A branched chain fatty acid promotes cold adaptation in bacteria

Bacterial strains that can survive extreme cold do so by adopting special strategies. At low environmental temperature, the fluidity of bacterial cell-membranes decreases and maintenance of an optimum membrane fluidity becomes crucial for survival. Incorporation of lower-melting point fatty acids (unsaturated, short chain and branched chain fatty acids) into lipids exerts a fluidizing effect on the membrane. These changes are known as the homeoviscous adaptation of membrane fluidity (Suutari and Laakso 1994).

Among branched chain fatty acids, synthesis of anteiso fatty acids increases in preference to the synthesis of iso fatty acids. This is a common change induced by a decrease in temperature. Branching occurs from the penultimate carbon atom furthest from the functional group in an anteiso fatty acid whereas branching occurs from the furthest carbon atom in an iso fatty acid. There is accumulating evidence that anteiso fatty acids play an important role in cold adaptation of bacteria.

An anteiso fatty acid (a–$C_{15:0}$) was found to be the major component in the fatty acid profile of one Gram-positive and one Gram-negative Antarctic psychrotroph, grown at low temperature (Chattopadhyay and Jagannadham 2001). *Listeria monocytogenes* is a food-borne pathogen that grows at refrigeration temperatures. In two strains of *L. monocytogenes*, a predominance of a–$C_{15:0}$ was found in the fatty acid profile when cells were grown at 5°C. Two cold-sensitive mutants of *L. monocytogenes* were found to be deficient in the synthesis of a–$C_{15:0}$ and also in the synthesis of another branched chain fatty acid, a–$C_{17:0}$. It is known that a switchover in the synthesis from iso to anteiso fatty acids in bacteria depends on selection of the proper primer. The primer for anteiso odd-numbered fatty acids is the CoA ester of 2-methylbutyric acid. It is derived from isoleucine. It was postulated that the cold-sensitivity of the mutants might stem from their inability to produce 2-methylbutyryl CoA. By adding 2-methylbutyric acid to the culture it was possible to restore both the ability of the mutants to grow at low temperature and their level of a–$C_{15:0}$ and a–$C_{17:0}$ to that found in the parent strain (Annous *et al* 1997). A question still remained regarding the exact role of these two components in membrane fluidity. Recently the gap has been bridged by measuring the membrane fluidity of one of the mutants and the parent strain with the help of electron paramagnetic resonance (EPR). The membrane of the mutant cell was found to be less fluid than the membrane of the parent strain. When the mutant was grown in the presence of 2-methylbutyric acid, its membrane fluidity was found to be restored to a level comparable to that of the parent (Jones *et al* 2002).

It is evident that these two-branched chain fatty acids significantly improve membrane fluidity of *L. monocytogenes* at low temperature and hence contribute to cold adaptation in this organism. Studies involving Antarctic bacteria indicate that a–$C_{15:0}$ may play a beneficial role in general in bacterial cold adaptation.

Annous *et al* (1997) showed that the amount of the major component of the fatty acid profile of *L. monocytogenes* at low temperature (a–$C_{15:0}$) was slightly enhanced when glycine betaine was present in the growth medium. The role of a–$C_{15:0}$ in membrane fluidity supports the hypothesis that glycine betaine acts as a cryoprotectant by virtue of its ability to enhance the biosynthesis of membrane fluidizing fatty acids.

References

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