Effect of Low Temperature on Bacterial Growth

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Article Summary: *"Low temperature can influence the response of a microorganism either directly or indirectly. Direct effects include decreased growth rate, enzyme activities, alteration of cell composition and differential nutritional requirements. Indirect effects are usually observed on the solubility of solute molecules, diffusion of nutrient.."*

EFFECT OF LOW TEMPERATURE ON BACTERIAL GROWTH:

Decrease in temperature cause an exponential reduction of the reaction rate, and the magnitude of which depends on the value of the activation energy. Consequently, most biological systems display a reaction rate 2-3 times lower when the temperature is decreased by 10°C (Q10 value). Temperatures outside the linear range of the Arrhenius plot (log of growth rate vs the reciprocal of the absolute temperature) are stress inducing temperatures. For psychrophiles, Arrhenius plots remain linear down to 0°C, for psychrotolerants and mesophiles they deviate from linearity at 5-10°C and at 20°C, respectively. Optimal growth temperature is often erroneously correlated to the maximal growth rate. The temperature at which the growth rate is maximal reflects only kinetic effects and occurs above the linear part of the Arrhenius curve, which means that the physiological conditions are not ideal and growth rate may not be as relevant as growth yield.

Low temperature can influence the response of a microorganism either directly or indirectly. Direct effects include decreased growth rate, enzyme activities, alteration of cell composition and differential nutritional requirements. Indirect effects are usually observed on the solubility of solute molecules, diffusion of nutrients, osmotic effects on membranes and cell density. As temperature falls, the lag phase that precedes growth extends, leading to a decrease in the growth rate and the final cell number. During the lag phase that precedes growth in mesophiles, many physiological changes occur, including a decrease in the saturation of fatty acids and inhibition of DNA, RNA and protein synthesis.The cold temperatures largely effect on the solute transport system. The lipid bilayer which is the basic structure of the microbial membranes must have proper fluidity to maintain the cell permeability and movement of essential solutes. The functional state of this bilayer is a liquid-crystalline phase, but a decline in temperature induces a gel phase transition and a drastic loss of the membrane properties. A major difference between mesophiles and psychrotrophs is the ability to transport sugars into the cell at temperatures near 0oC. The effect of the rapid cold shock on the membrane correlated with high rates of cell inactivation (90 and 70 %) in E.coli and Bacillus subtillis. Thus, membrane alternation seems to be the principle cause of cold shock injury in E.coli and Bacillus subtilis.

A decrease in the poly-b-hydroxybutyrate (PHB) content of non-cold acclimated Rhizobium DDSS69 cultures was also at low temprature. Cold stress induces a shift in the carbon source utilization and enhances the susceptibility of bacteria to antibiotics. Vibrio cholerae is known to enter the viable but non-culturable state in response to cold temperature shock. In some bacteria, production of pigments and other enzymatic activities are enhanced at low temperatures, e.g. lipase and proteinase production by Pseudomonas and certain other genera occurs preferentially at low temperatures. The prior temperature history of the cell has been found to be an important factor of the survival and growth of organisms because of its effects on the extent of lag phase before onset of growth.

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