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Research Article

A review on different types of coating material

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Abstract

Due to the obvious global population growth, there is a rising need for fruits and vegetables. By growing demand, enhancing distribution, and minimising losses, food supply and accessibility can also be improved. Fruit is prone to loss in post-harvest crops because of its perishable nature, especially when it is distributed widely. Fruit that has been coated will help to reduce the amount of deprivation. On fruits like bananas, strawberries, mangoes, pineapples, and avocados, various post-harvest coatings are used to reduce water loss and chilling damage while extending the fruit's storage life. Future generations' supply demands must be met; hence the food processing sector must stop postharvest losses. Numerous approaches are employed to preserve the food supply for longer periods of time in order to address these issues. The most often used techniques worldwide include heat treatments, cold storage, coating, Nano emulsion, and Nano technology. The food product is made more appealing, healthy, and has a longer shelf life when different types of additives are combined with the edible coating. For the purpose of boosting these properties, many foods have been coated. This study shows that adding edible film to tropical fruit can significantly increase its shelf life after harvest. Although the research's primary goal, more work is still needed, particularly to improve our understanding of how biopolymer materials behave after consumed in order to produce consumer-safe films. The information in this article will assist processors in making the best coating material and density decisions for a variety of processed foods.

Keywords: Edible food coating, Additives, Emulsifiers, Plasticizers, Antimicrobial agent

Introduction

As we all are aware, Plastic performs a very vital function in industries and household appliances such as hand baggage, containers, bottles, electrical equipments etc. It takes thousands of years to decompose but the plastic production nevertheless exceeded 300 million tons until year 2015. The Different type of plastic used to develop the plastic films from polyethylene. During the preparation of the plastic material, the release of hazardous gases causes contamination in atmosphere (Marichelvam et al., 2019). In recent years, the degradation of climate and the lack of petroleum resources have become a serious issue all over the world (Wittaya et al., 2012). These claims provide a new opportunity to develop the plastic material made from biopolymer resources that can degrade quickly. This biopolymer mainly consists of various natural occurring polymers that can be found in the living organisms (Suriyatem et al., 2019). The Biodegradable plastics were prepared mainly from various ingredients such as protein, starch, chitosan and cellulose extracted from biomass that is reusable. Plastic waste, fossil fuels, carbon dioxide emissions and other harmful gases can be limited with the use of biodegradable plastics. The production of biodegradable and edible films from starches, proteins and other components adds value to low cost products and also serves as a strong preservative (Dias et al., 2010). Basically, there are different methods such as refrigeration, active packaging, modified atmosphere packaging, controlled atmosphere storage have all are used to inhibit the losses in foods. These packaging techniques also help to reduce the post-harvest losses. Furthermore, these preserving processes have gained popularity from recent centuries due to its effectiveness in extending the fresh produce's post-harvest shelf life (Alharthy et al., 2020). Out of these all methods, Coating is the most common method of preserving the perishable foods (Mohebbi et al., 2012). This helps to prevent the physical, chemical and biological deterioration of the food. As these carry certain active ingredients that can change the metabolic process of fruit, prolong shelf life, preservation of texture, maintain the microorganisms, colouring and flavours which can helps to improve the various properties of food e.g. light induced chemical changes, microbial growth, oxidation of nutrients, moisture migration. By acting as a foil to gases, oils or vapours, the films or coatings will improve safety (Han et al., 2014). This also helps to maintain the security as well as presentation of the product. Additionally, edible films enhance shine of the food so making it more appealing and desirable for customers (Mohebbi et al., 2012). There are different ways to apply coating on food surfaces, such as dipping, spraying or brushing (Das et al., 2013). The fruit coating principal is same as the modified atmosphere packaging in which environment is adjusted by maintaining the amount of CO_2 and O_2. These significant environment changes will lead to the rate of respiration, conserve stored energy, inhibits microorganisms, and hence improves the quality and storage life of the food product (Nor et al, 2020). The Chinese invented this coating in the 12th and 13th centuries, which is used in food engineering for saving the food items. Wax was the first edible coating that was used on the oranges and lemons to enhance the internal gas composition. The Chinese were unaware of the importance of edible coatings; instead, they discovered that wax-coated fruits were better preserved than non-waxed fruits but later in 1930s melted paraffin waxes for apples and pears became commercially accessible (Jemilakshmi et al., 2020) (Fig 1).

Edible coating

Applying thin layer of edible coating made from protein and lipids can inhibit the product from decay and extends the shelf life. They serve as gas and moisture inhibitors which regulates the respiration rate, slowing down the ripening of vegetables. Antimicrobial agents, enzymes, minerals, and vitamins are also used in edible coatings, which boost practical properties (Cha & Chinnan 2004). According to the quality of the ingredients used in the coating solution preparation, edible coatings are divided into three groups: hydrocolloids, lipids, and composites (Valencia C. et al., 2011). Since hydrocolloids are a weak against water content and lipids have low gas barrier property so, they are often used together. The combination of the two strengthens structural stability and functionality (Sharma et al., 2019).

Hydrocolloids

Hydrocolloids are the polymers which are soluble in water. These are derived from plants and organisms. These are available natural but few of these can be derived from different chemicals e.g. chitosan. This type of coating alters environment, eliminating the metabolic reaction of several vegetables. Chitosan, gums, cellulose, and starch are examples of polysaccharides used as edible coatings.

Chitosen is non-toxic in nature, have great film-forming properties, good antioxidant and antimicrobial properties (Duran et al., 2016). Polysaccharide of chitosan is made by the deacetylation of chitin in crustacean eggs, such as shrimp shells, and insect shells (Yan et al, 2019). Chitosan is used as additive, active edible coating, drug manufacturing (Elsabee A. 2013). Basically chitosan has a backbone that is somewhat similar to cellulose, but the hydroxyl group is different. Is a synthetic polymer with (14)-glycosidic bonds linking the two forms of repeated units. Chitosan can form a semipermeable membrane, which slows the ripening of the fruit and lowers the rate of transpiration. Chitosan can

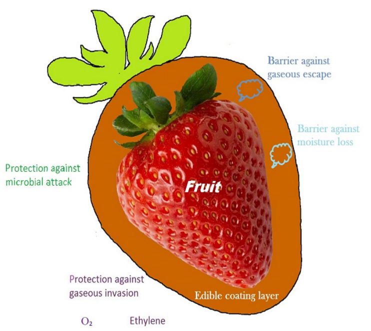

Figure 1. The edible coating on strawberry fruit (Kaur et al, 2020).

be used as an edible film without the use of any chemicals (Jemilaxmi et al., 2020). Many studies have shown that a chitosan-based coating containing tea polyphenols and clove EO (essential oil) protects Pacific white shrimp (Penaeus vannamei) from spoilage and Maillard reaction during refrigeration (Gan et al., 2021). The guava conditions were able to control more easily as the nanoZnO incorporation of chitosan and alginate done (Arroyo et al, 2020). Chemical composition of chitosan makes it a secure, free from allergy, bioactive solvent. This film has been used effectively on commercial level. This coatings material is superb antibacterial and has strong O_2 and CO_2 resistance capabilities (Hassan et al., 2018). Similarly, Gum arabic, also known as gum acacia. It is in dry, greasy form. This is mainly obtained from Acacia species' stems or branches. Due to the properties of formation of films, emulsification and perhaps easy to dissolve in hydrocolloids, it has been widely used in the food industries. In a recent analysis by (Zapata et al., 2008), edible coatings of alginate or zein applied on tomato fruit demonstrated effects in delaying the ripening process by reducing the rate of respiration rate and ethylene production, as well as changes in the colour and texture due to the hormonal changes. Also (Anany et al., 2009) found the coating on apple used different ingredients such as soybean and Arabic gum, delayed weight loss in weight, texture, total acidity, TSS and colour.

Cellulose is the synthetic form of plants, animals and several microorganisms. It has some useful properties for making polymer composites, such as low density, combustibility, non-toxicity, biodegradability, and, lower cost than other polymeric materials. Cellulose alternating cellobiose is a polysaccharide which is bonded by a -1, 4 linkages and inter - molecular hydrogen bonding. However, it has some significant disadvantages, such as low interfacial adhesion and heavy water absorption, making cellulose-fiber less appealing for industrial manufacturing processes.

Starch is a natural carbohydrate which is available all around the world. This is obtained from some of the natural resources, such as rice, wheat and potatoes (Woggom et al., 2015). This is basically made up of two components amylose and amylopectin. This contains approximately 0-30% amylose and varies with temperature change. Rice grains cultivated at lower temperatures have high content of amylose than the rice cultivated at higher temperatures (nakamura et al., 2015). Amylose is linear branched molecules, while molecular branching of amylopectin is large. Also the amylose has a major impact on the quality and gelatinization properties of cooked rice (Nakamura et al., 2016).

Fibrous proteins and globular proteins are the most common types of proteins. H-bonding keeps fibrous proteins together, while globular proteins are made up of hydrogen and covalent bonding that is folded into a complex form. Film formulation has been researched using globular proteins such as, wheat gluten, whey protein etc. Due to the chain to chain interaction between the protein molecules, it results stronger films but they will be less permeable to water, liquid and gas. Therefore, it is highly effective to resist oxygen at low relative humidity (Hassan et al., 2018).

Lipid based edible coating

Lipids have strong moisture resisting properties because of its weak affinity for humidity. Beeswax, candelilla wax, carnauba wax, triglycerides, fatty acids, fatty alcohols etc are some of the examples of edible lipids that are used in production of edible coatings. Lipid composites and films are primarily used for their hydrophobic qualities, which act as a strong moisture shield. It is also helps to minimize respiration, thus extending shelf life and enhancing the quality of fruits and vegetables by producing a shine (Mahajan et al., 2018). Paraffin, palm extract, soybean, sunflower, Stearic acid, palmitic acid are popular lipids used in coating formulations. On the other hand, Real and synthetic waxes, have greater water and oil barrier properties (Nasirifar et al., 2018). The study of (Ibrahim et al, 2014) has stated that the combining the two different components such as wax and sorbitol fatty acid inhibited the process of ripening in pineapple for longer period of time. While lipid coating has some of the negative effect on coating which can leads to the browning of some fruits and vegetables. (Jesmin et al., 2018) have discovered that browning occurs in litchi that has been covered with paraffin wax and inhibits the shelf life of fruit.

Composite coating

Composite film is made from different hydrocolloids. Particularly, polysaccharides, proteins are having excellent structural and mechanical property which helps to make good film-forming materials, but they also have a low moisture barrier. As a result, the hydrophobic lipid components plays great role by serving as excellent water barrier. To put it another way, these are designed for blending the benefits of two different components such as lipid and hydrocolloids (Yousuf et al., 2018). The key goal of composite film and coating production is to improve permeability and mechanical characteristics. The preparing process is the biggest disadvantage of this coating material or film. In general, there are four steps involved. Out of those, two are casting and two are dry method (Hassan et al., 2018).

Additives

According to the Food and Nutrition Board's Food Protection Committee, food additives are described as compound that is present in a food. Different chemicals have been applied to foods since ancient times to serve specific functions. While basic foods do not contain additives but more than 2500 different additives are applied to foods today to achieve a desired result. Different additives types are available such as flavouring agents, colouring agents, preservatives, texturizing agents and nutritional additives. In past years, there has been a rise in concern for food allergies and intolerance. Reactions have been linked to a wide range of foods and dietary constituents. The recent opinion, as adopted by the World Health Organization's Codex Alimentarius Commission, recognises eight foods or food categories to be the primary causes of food reaction. As the natural colour compounds are legitimately exempt from Codex's list of foods and food types (Lucas et al., 2001).

Plasticizers

Basically cohesion and adhesion are needed for film formulation as a coating. Different properties of polymer such as polarity, weight, structure are relevant to adhesion and cohesion which is related to unfavourable modifications. To control the problems, plasticizers have been added during film preparation. Monosaccharide, disaccharides, or oligosaccharides, polyols and lipids and derivatives are all widely used plasticizers in film preparation (Sothornvi & Krochta 2005).

Emulsifiers

Emulsifiers are added to the coating solutions to increase the consistent coating application. The use of a surfactant or emulsifier improves the film's ability to prevent ageing (Sharma et al., 2019). Emulsifiers are used to make the substance more stable and extend its shelf life. The final product characteristics, emulsion preparation methodology, the volume of emulsifier applied, the chemical and physical characteristics of each process, and the involvement of other functional components in the emulsion all play a role in emulsifier selection. For an example emulsifier is used in baking products as crumb softeners and dough conditioners as an example. A third function is to change the way fat crystallises, such as reducing bloom in some candy goods.

Antimicrobial agent

Fruit and vegetable deterioration is caused by a variety of microorganisms, which reduces their consistency and shelf life. Antibacterial coating without preservatives has been increasingly important in managing and avoiding foodborne microbial infections in past times. Several found naturally microbial enzymes, are already being used as antimicrobial agents in the food industry. Poor stability and operation are the major disadvantages of these enzymes if not held under favourable conditions (Fayaz et al., 2009). Basically antimicrobials in food can prolong the lag period or deactivates growth of microorganisms. (Raju et al., 2018) have discussed about the handling systems of postharvest vegetable crops. He has done value addition of the products to make it taste fresh and appeal to the senses. (Hoa et al., 2002) have used four different coating carnauba wax, shellac, zein, and/or cellulose derivative but carnauba wax slowed more rates of respiration, the production of external and internal colour, and the loss of firmness. On the other hand, there are also studies on the beneficial impact of AG as an edible surface layer on the shelf life of sweet cherries. He looked at the benefits in terms of stem browning and dehydration, as well as maintaining the fruit's visual appearance without affecting taste, scent, or flavour Tab. 1.

Future trends

Biodegradable materials, especially those extracted from natural resources, are

Table 1. Use of different coating materials on Fruits and Vegetables.

Fruit	Coating matrix	Antimicrobial agent	Conc. Of antimicrobial agent	Test conditions	Target microorganism	Effect of coating matrix	Antimicrobial activity	References
Strawberry	Sodium alginate, Chitosan, Carrageenan	Cassia oil as antifungal properties	0.5-0.25 minimum fungicidal concentration (MFC)	16 days at 4ºC	Total aerobic microorganisms and total yeast-mold	Coated sample showed better results in pH, TA values, and weight loss as compared to uncoated samples	Antifungal	De Paula et al, 2018
Strawberry	Chitosan	Nisin, natamysin, pomegranate and grape seed extract		40 days at 4ºC	Aerobic mesophilic bacteria	film coatings improved the stability of pH, total soluble solid content and texture	Antimicrobial	Duran et al, 2016
Strawberry	Sodium alginate, calcium chloride			15 days at 4ºC	Molds	Controls the TSS, pH content and also increase in moisture loss, respiration rates		Alharaty 2020
Mushrom	Fungal chitosan				B. subtilis, E. coli bacterium and S. cerevisiae yeast			Bodbodak et al, 2016
Sea foods	Chitosan			30 days at -3ºC			Antibacterial and antifungal	Elsabee and Abdou 2013
Sweet cherry	Chitosanand alginate	olive leaves extract (OLE)	Chitosan: 1% alginate: 3%	25±5°C for 20 days		retarding the ripening process of sweet cherries with a maximum retention of phenolic compounds compared with uncoated fruit samples.		Zam, 2019
Walnut	Chitosan	Green tea extract	--	18 weeks at RT	Yeast and Mold	Coating reduces oxidation activity and fungal growth; Green tea extract at 10 g/L had unacceptable sensory characteristic.	Antifungal	Sabaghi et al., 2015
Figs	Alginic acid, sodium salt and Agar	pomegranate peel extract (PPE)	0.5 %	15 days	Enterobacteriaceae	Inclusion of PPEwith high antioxidant and antimicrobial activities in an edible coating was best for preserving the quality of figs.	Antibacterial, Antifungal	Paolucci et al., 2020
Lamb meat	Alginate	Thyme and garlic essential oil	0.05 %	2-4 °C for 7 days		Alginate coating with 0.05% active concentration maintains lamb meat quality characteristics during the shelf life; lower lipid oxidation and better colour maintenance.		Guerrero et al., 2020
Beef patties	Carboxymethyl-cellulose	Apple-peel powder	3 % w/v		mesophilic aerobic bacteria, mold and yeast	Active coating solution treatment was effective in inhibiting microbial growth against MAB, MY and S. enterica, as well as the lipid oxidation of ground beef patties during refrigerated storage.	Antibacterial, Antifungal	Shin et al., 2017

Apple	candelilla wax and jojoba oil	fermented tarbush	500 ppm	27 °C for 8 weeks		Reduced weight loss: maintained the water activity and firmness thus improving quality and shelf life of apples.		De León-Zapata et al., 2015
Avocado	Carboxymethyl-cellulose	moringa leaf and seed extracts	2 %	5.5°C for 21 days	C. gloeosporioides, A. alternata, L. theobromea	Coated avocado had low rate of respiration and higher firmness; reduced postharvest loss; inhibitshyphal development due to phenols.	Antimicrobial, Antifungal	Tesfay et al., 2017
Almond	Apricot gum	*Satureja intermedia*	4 %	60 days	*Aspergillus flavus, Alternaria alternata, Fusarium oxysporum, and Penicillium citrinum*	Oxidative stability decreased; Reduced fungal contamination.	Antifungal	Hashemi et al., 2018

increasingly replacing synthetic polymers. Farmers and industry producers would gain greater economic benefits from the use of such bio-packaging. Bilayer and multicomponent films with physical and barrier properties are similar to synthetic materials. Another technique useful in composite biodegradable materials is cross linking of different molecules, either chemically or enzymatically (Tharanathan et al., 2003). Making use of by-products or waste can also help to produce environmentally sustainable fabrics. The processes of coating on food product can be relates to determine a satisfactory application of these products. Eventually, extensive analysis will be conducted to investigate the reliability of products that can be stored for extended periods, including mechanical properties, gas distribution, and thermal tolerance to respond to changing environmental conditions (Nor et al., 2020). Incorporating effective antimicrobial agents into packaging structures poses technical difficulties. According to current patterns, packaging may increasingly have antimicrobial substances, and sealing mechanisms will develop. Researchers have largely focused on designing novel approaches and evaluating new techniques on model structures, rather than real-world implementations. In addition to their environmental, bacterial, and physiological changes, antimicrobial packaging technologies would concentrate on the technological viability, market adoption, and food safety implications of antimicrobial agents (Cha & Chinnan 2004). Future developments are linked to manufacturing growth and the ability to manufacture goods that are sustainable in terms of value and price. Established polysaccharide membranes must be improved, especially in physical and mechanical properties, liquid water resistance, and water vapour permeability. Additives (such as lipids), compositions of various polymers, multi-layered membrane construction, nanoparticle application, and chemical modification of polysaccharides are all possible techniques. This great achievement is critical for a more environmentally friendly solution to food packaging manufacturing. As this process is time consuming, modern techniques should be used to minimise production costs and make it more cost effective. Designing an edible coating or film that used for different food products and boost the practical characteristics beyond shelf life should be prioritised.

Conclusions

Food processing enterprises must prevent postharvest losses in order to meet the supply needs of future generations. To address these issues, a variety of strategies for preserving food for longer periods of time have been developed. Heat treatments, cold storage, coating, nanoemulsion, and other methods are the most widely used around the world. The addition of various types of additives to the edible coating makes the food product more appealing, nutritious, inhibits microbiological growth, and extends the storage life. Several foods have been coated in order to improve these properties. In the bread and confectionery industries, though, it is also used. These films aid in the preservation of the physical and chemical qualities of fresh and highly processed fruits for longer periods of time. This study shows that edible film is a wonderful way to extend the post-harvest life of tropical fruits. Although the focus of the research, further work is needed, particularly to better forecast the process of biopolymer products till ingestion in order to create a safe film for consumer usage.

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