Chapter 3
Application of Edible Coatings and Packaging Materials for Preservation of Fruits-Vegetables

D. Manojj, M. Yasasve, N. M. Hariharan, and R. Palanivel

Abstract Fruits and vegetables are particularly perishable commodities as they contain 80–90% of water by weight. Several methods have been employed to protect and increase the shelf life of fresh goods during packaging, transport and storage. Edible coatings are thin films made applied to the exterior surface of a substance, which offers protection against external moisture, oxygen and pathogens. The various components commonly used in the manufacture of edible coatings includes polysaccharides, proteins, lipids, composites and resins. The packaging of fresh fruits and vegetables is an essential step to protect against further contamination, damage and excess moisture loss. Bags, trays, sleeve packs, boxes, cartons and palletized containers are the generally used packaging materials for convenient handling and transportation of fresh products. Various types of films made of polyethylene, polyester, polyvinyl, cellulose and aluminum are currently used in packaging as moisture-resistant materials. Preservatives are compounds added to food substances to prevent the deterioration of quality and spoilage induced by the growth of micro-organisms or unwanted chemical changes from decomposing. The same is also incorporated in fruits-vegetables through physical and chemical modes which prolong the shelf-life of the product even further. The present work discusses the use of different edible coatings, preservatives and packing methods as carriers of functional ingredients on fresh fruits and vegetables to maximize their quality and shelf life. Furthermore, recent developments in the application of antimicrobials during packaging to increase the functionality of foods have been elaborated.

Keywords Fruits · Vegetables · Edible coatings · Packaging · Preservation

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3.1 Introduction

Nutritional-Health is an important domain about technology, especially in the food industry. Fruits and vegetables play a crucial role in sustaining an individual's health by supplying the necessary macro and micronutrients [1]. Thus, they are the most sought-after products in the market. Consumers are willing to taste new fruits and vegetables even without considering its quality which leads to nutritional loss in overtime and then it continues to decay. This is an important barrier in the food and agriculture industry [2]. Fruits and vegetables start to ripen and decompose as soon as they are cut from the plant at a faster rate, also this becomes a problem in the availability fresh-cut ready-to-eat fruits and vegetables that shorten their shelf life with a loss in nutrition, undesirable look and their palatability [3]. To cease this biological process of ripening after harvesting, many technological methods are used especially in terms of preservation like physical and chemical methods [4]. Also, packaging plays a vital role in the preservation of post-harvest products, which protects them not only from the external environmental exposure but also helps in slowing the ripening process. Several advancements have been made in packing industry with the emerging nanotechnology methodologies recently [5].

Packaging is an essential step because the harvested product is not the final that reaches the consumer. It needs to undergo a series of processing steps to reach the consumer as a finished product [6]. There is a high possibility for them to undergo degradation during these long steps. Thus, preservatives are added intentionally to increase their shelf life along with the packaging [7]. Over the last decade, edible coating as a packaging medium has gained a lot of momentum over reducing the enzymatic and non-enzymatic deterioration of food products such as browning and fruit softening, particularly after cutting. Wide ranges of formulation are incorporated with antimicrobial, anti-oxidant, flavouring agents and others to increase the nutritional content and the aesthetic appeal of the product [8, 9]. This work mainly elaborates on the use of different kinds of edible coatings, preservatives and packing materials used in the fruits-vegetables industry.

3.2 Edible Coatings and Films

The edible coatings and films for the preservation of bio-products and other consumables that are easily perishable, has been in use for a very long time since 1990s [10, 11] and had undergone a lot of technological advancements in the recent decade. These coatings are made of very thin layers of biologically derived products that are edible [12] and it may include compounds like starch and starch-based composites, protein composites, and plant-based composites. Modern advancements combine nano-materials and other natural antimicrobial agents to control the microbial growth which causes damage [13]. The effectiveness of these films depends highly on their wettability, gas exchange property, stability and their ability to firmly adhere to the

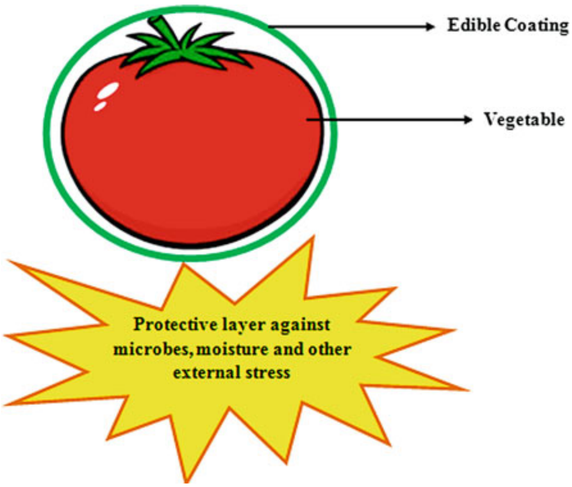

Fig. 3.1 Edible coating as a protective barrier

surface being coated [14]. The coatings are primarily used in increasing the shelf life of products, by creating a protective layer that acts as a barrier, forming a modified atmosphere. This barrier formation reduces susceptibility to degrading factors like oxidation, attack of pathogens, loss of moisture, and damage to surfaces as represented in Fig. 3.1. The common modification of these horticulture products has already been made in the market and has been greatly discussed like FreshSeal™, NatureSeal™, SemperFresh™ and others that greatly impact the transportation and preservation of the products [14, 15].

The coating for these products usually involves the techniques like immersion of products in large volumes of emulsions or air spraying in large scale and manual hand coating in small scale industries. In case of films, they are developed as thin membranes in industrial scales. Though these coatings provide a protective layer they essentially do not preserve the products, and it only act as an additional protective layer to increase the shelf life. This film formation technique works effectively only when it combines with the conventional preservation methods [16]. The different type of coatings from different derivatives is represented in Fig. 3.2.

3.2.1 Biomolecule Based Edible Coatings

Biomolecules are complex compounds composed of proteins, carbohydrates, lipids and other natural products formed by living organisms [17]. These biomolecule-based derivatives can be classified into polysaccharides, protein complexes and lipid complexes. Polysaccharides have high hydrophilicity and proved a barrier against the drying.

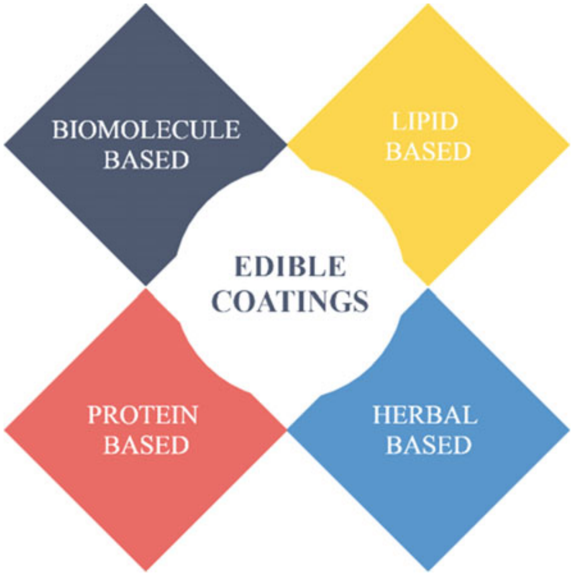

Fig. 3.2 Types of edible coatings

3.2.1.1 Polysaccharides

Polysaccharides are naturally occurring carbohydrate long chains, which are highly stable and easily degradable. Since these are a major part of human diet, they are edible and do not exhibit any toxicity. The plant-based carbohydrates are again classified into two broad groups as storage polysaccharides and cell wall polysaccharides [18].

3.2.1.2 Starch

This is an abundantly available storage complex of carbohydrate that is present in almost all the plant-based materials like tubers, legumes, and other vegetables. Starch-based coating forms transparent or a semi-opaque coating that does not contribute any taste, colour or odour [19]. When coated they maintain the integrity of fruits, carbon dioxide concentration, and reduce respiration and oxidation upon the surfaces. Also, it has a good oxygen barrier that is essential in increasing the shelf life [20]. Many starch derivatives include dextrin and pullulan, which are both used in the packaging industry and have demonstrated excellent results in food preservation [21]. It is the most economical and fastest way to make the coating edible. Commercial products include FreshSeal™ and Semperfresh™ are some of the examples that uses starch as their main ingredient [16]. An earlier study had reported that grapes coated with the blend of starch, gelatin and glycerol presented better appearance even after 3 weeks of storage under refrigerated conditions compared to control sample which is illustrated in Fig. 3.3 [22].

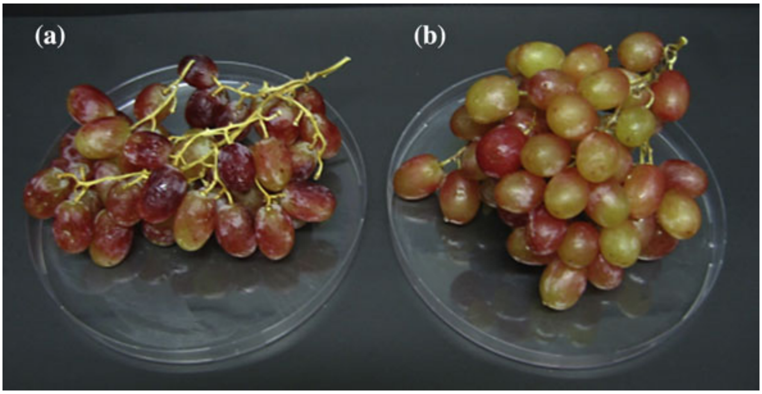

Fig. 3.3 Processed red crimson grapes **a** control sample; **b** Coated with Modified Waxy corn starch and Gelatin plasticized with glycerol [22]

3.2.1.3 Cellulose and Pectin

Like starch, cellulose is a material that exists naturally and is often derived from plants. It forms the cell wall which makes up the skeleton of the plant cell. Similar to starch they are colourless, odourless and tasteless, but unlike starch and its derivatives, cellulose is water-insoluble, rigid and tough [23]. Due to these qualities, cellulose in its native form cannot be used as coating medium. Though it is time consuming and a non-cost-effective process, cellulose was pre-processed by dissolving it in certain chemical compounds earlier. Recent developments in processing of cellulose made the conventional method easier and compound derivatives like carboxymethyl cellulose, methylcellulose, hydroxypropyl methylcellulose, and hydroxypropyl cellulose are now used as edible coatings and film to protect the fruits and vegetables. Compared to the starch-based coatings, cellulose derivatives proved better protection against oils, water and fat corrosion with a considerable amount of rigidity and flexibility [24]. Some of the commercial examples for this incorporation include Prolong, Tal Prolong, etc. [16].

Pectin on the other is also a component of the cell walls of fruits and vegetables that can be water solubilized and re-casted into thin films upon solidification. Researchers have shown results that are similar to increase the shelf life of the products [25] (Fig. 3.4).

3.2.1.4 Carrageenan, Alginates and Agar

The compounds carrageenan, alginates and Agar are derived from seaweeds. Alginate is derived from brown seaweed, to obtain alginic acid, guluronic monomers and salts. It is dissolved and re-casted to form a very thin property less film upon drying. It forms a good barrier against oils, water vapour and other fat bases [26]. It also acts

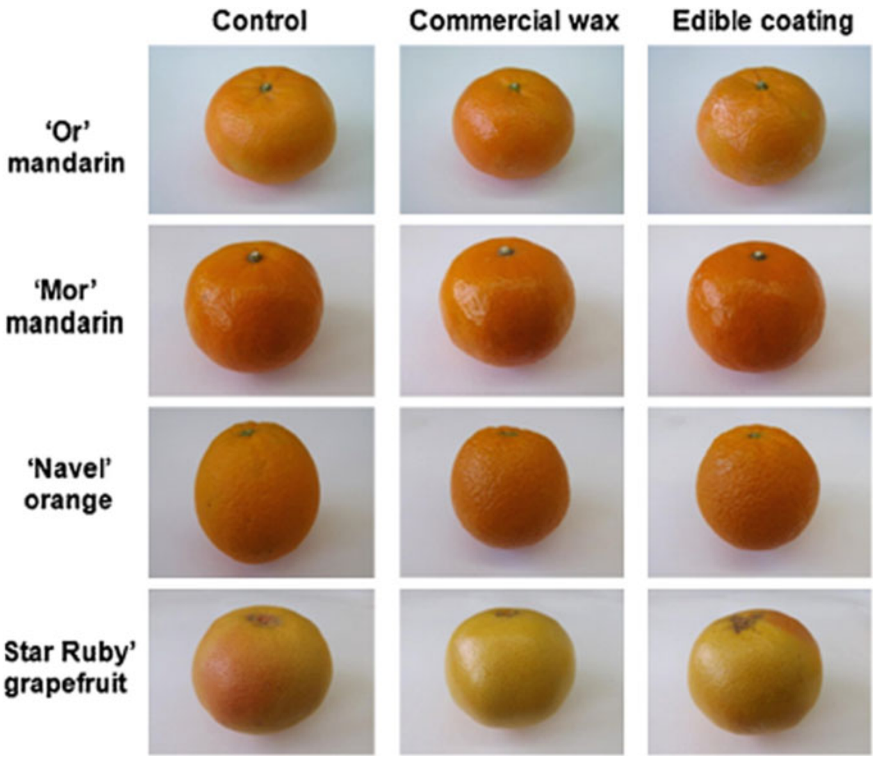

Fig. 3.4 Commercial polyethylene wax and carboxymethyl cellulose/chitosan bilayer edible coatings on mandarin orange [24]

as a good oxidation retardant. When cast as a wet film it acts as a sacrificial layer to the product that prevents drying and retains moisture to a certain extent [27]. Carrageenan is derived from red seaweed family, which is combined with several other compounds to enhance the preservation property [28]. Agar is also a similar compound as that of carrageenan derived from red seaweed is similar in properties. They are also mixed with other preservative compounds like antimicrobial agents to form a protective film [29] which in turn increases the shelf life of products.

3.2.2 Protein Derived Edible Coatings

Compared to the polysaccharide-based edible coatings proteins are not much preferred due to their brittleness and poor properties. They are mainly chosen for their nutrition content along with their moderate preservative property [30]. Some of the protein-based edible coatings include Corn-zein, Casein, gluten and soy proteins.

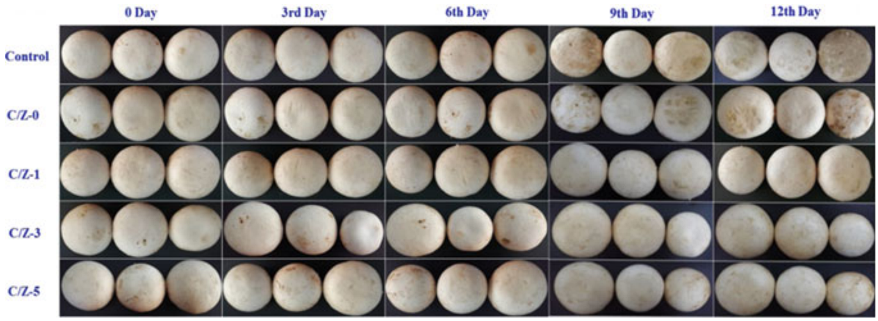

Fig. 3.5 Appearance of mushroom covered with Chitosan-zein film with various concentration [33]

3.2.2.1 Casein

Casein is a milk product of animal origin, used in the processing of foods. Owing to the presence of hydrophobic and hydrophilic ends, it is used as an emulsion base in the creation of edible films. The resultant film is less textured and clear and is extremely water-soluble. Owing to the weak properties of pure casein [31], a combination of compounds in the preparation of such films forms a composite that is generally favored.

3.2.2.2 Corn-Zein

Zein is a protein, and it is main derivative of labyrinths. For its extensive properties, corn zein is often favored to generate edible films as opposed to others. It has a rough, smooth texture and very strong adhesive properties. It also has a good oxygen barrier that prevents oxidation in easily perishable fruits and vegetables like tomato and apples. It is insoluble in water and thus it has to be processed with alcohol and glycols to dissolve and cast them into a film which prevents the products from oxidation of enzymes, microbial growth, senescence, and the loss of nutritional quality [32, 33] (Fig. 3.5).

3.2.2.3 Soy Proteins

Soy protein isolates (SPI) are derived from soybeans. It is added with some complex additives and plasticizers to enhance their properties. SPI are good oxidation retardants compared to other coatings, and also it has shown some effective preservation coatings on apricots [34].

3.2.3 Lipid-Based Coatings

Lipids are structural molecules of living cells, and it includes biomolecules like fats, oils and wax complexes. Lipid-based coatings have good water vapour barriers and are highly water repellent. This property aids in maintaining the product's moisture content but it is brittle [35]. Some of the common lipid coatings are made of bee wax, carnauba wax, and resins.

3.2.3.1 Wax-Based Coatings

The carnauba wax is derived from the palm tree, which is used as an edible coating due to hydrophobic and water repellent nature that provides moisture loss. This coating is mostly used for fruits and certain vegetables. Bee wax is another alternative to carnauba produced by bees. It is used in combination with other coatings to preserve the integrity of the fruits [36, 37].

3.2.3.2 Resin-Based Coating

Shellac wax is another compound similar to bee wax that comes under the category of resins produced by lac beetle that has a similar property to bee wax. It is glossier but is not deemed safe for consumption as it requires pre-processing steps to make it edible [38] (Fig. 3.6).

3.2.4 Other Alternatives in Edible Coatings

3.2.4.1 Herbal Coatings

Alovera gel is yet another recently explored edible coating that provides good moisture retention and anti-microbial property. Other herbal coatings from turmeric, tulsi, garlic, ginger, neem are being reviewed [39]. These herbal based coatings are good in retarding microbial growth compared to other edible films and coatings. Herbal coatings are environmentally benign and it is simple to prepare and process. Another notable quality of herbal coating is rich nutritional content along with the medicinal properties that are being coated on the product. The main drawback of this coating is that they do alter or add some flavours which are inherent [40].

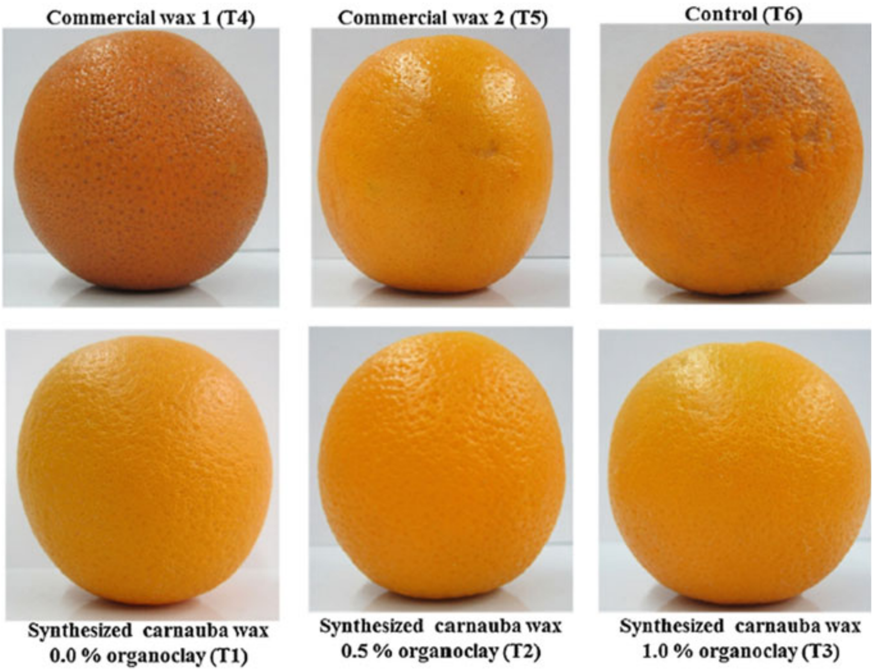

Fig. 3.6 Effects of commercial waxes and synthesized organoclay-carnauba wax emulsion coatings on the visual appearance of orange fruit [37]

3.2.4.2 Essential Oils

Essential oils are derivatives of plants that possess high antimicrobial, antioxidant and other medicinal properties. Due to these properties, these are extensively used in food preservation. The essential oils contain a phenolic compound that renders antioxidant activity. Similarly, the presence of volatile compounds in the oils provides antimicrobial properties against a variety of pathogens [41]. Some of the common essential oils used in preservation includes clove, lemon, sage, rosemary and others.

3.2.5 Need for Edible Coatings

Edible coatings do extend the shelf life of the food products to an equal range to that of synthetic coatings. Comparatively, these are much more environment friendly and less expensive to produce on a larger scale basis. Moreover, they do not pose any health hazards which makes them a popular choice. The products are allowed to consume along with the edible coatings as it has some nutritive value which is quite advantageous.

3.2.6 Challenges in Creating Edible Coatings

The key consideration of developing edible coating is to increase the adhesive properties of the coatings, particularly to prevent the loss of moisture content on the surface of freshly cut. In most cases, edible coatings are known for their hydrophobic nature, repelling water surfaces that lead to poor control of moisture and oxygen barriers. Most of the coatings are not robust enough to withstand much tension. It also deals with the wettability of the coating sheet. Without proper wettability and adhesivity, the products being coated will not provide a good shelf life. Another important aspect is to impart the texture quality and taste quality to the coatings that makes them more aesthetically pleasing to the consumers [42]. New technologies like nanoemulsions are being included in the mix, that raises concern over the cytotoxicity and biomagnifications in the body. Despite all this, edible coatings are good and economic alternative to synthetic and plastic packing technologies.

3.3 Packaging Materials

3.3.1 Need for Packaging Materials

The main aim of the packaging and preservation material is to increase the shelf life and transport of the product to the customer in pristine condition for consumption. The ideal challenge is to make sure that the fruits and vegetables are protected from the external damage through bruising in transport and handling, contamination, relative humidity, and reducing moisture loss [43]. Since the coating materials only contribute to a certain extent thus, packing plays a vital role in the preservation of the quality and the appearance of the fruits. Temperature and airflow control are yet another domain for serious consideration in the packing since the process of ripening depends on it and also there is the release of volatile vapours and chemical compounds that make it undesirable for consumption if not handled properly [44, 45]. Therefore, the packing of products must be done with utmost care and foresight.

3.3.2 Types of Packaging Materials

The type of packaging entirely depends on the purpose it is about to serve and the product involved. Simple and effective packing like using a cloth or polythene bag is sufficient for small quantity and also for immediate consumption rather than storing. But in case of long-distance transport, and for storing larger quantity this technique is not feasible [46]. Similarly, easily perishable fruits and vegetables can't be transported using very hard packing material. The different types of packaging materials currently used are listed in Fig. 3.7.

Fig. 3.7 Types of packaging materials

3.3.2.1 Consumer Packing

These involve the category of primary packing and secondary packing, also known as unit packing. This is the easiest and most reliable way to prepare items for immediate distribution. Often involves the way of packing that the consumer is finally given with. It is the most cost-effective and mass-produced materials for common household usage are packed with and it is easily disposed.

Bags

This forms the primary packing category. Bags may be made of either plastic (polythene) or plant-based (cloth, paper and others) materials. High-grade polythene bags are used for refrigeration purposes where the product needs to be kept in a cold environment. This provides two functions; one is to give a little thermal resistance and the other as storing for pre-processed products. The best example is a bag of fresh frozen peas or corn [47]. Low-grade polythene bags with ventilation holes, cloth and paper-based bags are mainly used for short term transport purpose [48]. This also includes the netted bags that offer ventilation to the produce like onions and potatoes.

Trays and Sleeve Packing

The main purpose of trays and sleeve packing is for display, short transport and storage that falls under the secondary packing category. Here the functionality is to immobilize the produce with a transparent or an open face for the consumer to view with at the same time providing a packing solution [49]. The trays are made of polythene, polyvinyl chloride, cardboard, and other materials with an open face on one side that is wrapped with stretch wrap or a shrink wrap that forms the secondary packing category along with the sleeves. In a sleeve packing an additional layer is covered with a box-like design that slides out which provides strength and integrity to the immobilized product. Even in this design, ventilation holes are present depending on the product's breathing needs [50]. Examples include a tray of dry plumes, baby corn and others with a tight wrap.

Clam Shell Packing

Clamshell packing is named after its design structure that is made of a single unit with two halves just like a clamshell. This method of packing is the modification of tray and sleeve packing which is more secure and tamper-proof comparatively. The purpose and function of clamshell is same as that of the tray and sleeve packing and even made out of similar materials. A greater advantage in this type of packing is that all sides of container can be made visible or transparent for viewing by the consumer if made by PVC materials. This is primarily used for berries and other small fruits-vegetables. In case of paper and cardboard, they are used to pack ready-to-eat consumer items, often in the fast-food chain [51, 52].

Tin Boxes and Cans

Tin Boxes and Cans are the common choice in packing food products that provide a very long shelf-life with only one storage option necessary. These have a solid protective shield for the goods within them, along with a changed atmosphere for longer protection of the substance that is not exposed to the external environment [53].

3.3.2.2 Transport Packing

This is a tertiary level of packing that mainly focuses on the transport of large quantities of the unit product for longer distances and time. These are large and sturdy compared to the primary and secondary packing materials. The transport packing category includes the following:

Wooden Boxes

Pre-processed and thoroughly dried plywood and other types of wood materials are used in this type of packing that usually requires a heavy-duty protection and impact resistance for a substantial load both in terms of quantity and weight for having a long-term storing purpose. These are mostly preferred for products that can withstand a lot of surface friction and aberration from tight packing with a longer shelf life like in case of coconuts [54].

Corrugated Boxes

Corrugated boxes are made of thin sheet materials that are lined over each other with air pockets that provide a little bit of flexibility and cushioning to the products placed within them. These are used for transport and storing for a short duration of time in days that do not require heavy-duty protection.

(i) Fibreboards and Cardboards:
These are made of plywood, wood pulp and wood fibres that are comparatively less strong than wooden boxes and provide a little bit of flexibility. These are used again for long transport with a longer time for a commodity that is less rigid, especially in the case of fruits like apples. These packing materials has

a relatively less moisture absorbance capacity to a certain extent. Despite their flexibility and corrugation for cushioning, an additional layer of cushioning is required for each unit as the box can't withstand impacts or heavy loads [55, 56].

(ii) Plastic Corrugated Boxes:
These are used as a replacement for cardboard and fibreboards for their ability to be reused multiple times and their cost-efficiency. They also have a low wright density compared to the fibre or cardboard but offer a higher mechanical strength comparatively. Also, they have excellent properties in terms of water resistance [57].

Plastic Crates

Plastic Crates are the new alternative for wooden crates to transport the products in larger quantities easily. These are made of high-density polyethylene that provides fairly similar resistance property to that of wooden boxes. In some cases, the crates are even specifically designed as a replacement for the wooden boxes as these have higher reusability and cost-effectiveness. But unlike wooden boxes, they can't be dismantled to make alterations as they are made out of mold castings [58].

Sacks

Sacks are made of jute and woven plastic and are mostly used in the food industry for the transportation of raw produces, especially in vegetables that have relative resistance to aberrations like in case of potatoes, carrots and others. These are highly cost-effective, less space occupying and easily disposable packings compared to the other large packing materials [59].

Palletization and Unitization

These are strategic packing options that are used in bulk transportation which involves machine handling to reduce cost. Unitization is the process in which multiple small units of the product are bulked over each other usually in large crates or boxes and are secured with reinforcements [60]. When higher quantities of unitized products are required for shipment, palletization is used. Palletization is the process of stacking large quantities of Unitized units over a pallet (a wooden framework) with reinforcers to hold them in place that has space provision for the use of mechanical handles in carrying them. This greatly reduces the requirement for larger spaces, organizing and sorting process in bulk transport. These techniques are followed in air or ship transport [61].

3.3.2.3 Active Packing

Active packing is a new technological innovation that can interact with the modified atmosphere inside the packing by altering the inner composition of gases like oxygen, carbon dioxide, and ethylene [62]. The mechanism depends on the coating provided or the packing with an additional material which has the property of interacting with

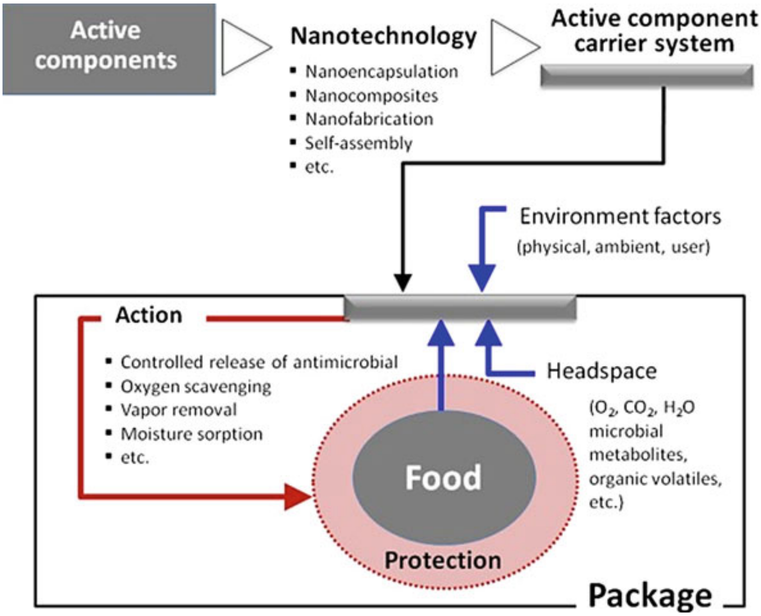

Fig. 3.8 Use of nanotechnology in active packaging [63]

a particular portion. For example, using desiccants like silica gels or zeolite inside a packing helps in moisture control. Others include metal chelators and oxygen scavengers that are used in extending the shelf life of sensitive products [63] (Fig. 3.8).

3.3.2.4 Anti-microbial Packing

This is a form of active packaging that includes, coating the packaging material with an antimicrobial agent to minimize the growth of microbes and has the potential to prevent food spoilage [64]. This packing methodology is under study and experimentation is required for the deeper understanding of the toxicity and diffusivity of agents into the products being packed with like in the case of coating with nanomaterials [65]. Popular methods like modifying the atmosphere with alternate gases like carbon and sulfur dioxide in fruit packings or nitrogen flushing have helped in reducing the growth of microorganisms [66].

3.3.2.5 Other Packaging Materials

Cushioning materials are used in protecting the bulk products when packed in a crate or containers from aberrations caused due to excessive movements or pressure. The natural materials used for cushioning includes paddy straw, paper shreds, and coir (coconut fibres) [67]. Synthetic options like foam nets, bubble wraps and cardboard liners are also used. Vacuum sealed bags are another popular option in both homes and industries. These are devoid of oxygen and it prevents the growth of microorganisms. It works even better when the products are stored under refrigerated conditions [68]. Though this may provide substantial protection against most of the microorganisms, anaerobic microorganisms may grow under these conditions [69].

3.4 Chemical Preservatives

Preservatives are the substances that delay the growth of microbes without necessarily destroying the nutrients or prevent the reduction in the quality during manufacture and distribution. They are naturally occurring or synthetic substance which is added to the products such as foods, biological samples, etc., to prevent decomposition caused by microbial growth or undesirable chemical reactions [70, 71].

3.4.1 Traditional Food Preservatives

Sugar and salt are the widely used preservatives added to the edible food-stuffs from ancient times. Salt is applied or added directly to the food which increases the osmotic pressure levels, thus preventing the growth of microorganisms. Salt will induce dehydration by absorbing the food's main water content; therefore, it inhibits microbial multiplication. Also, ionized salt-producing chloride ions will interfere the action of proteolytic enzymes produced by the harmful food microbes [72].

The sugar preservation process is measured by the ratio between the overall quantity of sugar in the finished product and the concentration of sugar in the liquid form. Sixty percent of sugar concentrations in the finished product guarantee food preservation. The water activity in the food material is reduced due to the addition of sugar; thus, inhibiting the growth of bacteria and yeast [73]. Packaged fruit products (Example: citrus and angelica) are usually cooked to the point of crystallization in sugar, and the resulting product is then stored dry.

3.4.2 Acidulants

Benzoic acid belongs to the sodium salt group, which is one of the most commonly used chemical food preservative. Sodium benzoate is an antimicrobial preservative that is added to acidified foods, such as fruit juices, sauerkraut, pickles, etc., which mainly prevents the yeast growth. Sodium benzoate is carcinogenic and has also been liable for aggravating the health problem of asthma patients which leads to further complications [74].

In general, sorbic acids are added to the food at low quantities which contributes to regulate antimicrobial activity. The World Health Organization (WHO) suggests sorbic acid as a non-toxic food preservative found in a wide range of fruit-vegetable products for the prevention of yeast/mould growth [75]. Furthermore, lactic acid produced in food fermentations reduces the pH levels, contributing to unfavourable conditions for the development of spoilage microbes such as putrefactive anaerobes and acid-producing bacteria [76].

3.4.3 Gaseous Food Preservatives

Sulphur dioxide (SO_2) and sulphites are chemical preservatives added to fruit juices for controlling the microbial growth. The different dissolved sulphites in water contain 50–65% active sulphur dioxide, which reduces the pH values contributing to maximum antimicrobial activity [77]. Besides, sulphur-containing preservatives inhibit enzymatic browning and keep products fresher for a longer period. In recent years, the authority of Food and Drug Administration (FDA) has prohibited the use of sulphur preservatives because of the serious side effects caused to many consumers [78].

In many countries, carbon dioxide (CO_2) also known as "dry ice" is used as an additive for the storage and transport of food products at low temperatures. Gaseous carbon dioxide generally inhibits the growth of psychrotrophic microorganisms and prevents fruit and vegetable spoilage. An artificial environment consisting of the right proportion of oxygen-carbon dioxide delays ripening of fruits as well as retarding mould and yeast growth [79].

3.4.4 Antioxidants

In the prevention of rancidities in foods and fats, antioxidants are beneficial. Fats that are exposed to light, moisture, heat or heavy metal ions become activated and oxidize to peroxide. The widely used antioxidants are Butylated Hydroxy Anisole (BHA), Butylated Hydroxy Toluene (BHT), propyl gallate, Natural/Synthetic tocopherols (Vitamin E) ascorbic acid (vitamin C) and lecithin [80, 81].

3.4.5 Flavour Additives

Natural flavours of food are hardly used because the methods to obtain the quantities needed are expensive. Flavour consistency or chemical composition cannot be standardized and depends on seasonal availability. Therefore, the artificial flavours are required if the demand for flavouring agents in our food supply needs to be fulfilled. The most widely used flavouring agents are esters-c pentyl acetate which has a banana flavor, and aldehyde such as benzaldehyde which is cherry-flavored [82, 83].

3.4.6 Sweeteners

Sweeteners may be categorized as nutritious or non-nutritious to improve the flavor of certain foods. Nutritive sweeteners contain calories because they are metabolized by the body to produce energy [Example: sucrose, glucose (dextrose, fructose, invert sugar and high fructose syrup)]. Non-nutritious sweeteners like carbohydrates do not provide calories because they aren't metabolized. Aspartame is categorized as non-nutritional, but metabolic since the amounts of aspartame alone are exceedingly low and aspartame is weeded to produce sugar that is similar to sucrose [84, 85].

3.5 Conclusion

A new era of edible coatings is under development, which aims to incorporate, integrate and/or monitor the release of active compounds using nanotechnological solutions such as nanoencapsulation and multi-layers in a new generation of comestible coating products. Nano-technologies are currently used to improve food nutrition by using nanoscale additives, nutrients and bioactive compound delivery systems. The vision for the future of packaging is one in which the material can eventually act as an integrated device that combines both modern and traditional products, across the supply chain.

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