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**Ritika**
Department of Food Science and nutrition Lovely Professional University Jalandhar- Delhi, Grand Trunk Rd, Phagwara, Punjab, India

**Roopin S**
Department of Food Science and nutrition Lovely Professional University Jalandhar- Delhi, Grand Trunk Rd, Phagwara, Punjab, India

**Corresponding Author:**
**Ritika**
Department of Food Science and nutrition Lovely Professional University Jalandhar- Delhi, Grand Trunk Rd, Phagwara, Punjab, India

# A concise review: Edible films, coatings, and their impact on food products

**Ritika and Roopin S**

**Abstract**
Food is an essential product for human survival, and consumer quality concerns are growing with the passage of time. Edible films and coatings are thin layers that are applied to food products to maintain and enhance their quality. They have gotten a lot of attention in the food sector because of their potential to improve food quality and shelf life. These materials are often manufactured from natural polymers such as starches, proteins, and lipids that are safe for human consumption. The type of material utilized, the thickness of the layer, and the manufacturing circumstances all have an impact on the efficiency of edible films and coatings. They can provide a barrier against moisture, oxygen, and environmental elements that might cause food to spoil and are also used to add flavour, colour, and nutrition to food goods.

**Keywords:** Such as starches, proteins, lipids

## 1. Introduction

An edible coating is a thin covering of edible material that forms a protective coating on meals and can be ingested with them. These layers are normally applied to the food surface in liquid form by immersing the product in a film-forming solution formed by the structural matrix (Kocira *et al.*, 2021) [13]. It can be consumed with or without meals and is easily eliminated from the diet. Although edible films and edible coatings are sometimes used interchangeably, films are made separately and then applied to the food surface, whereas coatings are applied directly to the food surface (Embuscado & Huber., 2009) [7]. In nature, edible films are free-standing structures, whereas edible coatings attach to the food surface. Coatings have been used to reduce water loss and give gloss to fruits and vegetables since the early to mid-twentieth century. Chemical, physiological, and biological changes are blocked by edible films and coatings (Pavláth & Orts., 2009) [20]. When buying fruits and vegetables, the user chooses the healthiest food item based on its freshness and look. Several bio-based polymers have been studied in order to create a continuous structure of films or coatings (Gupta *et al.*, 2022) [8]. The most frequent type of biopolymer employed in the manufacturing of edible materials is hydrocolloids, which include both polysaccharides and proteins (Teixeira & Andrade., 2021) [30]. They can be acquired from plants, animals, or microbes. Cellulose derivatives, which are starches, alginates, pectin, chitosan, pullulan, and carrageenans are the most used polysaccharides in the production of edible films and coatings, whereas wheat gluten, soybean proteins, corn zein, sunflower proteins, gelatin, whey, casein, and keratin are the most used proteins (Tran *et al.*, 2021) [33]. These materials are hydrophilic in nature as a result, various oils and fats are added to the hydrocolloid matrix to improve their water vapour barrier qualities. Waxes, triglycerides, acetylated monoglycerides, free fatty acids, and vegetable oils are the most common (Kocira *et al.*, 2021) [13]. Edible films and coatings improve food quality by preserving it against physical, chemical, and biological deterioration. Edible films and coatings can easily improve food products' physical strength, eliminate particle clumping, and improve aesthetic and tactile aspects on product surfaces (Suput *et al.*, 2015) [29]. It can also protect food from moisture migration, surface microbial development, light-induced chemical changes, and nutrient degradation. Edible films and coatings are widely used as barriers against oils, gases, or vapours, as well as transporters of active chemicals such as antioxidants, antimicrobials, colouring, and flavours (Han., 2013) [13]. Plasticizers, particularly polysaccharides and proteins, are necessary elements in edible films and coatings. Because of the strong connections between polymer molecules, these film formations are frequently brittle and stiff. Plasticizers are low-molecular-weight compounds that are introduced into polymeric film-forming materials to boost the polymers' thermoplasticity (Vieira *et al.*, 2011) [35].

To improve flexibility and processability, they can place themselves between polymer molecules and interfere with polymer-polymer interactions. Plasticizers improve the free volume of polymer structures or polymer molecules' molecular mobility. Edible films and coatings can contain a variety of active agents, including emulsifiers, antioxidants, antimicrobials, nutraceuticals, tastes, and colourants, and can improve food quality and safety to the point where the additives interfere with the mechanical and physical characteristics of the films (Sothornvit & Krochta., 2005) [28]. Emulsifiers are amphiphilic surface-active substances that can reduce surface tension at the water-lipid interface or the water-air interface. They affect the stickiness and wettability of the film surface by modifying surface energy. In addition to emulsifiers, antioxidants and antibacterial agents can be added to film-forming solutions to accomplish active packaging or coating functionalities (Mcclements & Jafari *et al*., 2015) [15]. The growing consumer desire for natural food preservation has resulted in the development of alternative protection methods, such as the use of biopolymers derived from renewable sources or industrial by-products (Baranwal *et al*., 2022) [3]. The usage of edible films and coatings is gaining popularity in the food sector due to their ability to extend the shelf life of goods. Product shelf life can be extended by inhibiting respiration with edible coatings (Pham *et al*., 2023) [21]. Biodegradable and environmentally friendly edible coatings are utilised to limit the need for plastic packaging. Food product shelf-life augmentation is critical since even a few days of shelf-life extension can represent a considerable economic benefit for food firms (Soro *et al*., 2021) [27]. Edible films and coatings' most advantageous properties are their edibility and innate biodegradability. To ensure edibility, all film components (biopolymers, plasticizers, and other additives) must be food-grade materials, and all process facilities and equipment must be food-grade (Montes & Muñoz., 2021) [6]. Every part should be biodegradable and environmentally safe in terms of biodegradability. In the case of biodegradable film applications, human toxicity and safety for the environment should be tested using conventional analytical techniques by authorised agencies before claiming commercial biodegradability Song *et al*., 2009) [26].

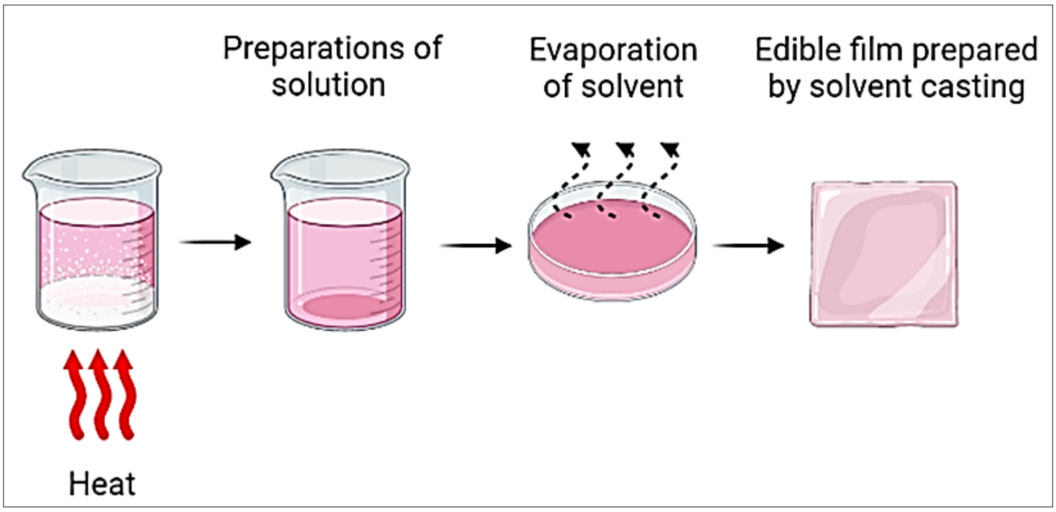


**Fig 1:** Preparation of Edible Film by Solvent Casting Method.

**2. Different studies on edible films its impact on food items**

Egg yolk contains proteins that can be exploited to create innovative food packaging materials. Three different bioactive films were developed using delipidated egg yolk proteins in this study by Orviz *et al*., 2021 [22], the first with a probiotic (PRO, Lactobacillus plantarum CECT 9567), the second with a prebiotic (PRE, lactobionic acid (LBA), 10 g/L), and the third with both (SYN, containing L. plantarum and LBA). The films' mechanical characteristics, water solubility, light transmittance, colour, and microstructure were all thoroughly investigated. The inclusion of LBA at the concentration tested had a minor effect on the strength and water solubility of the films, whereas the light transmittance of the SYN film reduced in comparison to the other films. It was noted that the addition of LBA increased the viability of the probiotic, in both the edible films and coatings.

Tokatli and Demirdoven, 2020 [31] show the effects of chitosan edible film coatings on the physicochemical and microbiological qualities of sweet cherries (*Prunus avium* L.) were investigated. Sweet cherries were coated with 1% chitosan [two of which were produced from shrimp waste originating from the Marmara Sea in Turkey (Chitosan-1, Chitosan-2) and the other two of which were commercially produced (Commercial-1 and Commercial-2)] and stored at 4 °C for 25 days or 20 °C for 15 days. Various physicochemical (weight loss, pH, titratable acidity, total soluble solids, water activity, respiration rate, total carbohydrate content) and microbiological (total mesophilic aerobic bacteria, total psychrophilic aerobic bacteria, total coliform bacteria, yeasts, and moulds) qualities were measured. When microbiological investigations are taken into account, it is possible to infer that chitosan, particularly those derived from shrimp wastes, has strong antibacterial properties and can be utilised effectively to extend the shelf life of sweet cherries.

The current study by Pavinatto *et al*., 2019 [19] describes the creation of chitosan-based films for use as a protective covering for natural foods such as fruits and vegetables. Chitosan is a biopolymer noted for its antibacterial and antifungal qualities, which, when paired with its biocompatibility and biodegradability, make it suitable for use in a variety of industries including cosmetics, pharmaceuticals, and food. Thin films based on chitosan were created using the drop-casting process and glycerol to improve flexibility and hydrophobicity. Such qualities are desirable for forming a water-resistant protective layer. The results demonstrated that chitosan retains its bactericidal activity against both gram-positive and gram-negative bacteria following plasticization. Strawberries coated with chitosan/glycerol 30% films (Chi/30% Gly) showed resistance against grey fungal assault while retaining their flavour, look, aroma, and texture. To put it another way, the chitosan film protected the strawberry from fungus assault, demonstrating its immense potential as an edible coating for fruits and vegetables.

Torres-Leon *et al*., 2018 [32] reported that fruit waste and its by-products are cost-effective materials for developing biodegradable and active packaging. The goals of this work were to create, characterise, and assess biodegradable coatings and films using mango peel and seed kernel antioxidant extracts. The peel's proximate composition was also identified. The films' structural, barrier, optical, and antioxidant properties were investigated. Gas transfer rates and ethylene generation in peaches were both measured. It was made with mango peel shown good barrier qualities, with water vapour permeability ranging from 0.88 1010 to 1.00 1010 g m1 s1 Pa1. The addition of antioxidant extract had no significant influence on optical characteristics ($p > 0.05$). In addition, antioxidant activity and polyphenol content both increased by 18% and 60%, respectively. Peaches coated with a solution of mango peel (1.09%), antioxidant extract of mango seed kernel (0.078 g L1), and glycerol (0.33%) produced 64% and 29% less ethylene and CO2, respectively, and consumed 39% less O2. The reduction in gas transport means that the shelf life of treated fruit is extended. Mango by-products may thus be ideal to produce low-cost biodegradable and active materials.

Martínez *et al*., 2018 [14] showed that the sea bass (*Dicentrarchus labrax*) was recommended as a raw material for value-added smoked goods. As possible conservative techniques, resveratrol powder addition and chitosan and alginate edible coatings were investigated. There were two stages of testing. First, resveratrol was applied topically to liquid smoked salmon. The following were the experimental groups: U represents untreated fillets; B represents brine salted fillets; S represents brined, salted, and smoked fillets; and SR1 and SR2 represent 2.5 and 5.0 g resveratrol added per fillet, respectively. Second, after brining, resveratrol was suspended in liquid smoke (20 g/L) and applied to the fillets (SR); some of them were also coated with chitosan or alginate (SRQ and SRA). The control (S) consisted of brined and smoked fillets. Although both alginate and chitosan served to slow oxidation, only chitosan reduced microbiological development. SRA had the highest max value (3.546), whereas SRQ had the lowest 1 (0.123) and max value (1.847). Resveratrol may be a viable antioxidant option for use in value-added fish products. Its effect can be boosted further by utilising edible coatings.

Salama and Abdel Aziz., 2021 [23] reported that because of their weak antibacterial, UV-shielding, and water-barrier qualities, alginate-based coatings have limited utility in food preservation. To address this issue, multifunctional alginate films containing aloe vera (AV) and frankincense oil (FO) were developed for the preservation of green capsicums. FTIR demonstrated the effective integration of AV and FO, while XRD revealed a decrease in crystallinity in the presence of FO. The addition of AV and FO resulted in significant increases in thermal stability and mechanical qualities. The inclusion of AV and FO made the films brighter, yellower, and greener but had no effect on the film's transparency. The films comprising AV and FO show excellent inhibitory capabilities against a variety of bacteria and fungi. For green capsicums, the produced films displayed good senescence retardation and resistance to mass loss. The produced active films could be employed in food preservation due to their increased UV-barrier, physical, and microbial-inhibition capabilities.

Bersaneti *et al*., 2019 [4] reported edible films and coatings have piqued the interest of the industry due to their ability to extend the shelf life of food products and to incorporate bioactive substances that improve the nutritional quality of food. In this study, we looked at the prebiotic activities of nystose synthesised by *Bacillus subtilis* levansucrase and consumable starch-nystose as the sole source of energy for Bifidobacterium and Lactobacillus strains. The generation of organic acids and the growth of lactic acid bacteria proved that nystose and the edible starch-nystose film had a prebiotic impact. In addition to the protective coating effect, the edible starch-nystose film may have a prebiotic function. This biotechnology product has potential functional applications in the food business, including coating fresh fruits and vegetables and the inclusion of prebiotic nystose.

Hosseini *et al*., 2020 [11] investigated the mechanical properties of edible films and coating % on sunflower seed kernels (SUKs) were evaluated to find an optimised mix of whey protein concentrate (WPC), glycerol, and carboxymethyl cellulose (CMC). To increase the oxidative stability of SUKs, optimum coating solutions with/without rosemary extract (RAE) were utilised. Furthermore, the coated SUKs were evaluated in a sesame-based product as a food system. In comparison to the control formulation created with uncoated nuts, the food system comprising coated nuts showed less oxidation. As a result of using an optimal composite coating, the reddening of WPC at high temperatures and lower oxidation protection efficiency of CMC were resolved as kernels with desirable colour and oxidative stability properties were produced, which can be used in the formulation of thermally processed products.

## 3. Impact of edible films and coatings on food product

Food preservation from farmer's fields to consumer plates is currently a major concern in food supply chain systems. Food packaging, on the other hand, is becoming increasingly important in the food business as demand for organic and healthful foods grows (Amit *et al*., 2017) [2]. Several novel processes, including reactive extrusion electrospinning, 3D printing, and nanotechnology, have been used to create biodegradable materials based on starch, cellulose, chitosan, protein, etc (Gupta & Srivastava., 2022) [8]. Any packaging material's major purpose is to keep food secure from infection while extending shelf life. Because of their long-lasting properties and durability, synthetic polymers such as PP, LDPE, HDPE, PET, and nylon are widely utilised; yet, plastic waste from packaging is a major source of environmental pollution (Huang *et al*., 2019) [12]. However, these polymers or thermoplastics have the advantage of being able to be moulded into a variety of forms and recycled, making them more suited for food packaging. These materials, despite their long-lasting characteristics and durability, are being used as short-term food packaging (Samir *et al*., 2022) [24]. Moreover, due to food contamination, recycling of these products is problematic. Recently, biodegradable materials are being evaluated as an alternative to synthetic plastics. Biodegradable polymers are often seen as environmentally friendly, renewable, and recyclable materials (Moshood *et al*., 2022) [17]. Many biopolymers have been used to make eco-friendly food packaging as an attractive alternative to traditional plastic materials (Agarwal *et al*., 2022) [1]. To minimize the amount of plastic packaging, biodegradable films and coatings may be employed. These edible packaging films and coatings have grown in popularity in recent years as a result of expanding consumer demand for accessible, safe, and healthy food options, as well as growing public concern about the environmental impact of non-biodegradable packaging (Kumar *et al*., 2022). Gelatin, starch, chitosan, cellulose, polylactic acid and alginate are popular biodegradable materials used in fruits and vegetables, coated cookies, cold smoked salmon, gammon slices and hake fish (Montes & Muñoz., 2021 and Nygaard *et al*., 2021) [6, 18]. The shelf life and quality of intact fruits and vegetables have been extended by employing edible films and coatings rather than the cut version (Mitelut *et al*., 2021) [16]. However, substantial-quality decline and postharvest losses are almost certainly unavoidable due to a range of circumstances both before and after harvest. Intrinsic physiological senescence and fungal pathogen infection are the two most prominent mechanisms affecting such losses. Approximately 30% of fruits and vegetables are rendered unfit for food after harvesting owing to spoiling. Real-world applications benefit from biodegradable and edible films/coatings in terms of aesthetics, barrier properties, nontoxicity, and affordability (Sarker & Grift., 2021 and Vaishali *et al*. 2019) [25, 34]. These initiatives aimed at generating biopolymers with properties equivalent to synthetic polymers, as well as producing them at a low cost by utilising agricultural byproducts as raw material. Biodegradable/edible films, which extend the shelf life of perishable vegetables and fruits by including various antibacterial and antioxidant components in their underlying polymer matrix, have been identified as an important focus area in packaging research in recent decades (Chawla *et al*., 2021) [5].

## 4. Conclusion

Demands from consumers for more natural foods, as well as environmental preservation, have sparked the creation of innovative packaging materials. Edible films and coatings have attracted a lot of interest in recent years since they can be used as edible packaging materials instead of synthetic ones and help to minimise pollution. The use of biodegradable films instead of standard synthetic polymers should be promoted as a highly desirable strategy. Many new materials have been researched for their possible use in the manufacture of edible films and coatings. The most essential aspect in determining the final functional qualities and attributes of biopolymer films is the source of the biopolymer. Plant residues are commonly available and low-cost edible packing materials that also serve as a fantastic source of nutrients. The benefits of edible coatings applied to food goods are equally considerable. Reduced weight losses and extended shelf life of food products have a significant impact on food waste reduction and, as a result, food production costs.

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