation is

$$P^{-1}(t) = 1.6585e^{-0.03074t} - 0.0066 \qquad t < 110 \text{ min}$$

$$\mu = 0.03074$$

$$P^{-1}(t) = 0.4818e^{-0,01278t} - 0.0021 \qquad 130 < t < 225 \text{ min}$$

$$\mu' = 0.01278$$

where μ and μ' are the growth rate constants of the first and second peaks for the promoter action of ginseng.

The growth rate constants calculated for different concentrations of ginseng are shown in Table 2.

Table 1 $P(t)$ and t values at different concentrations of ginseng

Concentration of ginseng/g ml^{-1}									
0.01890		0.03734		0.0729		0.1701		0.3062	
t/min	$P(t)$/μw	t/min	$P(t)$/μw	t/min	$P(t)$/μw	t/min	$P(t)$/μw	t/min	$P(t)$/μw
25	1.2	25	1.3	25	1.4	25	1.8	25	2.2
50	2.0	50	3.2	50	4.2	50	5.8	50	7.1
75	3.6	75	6.1	60	6.1	60	8.2	60	9.9
100	7.0	100	12.2	75	9.5	75	13.2	75	15.9
125	13.0	110	15.8	90	14.3	85	19.0	80	19.2
135	16.2			100	17.7				
150	9.0	130	10.0	130	11.0	125	11.7	125	12.3
165	13.0	150	15.0	155	19.0	150	20.2	150	21.2
175	15.0	175	22.3	180	26.4	165	25.4	165	27.3
200	19.5	200	27.0	205	33.5	175	28.9	175	31.0
225	22.2	225	31.0	230	39.2	200	37.3	200	39.0

Table 2 Growth rate constants (μ) at different concentrations of ginseng

c/g ml^{-1}	μ/min^{-1}	μ'/min^{-1}
0.01890	0.02652	0.01213
0.03734	0.03074	0.01278
0.07290	0.03600	0.01350
0.1701	0.03977	0.01575
0.3062	0.03981	0.01580

μ is the growth rate constant of the first peak;
μ' is the growth rate constant of the second peak.

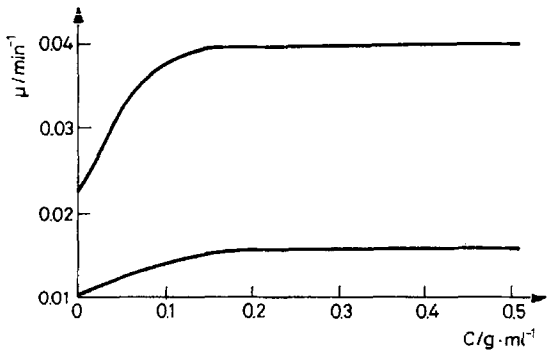

Fig. 2 Growth rate constant (μ) different concentrations of ginseng for promoter action

From these growth rate constants at different concentrations of ginseng, we determined the minimum concentration of ginseng for promoter action (Fig. 2). We can be extend and maintained constant within 0.200 g ml^{-1} of growth rate constant at a given concentration.

Conclusion

The given curves provide much information concerning the kinetics of promoted metabolic processes. From the new model, the growth rate constant (μ) and minimum concentration of ginseng were calculated. These data are very useful in studies of thermokinetic properties of bacteria.

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