Active Edible Packaging

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Active edible packaging is a food packaging made of comestible bioproducts and active compounds that interacts with the food. The bioproducts, usually biopolymers, must be recognized as safe and with characteristics to be consumed by humans—comestible—and not toxic and capable of carrying an active compound, like anti-browning agents, colorants, flavors, nutrients, antimicrobial and/or antioxidant compounds, in order to extend the product shelf-life, reduce contamination and maintain or even enhance the nutritional value.

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Food packaging intends to pack and protect food from environmental, chemical and physical damage during transport, distribution, storage and retailing up to its final consumer. In recent years, concerns have arisen regarding conventional packaging, specifically plastic and its derivates, due to the impact it has on the environment when disposed of and due to its non-renewable character. To avoid this problem, researchers are developing new packaging systems that are produced from renewable raw materials and that are biodegradable, such as active edible packages; therefore, they present low environmental impact [1][2][3][4].

Edible packaging is used with foods to prolong shelf-life and can be consumed with food. Edible packaging can be used in the form of thin film and applied to the food surface or as a coating, which is a thin layer formed directly on the food surface. Both provide a barrier to moisture, oxygen and others from and to the food, and can be a carrier of active compounds [2][5][6][7][8].

The use of edible packaging goes back to the 12th century where, in China, wax was used in citrus fruits to prevent moisture loss and to promote a shiny surface. This type of packaging can be produced from bioproducts, e.g., polysaccharides, proteins, lipids or biocomposites, that are biodegradable, biocompatible and recyclable and of renewable origin.

Active packaging incorporates components, and it can release or absorb substances into or from the packaged food, or the environment surrounding the food, intending to extend the shelf-life or to maintain or improve the condition of packaged food [9]. The active compounds can be anti-browning agents, colorants, flavors, nutrients, spices, antimicrobial or antioxidant compounds, and they can have a natural or synthetic origin. Butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG) and tertbutyl hydroquinone (TBHQ) are common synthetic compounds used in active food packaging. Nonetheless, more recently, the interest has been towards compounds of natural origin because some of the synthetic antioxidants have been associated with adverse health effects. Compounds of natural origin commonly used include essential oils, extracts of plants and spices, and probiotics. In addition, studies are being carried out on the use of extracts obtained from food by-

products, such as fruit and vegetable by-products, as a source of antioxidant compounds, or other bioactive compounds, in the preparation of active edible packaging [2][10][11][12][13], thus contributing to the circular and bio-economy.

In the European Union, active edible packaging is regulated by several regulations. As a material or article intended to come into contact with food, it is regulated by Regulations No. 1935/2004 and its amendments, and Regulation No. 2023/2006, regarding its good manufacturing practice. According the European Union, food additives are “any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food, whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods”. Therefore, the active compounds added to food packaging are considered food additives, specifically indirect food additives as they are not added directly to the food. In this sense, active edible packaging is also regulated by Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives and Regulation (EC) No 1334/2008 of the European Parliament and of the Council of 16 December 2008 (on flavorings and certain food ingredients with flavoring properties for use in and on foods). Finally, as an active packaging it is regulated by Regulation No. 450/2009 (active and intelligent materials) [9][14][15][16][17].

Additionally, in the great majority of the cases, in order to obtain a package with the best mechanical properties, it is necessary to add a plasticizer, such as sorbitol, glycerol, polyethylene glycol, monoglycerides or glucose. Still, taking into account that the packaging is edible, all the materials from preparation to obtaining the packaging must be able to come into contact with food and fit for consumption [6][18][19].

Finally, since the ideal packaging depends on the food, studies are being carried out to determine the best combination of polymers and active compounds for each group of food, so that the best edible active packaging can be obtained. Still, it is necessary to optimize the packaging preparation process so that it is fast, efficient and low cost.

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