Anaerobic LCFA degradation: a role for non-syntrophic conversions?

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For many years the focus of lipids/long-chain fatty-acids (LCFA) wastewater treatment was on technological and process developments. More recently, promising results on the anaerobic treatment of LCFA-containing wastewaters¹ widened the attention to the microbiology aspects as well. In anaerobic bioreactors, LCFA can be β-oxidized to acetate and H₂ by acetogenic bacteria, in obligatory syntrophy with methanogens. Presently, 14 species have been described that grow on fatty-acids in syntrophy with methanogens, all belonging to the families Syntrophomonadaceae and Syntrophaceae². Among these, only 4 species are able to degrade mono- and/or polyunsaturated LCFA. The reason why the degradation of unsaturated LCFA is not more widespread remains unknown. Early studies suggested that degradation of unsaturated LCFA requires complete chain saturation prior to β-oxidation². Unsaturated LCFA, such as linoleate (C18:2) and oleate (C18:1), would be metabolized through a hydrogenation step yielding stearate (C18:0), then entering the β-oxidation cycle. However, this theory is inconsistent with the observed accumulation of palmitate (C16:0) in continuous bioreactors fed with oleate¹.

We hypothesize that LCFA chain saturation might be a non-syntrophic process, i.e. unsaturated LCFA can function as electron donors and acceptors, as protons released in a first β-oxidation step can be used to hydrogenate the unsaturated hydrocarbon. To test this, linoleate (C18:2), oleate (C18:1) and a mixture of stearate (C18:0) and palmitate (C16:0) were continuously fed to bioreactors with methanogenesis-active or -inhibited anaerobic sludge.

In the reactors fed with linoleate and oleate, palmitate accumulated in methanogenesis-active and -inhibited bioreactors up to concentrations of approximately 2 mM and 8 mM, respectively. In methanogenesis-inhibited bioreactors fed with a mixture of saturated LCFA (stearate and palmitate) no biological activity occurred. These results suggest the occurrence of a non-syntrophic step during the degradation of unsaturated LCFA in anaerobic bioreactors. The identification of microbial communities involved in non-syntrophic linoleate/oleate to palmitate conversion will give more insights into this novel biochemical mechanism.


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