Research in Microbiology 167 (2016) 254–261

www.elsevier.com/locate/resmic

Original article

Alternative scenarios of starvation-induced adaptation in *Pectobacterium atrosepticum*

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Received 30 November 2015; accepted 29 January 2016
Available online 18 February 2016

Abstract

Bacteria have high adaptive potential that ensures their survival during various environmental challenges. To adapt, bacteria activate a physiological program of stress response that makes them able to persist under adverse conditions. The present study sought to examine the ability of a particular bacterial species to induce a stress response in alternative scenarios. Cells of the phytopathogenic microorganism *Pectobacterium atrosepticum* were taken as a model. The cells were exposed to starvation in different physiological states (actively growing exponential phase and stationary phase cells), and the resulting starving cultures were monitored using CFU counting, quantitative PCR and electron microscopy. When exponential phase cells were subjected to starvation, the nucleoids of the cells became condensed and their DNA was detected by qPCR less effectively than that of cells growing in nutrient-rich medium, or stationary phase cells after starvation. Exponential phase cells subjected to starvation showed increased expression of genes encoding DNA binding histone-like proteins, whereas, in cultures inoculated by stationary phase cells, cell-wall-deficient forms that were inefficient at colony forming and that had a non-culturable phenotype were formed. The cell-wall-deficient forms displayed reduced expression of genes encoding synthases of cell wall components.

Keywords: Adaptation; Stress response; Nucleoid condensation; Cell-wall-deficient forms; Viable but non-culturable cells

1. Introduction

Since bacteria are among the most simply organized organisms, they possess high adaptive potential that enables them to endure a variety of environmental challenges. Adaptive responses are often related to dramatic physiological and morphological changes in the cells. It is generally accepted that a bacterial cell must be specifically pre-prepared physiologically in order to realize its adaptive potential. First, the cell must "feel" itself as part of the population, since the stress response is under the control of cell-to-cell communication, and thus adaptation is a function of the population, but not of the particular cell [3,39,44]. Second, the cell must be targeted toward performing one or at least a limited set of the physiological programs. It is known, for instance, that actively proliferating cells are deficient in their stress resistance [43,47].

However, bacterial cells in a natural ecosystem may be exposed to a stress effect without being pre-prepared physiologically to adapt–for example, when existing at low population density or using the strategy of intensive reproduction. Our previous works on the plant pathogenic bacterium *Pectobacterium atrosepticum* [10,31] and other microorganisms (unpublished data) showed that additional steps within the framework of the stress response resulted in overcoming some restrictions that limited formation of the adaptive response in

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http://dx.doi.org/10.1016/j.resmic.2016.01.009