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Edible Coating and Films in Foods

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Introduction:

The surge in population growth and the ongoing food supply chain crisis have worsened the issue of global hunger. Moreover, various geopolitical, socio-economic, and post-pandemic factors have further complicated the global food crisis. In 2009, the world generated 1.3 billion tons of food waste, with reports indicating that about 32% of food produced for humans is lost throughout the global supply chain. The Food and Agriculture Organization (FAO) says, around one-third of global food production, equivalent to 1.3 billion tons, is wasted annually. A major challenge in contemporary economy is addressing the food crisis while ensuring sufficient agricultural output. Consequently, there is a pressing need to develop innovative strategies for food protection and management of processing wastes.

After foods, minimum undergoal or full processing, packaging becomes a crucial step as it enables their transportation from factories to points of sale or distribution. This packaging material plays a potential role in maintaining most of the food's physicochemical, functional, and sensory characteristics. Additionally, it must not react with the product and should protect it from various forms of external damage, including chemical, physical, and biological factors. Chemical damage involves exposure to gases, moisture, and light; physical damage encompasses any harm caused by shock or vibration; and biological damage results from pathogens, insects, animals, or the natural aging of the food. The current packaging materials for foods are such as plastic, metal, glass, and paper, and their roles in preserving food.

Edible films, which are thin layers applied to products, have gained prominence. The environmentally friendly nature and ensuring safety materials are used to make these films. Edible coatings, produced through various methods, play a significant role in preserving nutrients such as flavoring agents, antioxidants, and antimicrobials. Impact of these coatings largely depends on factors like permeability, solubility, and mechanical properties. While the use of edible films and

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coatings is not new, it evolved in ancient times and it remains a valuable technique for preserving product quality of foods.

Advantageous of Edible films and coatings

The advantageous functions of edible films and coatings are:

- Shielding against transportation, handling, mechanical harm, and UV rays.
- Barrier capabilities:
- Moisture obstruction: prevents water vapor transmission to prevent dehydration.
- Gas obstruction: regulates the passage of oxygen and carbon dioxide through the protective layer.
- Organic volatile compounds blockage: defends natural vapors such as aromas, solvents, additives, and pigments.
- Prolongation of product shelf life.
- Bioactivity: displays antifungal and antimicrobial qualities, and can function as probiotics.
- Biodegradability.
- Maintenance of structural integrity: remains intact above 40°C without breaking down, is resistant to water, easily forms emulsions, not sticky or tacky, and dries efficiently.
- Preservation of food quality: minimizes impacts on texture, taste, or appearance.
- Composed of cost-effective, readily available, and safe GRAS (Generally Recognized as Safe) materials for consumers.

Types of Films

Protein based films

Edible films and coatings are often made using milk proteins. However, due to the high lactose content in milk, which leads to crystallization in the film, it's recommended to use whey protein instead of whole milk proteins. Whey protein serves as both an emulsifier and plasticizing agent, commonly available in two forms: whey protein concentrate and whey protein isolates. Films based on whey protein are suitable for low humidity conditions, exhibiting high oil barrier properties and strong resistance to oxygen aroma. Whey proteins are also employed in edible coatings and films as sources of probiotics and prebiotics. Milk proteins are valuable biopolymers, offering high thermal stability and being non-toxic. Their unique structure grants them remarkable gas barrier properties. Despite these advantages, milk-based proteins have drawbacks such as sensitivity to moisture and low elasticity.

New edible films and coatings, comprising combinations of beeswax emulsions with caesin, were developed to tackle challenges like minimizing white blush and enhancing vapor resistance in carrots which are processed. To achieve this, acetylated monoglyceride or stearic acid were incorporated. Furthermore, edible films made of natamycin and caesin effectively managed mold and microbial growth. Factors such as cross-linked calcium, pH and lipid content significantly impact the water vapor transmission rate (WVTR) of caseinate edible films. The permeability of heat-sealed edible films, formed from casein and wax, revealed that higher wax content resulted in reduced WVTR without altering oxygen permeability.

Lipid based films

To extend the freshness of fresh fruits and cut fruit products, films and coatings are enriched with essential oils having sesquiterpenes and monoterpenes. These oils act as both antioxidant and antimicrobial agents, with important additives such as carvacrol, cinnamaldehyde, 1,8-cineole, thymol, eugenol, which boost their effectiveness in combating microbes and oxidative deterioration.

Wax-based micro-emulsions are widely used in coatings for fruits and vegetables. These coatings, which incorporate materials like carnauba wax, candelilla, beeswax, and polyethylene (PE), exhibit unique moisture barrier characteristics. Notably, carnauba waxes and PE are recognized for their glossy finish and tendency towards brittleness.

Resins serve as another ingredient incorporated into edible coatings and films. Terpene resin, resulting from the bonding of terpene hydrocarbons naturally present in wood, is considered for use as a direct food additive.

Figure-1: Wax coating of apple

Polysaccharide based films

Cellulose and its complexes are applied to creating impact on edible coatings and films by their potential capability. Hydroxypropyl methylcellulose was effectively used as an edible coating for blueberries. Hydroxyethyl cellulose and Sodium carboxymethyl cellulose were linked with citric acid to trap probiotics in various food items like fruits and vegetables. Encapsulation with specific function is an emerging cost-efficient, and eco-friendly method to boost the protective properties of these films and coatings.

Edible coatings and films containing plant source oils such as lemongrass, rosemary, pepper, and basil, encapsulated with cellulose acetate butyrate and propionate, cellulose acetate was studied for their scent and exhausting air quality under colloidal state. The Kappa carrageenan is majorly used substance in these coatings as it helps reduce moisture evaporation, maintain firmness, and prevent oxidation.).

Pectin-based edible coatings and films have been used as carriers for oregano essential oils to enhance their preservation against food-relevant microorganisms. Similarly, coatings and films made from blends of pectin and whey protein cross-linked with transglutaminase were applied to protect the vegetable and fruits.

Coatings and films composed of chitosan and processed with 30% glycerol have been demonstrated to enhance mechanical and the biological protection of strawberries against fungal attacks.

Methods of making edible coating and films

The several crucial stages involved in the melt extrusion method: Preparation, melt blending, extrusion, chilling, and storage. Commercial techniques such as blown film extrusion, sheet extrusion, and reaction extrusion are commonly employed for producing edible films. Biopolymers with thermoplastic characteristics tend to perform exceptionally well in melt extrusion. Nevertheless, plasticizers and process aids are often added to enhance the melt flow of polymer during extrusion

Solvent casting is another mostly used method for film processing. Unlike melt extrusion, the casting with solvent shows variations in the solvent system and intended application. Therefore, it's crucial to develop steady colloidal state by considering the solubility characteristics of the components and the chosen solvent system.

Conclusion

Edible coatings and films play a crucial role in enhancing food preservation, quality, and safety. These biodegradable, environmentally friendly materials can extend the shelf life of fresh produce, dairy products, meats, and other perishable items by acting as a barrier against moisture, oxygen, and microbial contamination. They also offer potential as carriers for active ingredients such as antioxidants, antimicrobials, and flavorings, contributing to improved food quality and safety. With increasing consumer demand for natural and sustainable packaging solutions, edible coatings and films present a promising alternative to traditional synthetic packaging, aligning with global trends towards more eco-friendly food practices. However, further research and innovation are necessary to optimize their effectiveness, cost-efficiency, and scalability for widespread commercial use.