**Use of gelatins and chitosans encapsulating natural extracts for the development of active bio-packaging:**

**a review and latest results**

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Biopolymers are polymers produced by living organisms; in other words, they are polymeric bio-macromolecules. Biopolymers (also called renewable or biosourced polymers) are produced from biomass for use in the packaging industry. Most of the biopolymers are hydrocolloids as they are hygroscopic and totally or partly soluble in water and aqueous solution. Biopolymers are used in industries as diverse as paper, plastics, packaging, food, textiles, pharmaceuticals, and cosmetics. Biopolymers are available in large quantities from renewable sources, while synthetic polymers are produced from non-renewable resources [1]. According the social demands and the drawback of petrosourced plastics used for packaging (microplastic pollution), biopolymers have a great potential for production of safe and environmental friendly packaging materials. Hydrocolloids have been early proposed as food coatings since several centenary and more recently considered as edible packaging materials [2,3].

The polysaccharides represent one of the most abundant industrial raw materials and

have been the subject of intensive research due to their sustainability, biodegradability and

bio-safety. Among these, cellulose is the most abundant biopolymer on earth, and was one of the first biomaterial to produce packaging material well known as Cellophane® in late 19th century. However, due to its water sensitivity, it was substitute by petro-sourced synthetic polymers. The second most abundant biopolymer envisaged for producing flexible packaging is starch, used lightly processed or chemically/enzymatically converted into polylactic acid (PLA), the leading biodegradable and biosourced flexible film commercialised. However, starch is also a crop production dedicated to food and feed.

Dealing with chitin, the third most abundant biopolymer, it is the deacetylated form called chitosan which is the most promising biomaterial for packaging applications. Indeed, 2431 publications relates to chitosan films/coatings in their title since 1985, and more than 250 for 2018 [4]. Among these papers, more than half deal with edible films and coatings. Indeed, chitosan could be obtained from crustacean shells (waste from fish industry), insects exoskeleton (future protein source for human feeding), from fungi or from some plants. Chitosan and derivatives have been explored in the development of nanomaterials, bioadhesives, edible films and coatings for food preservation, for packaging applications and as drug delivery and in medical devices. Chitosan is inexpensive, biodegradable, nontoxic and and possesses reactive amino groups that has shown to be useful in different areas as an antimicrobial and antioxidant compound, as an additive in food industry, as a hydrating agent in food and cosmetics, as a flocculating agent in wastewater treatment and more recently as a pharmaceutical bioagent in biomedicine, and as active film-forming agent [5].

Gelatin, is the most abundant protein biopolymer, extract from the denaturation of the collagen from principally mammalian, fish and cephalopods. Gelatin has been used for long years ago in pharmaceutical formulation (capsules), cell culture and tissue engineering due to its excellent biocompatibility, ease of processing and availability at low cost. Since few years, it is envisaged for packaging application because of its very good filmogenic properties [6]. 1069 publications deals with gelatin films/coatings in the last 25 years, and 116 for only 1918 [4].

Chitosan and gelatin are the most studied hydrocolloids for edible films coatings and applications. As their functional performances (barrier and mechanical properties) are too low to be competitive with synthetic petro-sourced polymers, they are considered as carriers of active compounds to provide to packaging films active properties [7,8]. Their edibility allows focusing toward applications as active packaging because both gelatins and chitosans respond to the regulations on food contact materials with no limitation. Even though the natural extracts and essential oils, from mainly plants but also from animals and microorganisms, are known since 4000 years, their use for food and packaging applications reborn in the last decade because of consumer demand for safer, sustainable and more natural products. These natural extracts could provide to active packaging various bio-active properties like antimicrobial, antioxidant, radical scavenger, antifungal, enzyme inhibitor, anti-adhesion of microbial biofilm, etc. [9,10]

The presentation will focus on the literature survey on the main trends of investigation on edible active films based on gelatin and chitosan and on the latest results and applications including the following aspects:

Influence of raw material sources on properties

Enzymatic, chemical, physical (thermal treatment, irradiation,) modifications to improve properties (mechanical, barrier, water solubility…)

Natural compounds incorporated, bioactivity and impact on edible film structure

Process of film making or coating applications

Mechanism of release of the bioactive compounds according film properties and media

Some examples of applications and feasibility

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