Innovative encapsulation strategy to improve sustainability of biodegradable bioactive food packaging: case of PHBV (Poly-3-hydroxybutyrate-co-3-hydroxyvalerate) containing carvacrol.

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Increasing sustainability of the food chain means tackling, among others, the negative impacts of packaging material, especially those linked to persistent plastic packaging, while reinforcing the positive impact of packaging, which is food quality preservation and food loss and waste mitigating prevention. To reach this goal, one solution is to use biobased (but nonfood or nonfeed sourced), bioprocessed, biodegradable and bioactive packaging. Bioactive means that a natural compound is added to the polymer to enhance its ability to preserve food and extend shelf-life while the intrinsic biodegradability of the polymer is maintained. In this context, (Poly-3-hydroxybutyrate-co-3-hydroxyvalerate) is a good candidate as polymer as a biosourced, bioprocessed and biodegradable molecule, and carvacrol is a good active molecule candidate, as it has a strong antimicrobial effect. However, carvacrol is also volatile and heat-sensitive, and encapsulation is necessary to avoid a loss of the molecule during the thermal formulation process of the packaging and during packaging storage. On the other hand, encapsulation must not hamper the release of the active compound when needed, i.e., in contact with food. Finally, adding an active compound must not modify biodegradation kinetic; therefore, a strategy is to apply encapsulated carvacrol on the packaging surface in a thin coating layer. In this context, this work aimed to encapsulate carvacrol in PHBV (Poly-3-hydroxybutyrate-co-3-hydroxyvalerate) nanoparticle - intended to be deposited on the packaging surface - and to study the carvacrol release kinetic during storage. To do that, a nanoprecipitation method was adapted to shape PHBV nanoparticles. For instance, the molar mass of PHBV must be necessary below (150 kDa) to successfully obtain nanoparticles (SEM observations). Then encapsulation was characterized, and the release of carvacrol from the nanoparticles powder/material coated with PHBV nanoparticles was studied. A model describing the molecular diffusion using the second Fick's law was developed and adjusted to experimental release data, with a good fitting. Such a model would permit us to anticipate the dimensioning of such active packaging as a function of food requirements (e.g., antimicrobial compound concentration in the headspace, for instance).