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Edible and Eco-Friendly: The Rise of Polysaccharide-Based Food Packaging

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Nowadays, the majority of food packaging on the market is made of synthetic conventional polymers like polyethylene, polypropylene, or polystyrene, which can migrate harmful compounds into the product and pose health risks. Moreover, edible films and coatings are thin layers applied on food products to protect them and improve their quality. Edible films and coatings are defined as a skinny layer for the primary packaging of foods; made up of edible components that we can eat (Hassan et al. 2022) Recently, edible coatings and films have received considerable attention because of their advantages compared to synthetic films and the most important is that they can be safely consumed with the packaged products (Bourtoom, 2008).The use of edible coatings can overcome some problems, while providing additional benefits, such as improving health through the fortification of nutrients and acting as a carrier for natural preservatives such as antioxidants and antimicrobial agents (Andriani et al. 2023).

Components used for edible films and coatings for food

The components and ingredients that compose the edible film include lipid-based, proteins, and polysaccharides. These elements are utilized to create the composition of edible coatings and formulations. Commodity-to-commodity variations exist, and differing ratios and combinations with additives and plasticizers can better convey functionality (Kumar and Neeraj, 2018).

Polysaccharide-based film forming material and component

Polysaccharide-based film is widely used for edible film formation in agro-food and pharmaceutical industries. The polysaccharide-based film is made up of different polysaccharide components such as starch, chitosan, cellulose ethers, alginate, carrageenan, and pectin. These components are produced from plant sources in the ecosystem**.** The polymer chains of the polysaccharide-based components formed edible film and coatings. The main polysaccharide components used for prepared edible coating are the followings: chitosan, pullulan, starch, alginate, carrageenan, modified cellulose, pectin, gellan gum, xanthan gum, etc (Han 2005).

1. Chitin / Chitosan based coatings: Chitin is a naturally occurring polysaccharide found in invertebrates, insects, marine diatoms, algae and fungi (Hassan et al. 2018) According to Codex Alimentarius Commission (2009), Chitosan is classified as a dietary fiber. Chitosan is a safe, natural, allergen-free and biocompatible polymer with health benefits. Chitosan coatings have been used successfully in the food industry, mostly due to their structural properties that allow formation of a continuous layer of coating on foods (Devlieghere et al. 2004). Chitosan films and coatings possess good oxygen (O_2) and carbon dioxide (CO_2) barrier properties and have excellent antimicrobial characteristics (Casariego et al. 2009;

Dutta et al. 2009). Chitosan coatings are most commonly used for cucumbers, strawberries, bell peppers as antimicrobial coating and on apples, peaches, pears and plums as a gasoline barrier (Davies et al. 1989). According to Shahidi et al. (1999), chitosan is a derivative of chitin and the second most common polysaccharide in nature after cellulose. It is non-toxic and exhibits permeability to both CO_2 and O_2. Its film-forming ability is accompanied with strong mechanical and antibacterial properties (Vartiainen et al. 2004). These clear films are used to extend product shelf lives while enhancing product quality (Ribeiro et al. 2007).

According to Coma et al. (2002), the chitosan-based film has a smooth surface, is generally cohesive and sticky, and is poorly soluble in neutral water. Chitosan has been shown to have a variety of biological activity against chronic diseases in both in vitro and in vivo studies (Luo et al. 2013). Chitosan is a linear polysaccharide made up of 2-amino-deoxy-b-D glucan connected by a (1, 4) bond.

2. Pullulan based coatings: According to Babu et al. (2013) and Danjo et al. (2017), the fungus strain *Aureobasidium pullulans* produces pullulan, an extracellular, neutral, and linear exopolysaccharide. Pullulan has a molecular weight of 4.5 ✗ 104 ✗ 105 Da and is a tasteless, odorless, water soluble, biodegradable, and nontoxic component of nature. Pullulan is a useful film-forming agent and food ingredient. Its most significant edible components are edible and it is transparent, heat stable, homogeneous, flexible, and printable (Kristo and Biliaderis, 2007; Gniewosz and Synowiec, 2011; Freitas et al. 2014). The pullulan-based film is highly oxygen-impermeable and it directly applied to food as a protective glaze and with the addition of color and flavoring agents (Oguzhan and Filiz, 2013). The effects of combining pullulan-based edible coatings, antibrowning agents, and antibacterial agents for minimally processed items to improve their shelf lives have not received much attention (Qi et al. 2011).

3. Alginate based coatings: Alginates are hydrophilic substances that are derived from brown seaweed possesses special colloidal features that include thickening, suspending, stabilizing, film-forming, and gel-producing capabilities that stabilize emulsions (Rhim et al. 2004), By lowering dehydration and controlling respiration, the alginate-based edible film offers appealing qualities for enhancing the quality (moisture retention, texture, color, and odor) and shelf life of the food products such as fruit, vegetable, meat, poultry, fish and cheese (Parreidt et al. 2018). Sodium alginate was the first byproduct obtained from the extraction of brown seaweeds through algal purification, it is an environmentally friendly polymer that is extensively utilized in the food industry for packaging and other purposes in the pharmaceutical and paper industries (Parreidt et al. 2018; Tavassoli-Kafrani et al. 2016).

4. Carrageenan based coatings: Carrageenan is soluble in water and naturally extracted from the red seaweeds cell wall. It has high potential activities for film-forming materials. The Carrageenan-based film has poor transparency as comparable to starch based film (Ribeiro et al. 2007).

5. Starch based coatings: Mostly starches comprise of amylase a linear chain polymer and amylopectin on which is a polymer of glucose having branched chain structure (Rodríguez et al. 2006). They are water soluble, oxygen impermeable, flexible, heat stable, and resistant to oil (Krogars et al. 2003). Amylose possesses starches ability to form films (Claudia et al. 2005). The film made of starch displays physical properties. They are biologically absorbable, colourless, odourless, tasteless, semi-permeable to CO_2, resistant to the emission of O_2 , and harmless. The edible film made of starch inhibits microbial development and regulates enzymatic reactions and lowering water activity of packed food products (Parreidt et al. 2018). The modified starch specially designs and using for the formation of films and coating. Edible films and coatings made up from starch are extensively applied because they are transparent, odourless, tasteless, and good $CO_2$and O_2 barrier (Jiang et al. 2011). A massive delivery for synthesis of edible films and coating is offered by corn starch comprises of high amylose.

6. Cellulose based coatings: The most prevalent hydrophilic polymer in nature is cellulose (Bochek, 2003). Plants and cotton, a natural fiber, are the main sources of cellulose

(Myasoedova, 2000; Gross and Scholz, 2000). They're β (1-4) glucosidic chains linked by hydroxypropyl, methyl, and carboxyl substituents make up this polysaccharide. The production of edible films and coatings involves the use of four different forms of cellulose derivatives: hydroxypropyl cellulose (E463; HPC), hydroxypropyl methylcellulose (E464; HPMC), carboxymethylcellulose (E466; CMC), and methylcellulose (E461; MC). Moisture barrier and mechanical qualities are weak in cellulose derivatives (Marquesinho and Vianna-Soares, 2013).

Conclusion

The use of edible films and coatings in food is a convincing strategy for improving preservation, quality, and safety standards. The present article revealed that various polysaccharides can be used to create biodegradable coatings or films. These films/coatings could be utilized to prolong the shelf life and securely improve the quality of food. Furthermore, their utilization has the potential to reduce the reliance on conventional packaging materials, therefore minimize the environmental impact. Edible film and coating represent the eco-friendly approaches to traditional packaging materials. Overall edible films and coatings hold significant potential for improving the sustainability and marketability of food products.

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