Sustainable biotechnological approach to produce chitooligosaccharides from marine biomass: from biotechnological concept to downstreaming

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Every year, the processing of crustaceous generates more than 20 tons of highly perishable by-products that represent up to 45% of shellfish weight, including heads, thorax, claws, and shells. Marine by-products contain proteins and lipids of high value, with recognized biological properties. However, chitin and proteins in the shells are underexplored. Once extracted from proteins and minerals present in the shells, during two processes called demineralisation and deproteinisation, chitin can be chemically converted into chitosan (deacetylation), which in turn can be depolymerized into fragments of lower molecular weight, called chitooligosaccharides (COS). COS are a group of molecules with many applications in food, pharmaceutical and medical industries. Although common, the chemical production of COS is polluting and do not allow to control the structure of fragments, essential for the expression of COS's biological properties. We propose an innovative biotechnological approach to produce COS from marine waste using strains of microorganisms capable of generating enzymes can directly degrade chitin. We present all the strategies and challenges involving the creation and validation of a bioprocess for this purpose, from the choice of microorganism and biotechnological concept to the establishment of the bioprocess. The first step is the characterisation of the marine waste, because the properties of chitin (crystallinity and molecular configuration) change between species and influence subsequent processing. Then, microorganism selection is done, according to the referring processing step needed to transform the marine residue into COS: demineralisation, deproteinisation, deacetylation and depolymerisation. A screening of microorganisms is done for each one of these four steps, aiming maximum enzyme production and production yield. Each unit operation can either be done (a) by direct fermentation or (b) the enzyme is produced, purified, and then applied to the marine biomass. Finally, the material will be separated and purified using membrane separation technology to produce COS and protein-enriched fractions. The proposed biotechnological approach can produce COS from a high pollutant waste, with the quality required to express COS health-promoting properties and proposing the recovery of residual proteins that can reduce the cost of production and decrease the environmental impact of the marine industry.