**Biotechnologies: an advantageous tool for obtaining chitin, chitosan, and PHA from low-value matrices**

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**Abstract**

Chitin, chitosan, and polyhydroxyalkanoates (PHAs) are biopolymers of great commercial interest, owing to their unique properties and their possible applications in numerous industrial sectors [1,2]. Chitin and chitosan exhibit significant biological activities, such as antioxidant, antimicrobial, and antitumoral [3], and chelating effects against metal ions (e.g., iron, copper, and cadmium) [4]. PHAs can replace fossil-based plastics and thus provide an alternative for reducing environmental problems [5].

These biopolymers can be produced by or derived from living organisms. Chitin and chitosan sources are mainly the shells of aquatic crustaceans and, to a lesser extent, various fungal phyla. Insects represent an alternative source, with several advantages compared to crustaceans [1]. Chitin and chitosan are recovered by chemical methods characterized by high environmental impacts. A valid alternative is a biological approach based on microorganisms, such as *Lactobacillus* sp., *Bacillus* sp., *Pseudomonas* sp., and *Aspergillus* sp., or enzymes produced by fungi or bacteria [1]. This approach represents an eco-friendly method also for mild reaction conditions. However, the high cost of enzymes and the long reaction time can limit the process scale-up [6].

A variety of microorganisms, among which *Aeromonas*, *Azotobacter*, *Clostridium*, and *Pseudomonas*, are employed to synthesize PHAs under nitrogen- or phosphorus-limited conditions [7]. PHA accumulation in these prokaryotes acts like energy storage improving microorganisms' survival. PHA-producing microorganisms can convert many feedstock sources (e.g., used cooking oils and dairy processing by-products), producing several types of PHA [8]. However, PHA still does not compete with traditional synthetic plastics, due to its high production cost. The need to lysate bacterial cells to recover PHA granules leads to the use of different methods (e.g., enzymatic cell lysis, hypochlorite digestion, or use of solvents such as chloroform or acetone) that increase production costs, and environmental and safety impacts. An alternative PHA recovery system uses mealworms which feed with dried PHA-containing bacterial cells and, by digestion, release PHA into their feces. A biorefinery strategy can increase the process sustainability: PHA-producing microorganisms can grow on agro-industrial by-products and once freeze-dried, can become food for mealworms that release PHA from the bacterial cells [8].

The relevance of these biopolymers is confirmed by their market trend which is expected to grow in the coming years [1,2]. Therefore, the main challenge will be to produce them at a low cost and on an industrial scale. Biotechnology can offer a valuable tool to achieve these goals using modern scientific and engineering practices, and exploiting low-value by-products as substrates, in the circular economy context.

***Keywords:*** *Chitin; chitosan; polyhydroxyalkanoates; biopolymers; circular economy.*

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**Biography**

Alessandra Verardi holds a master’s degree in Biology and a PhD in "Environment, Health, and Eco-sustainable Processes" at the University of Calabria (Italy). She has completed her doctoral studies at the University of Lund (Sweden) and her post-doctoral studies at the Katholieke Universiteit Leuven (Belgium). She is currently a permanent researcher at ENEA- Italian National Agency for New Technologies, Energy, and Sustainable Economic Development. Her studies and research activities aim to recover high-added-value by-products from agro-industrial waste, from a circular bioeconomy perspective. Her scientific production includes articles in reputed journals, book chapters, and proceedings of national and international conferences.

**Photograph**

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