Beatriz Martínez Fernández

Food Biopreservation by Means of Bacteriophages, Phage Endolysins and Bacteriocins

The rise of antibiotic resistant bacteria and the increasing demand for naturally preserved food have fueled research on natural (or food-related) antimicrobials. Bacteriophages are viruses that exclusively infect, and in most cases, kill bacteria. Phages are abundant and ubiquitous in nature, including food, and may proliferate in any environment in the presence of their host bacteria. Virulent phages follow a lytic cycle and replicate inside the host cell right after infection, new virions are assembled and eventually released to start a new infection cycle. On the contrary, temperate phages may integrate into the bacterial chromosome as prophages until specific environmental conditions trigger excision and they enter the lytic cycle. On the one hand, phages have several advantages as food biopreservatives, including their ability to amplify and their highly specific host range that keeps the natural microbiota undisturbed. On the other hand, bacteria and their phages are in a continuous "arms-race" and resistance may occur. Phages promote bacterial evolution, may also contribute to bacterial fitness and may carry virulence factors that should be avoided. Therefore, in order to be used as food biopreservatives, phages must be characterized in depth to tailor specific phage cocktails. Endolysins are phage-encoded enzymes that specifically hydrolyze different bonds within the peptidoglycan of the bacterial cell wall, causing cell lysis. They are required to liberate the phage progeny once a phage has replicated inside the host. They may also have a potent lytic activity, explicitly against gram positive bacteria, when added from the outside. Moreover, in many instances, phage endolysins are modular enzymes enabling the reorganization of catalytic and cell wall binding domains creating chimeric enzymes which may have improved properties. Research on the application of phage endolysins as food biopreservatives is lagging behind that of phages but results hold promise so far. Lastly, to improve the antimicrobial activity of both phages and phage endolysins in food, several strategies are being explored such as encapsulation. Combined treatments with bacteriocins have also been approached. Bacteriocins are a highly diverse group of antimicrobial peptides produced by bacteria that often disturbed the bacterial cell envelope. Although it should be studied on a case-by-case basis, synergy with phages and endolysins is frequently observed. All-in-all, phages and phage-based products may find their way as food biopreservatives. Indeed, several phage-based products are commercially available in several countries. Additionally, further applications from farm to fork are envisaged encompassing their use for treatment and prevention of animal and plant diseases and disinfection against biofilms.

References

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