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EDIBLE COATING OF FRUITS AND VEGETABLES: A REVIEW

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Abstract:

Nowadays, fruits and vegetables are highly demanded in the market because of its nutritional value. Fruits and vegetables have short shelf life due to its perishable nature. About 30% fruits and vegetables are affected or damaged by insects, microorganisms, pre and post harvesting conditions during transport and preservation. Preservation of fruits and vegetables is a big challenge for world. Edible coating is an effective method to solve this problem. It provides protective edible covering to fruits and vegetables. It is beneficial for consumers and environment. Today herbal edible coatings are used as a nutraceutical and beneficial for consumer health. Edible coatings are of different types such as hydrocolloids, lipids and plasticisers. These have good barrier properties to O_2, CO_2, moisture and water vapour.

Key Words: Edible coating, Fruits, Vegetables, Coating Types, Hydrocolloids & Shelf Life.

1. Introduction:

Fruits and vegetables are essential constituents of daily diet and are highly demanded in the recent years from most of the population. They are reservoir of vitamins, essential minerals, antioxidants, bio-flavonoids, dietary fibres and flavour compounds which fall easily victim to abiotic and biotic adversities. Fruits and vegetables are highly perishable and during the post- harvest, there are considerable losses due to microbes, insects, respiration and transpiration [96].

The external factors include atmospheric composition such as O_2, CO_2, ethylene ratios, temperature and the stress factors while the internal factors include the species, cultivar and its growth stage [43]. In addition, contamination of the fruits and vegetables flesh can occur from the skin increasing the fruits and vegetables spoilage leading to biochemical deterioration such as browning, off flavour and texture break down, decreasing the fruits and vegetables quality and the risk to the consumers due to the presence of pathogenic microorganism [36].

The important quality factors of fresh produce contributing to the marketability are texture, colour, appearance, flavour, nutritional value and microbial safety. These quality factors are measured by plant variety, ripening stage, maturity stage pre-harvest and post-harvest conditions [49]. The Post-harvest losses of fruits and vegetables are a serious problem because it rapidly deteriorates them during handling, transport and storage. Edible coating over fruits and vegetables are used to improve their quality and shelf life [47].

Edible coatings are used for extension of shelf life of fruits and vegetables. These can also be safely eaten as part of the product and do not add unfavourable properties to the foodstuff [9]. Edible coatings or films increase the shelf life of fruits and vegetables and are environment friendly. In recent years, new edible films and coatings have been developed with the addition of various and edible herbs, antimicrobial

compounds to preserve fresh fruits and vegetables [89]**.** Edible coatings to prevent loss of firmness and moisture. They control maturation, development and respiratory rate. Edible coatings prevent oxidative browning and decrease growth of microorganism in fruits and vegetables for example, Tomato, Cucumber, and Cherries etc., [47]**.** Edible coatings or edible films are contributed to enhance the shelf life of fruits and vegetables by reduction of moisture loss solute migration and gas exchange etc.; as well as by reducing the physiological disorders. Edible coatings have high potential to control browning, discolour activity, off flavour, microbial activity of fruits and vegetables and to extend shelf life [24].

According to Baldwin [9], the main purpose of edible coating for fruits and vegetables is basically to increase the natural barrier, if already present and to replace it in the cases where handling and washing have partially removed or altered it. Moreover, one of the most important things of this edible coating is the fact that they can be eaten together with the fruits and vegetables.

2. Edible Coating:

History:

Edible coatings or edible films have been used for centuries in the food industry to preserve food products this is not a new preservation technique. For example waxing on fruits and vegetables and cellulose coating in meat casings [38]. Edible coatings have been used since 12th century in China. It was not until 1922 the waxing on fruits was invented and first time was commercially applied on fruits and vegetables [19]. Edible films and coatings form a barrier for chemical, physical and biological changes [90].

At the time of purchasing fruits and vegetables, consumer judge the freshness and quality of the produce on the basis of its appearance [40]. The most common and challenging problem are to maintain and control fresh quality, growth of spoilage and pathogenic microorganism in fresh cut fruit industry. The solution of this problem is edible coating [81]. Edible coating provides an additional protective coating for fresh fruits and vegetables and can also provide the same effect as modified atmosphere storage in modifying internal gas composition. Recently, various edible coatings were applied successfully for preserving fruits and vegetables such as orange, apples, grapefruit, cherries, cucumber, strawberry, tomato and capsicum were applied successfully. Edible coating of fruits and vegetables is successful or not totally depends on the control of internal gas composition [87].

Definition:

Edible coatings are defined as the thin layer of material which can be consumed and provide a barrier to oxygen, microbes of external source, moisture and solute movement for food. In edible coating a semi permeable barrier is provided and is aimed to extend shelf life by decreasing moisture and solute migration, gas exchange, oxidative reaction rates and respiration as well as to reduce physiological disorders on fresh cut fruits [11, 69].

According to Pavlath and Orts [72], different type of materials were used for coating and wrapping various fruits and vegetables to extend their shelf life, and this is eaten together with foods, with or without removal is considered an edible coating. Edible coating or edible films provide shiny appearance to fruits and vegetables. Thickness of edible coating is generally less than 0·3 mm, [95]. The main characteristic feature of edible coating is to increase shelf life of fresh or processed fruits and vegetables and it is protected from postharvest damages and environmental damages [95]. An edible coating protects outer membrane of fresh fruits and vegetables [60]. The edible coatings are served as carrier of texture enhancer, antioxidants and it is used as a

nutraceutical [97, 82]. Under high relative humidity, edible coating should be stable, generally recognised as safe. Edible coating or edible films are mostly tasteless, colourless and odourless they should have good mechanical properties. Edible coatings have good gas barrier and moisture barrier properties [97].

Properties:

Properties of edible coatings are based on their molecular structure, molecular size and its chemical composition [4]. These properties are following-

✓ Edible coatings have good barrier properties to water, moisture, O_2, CO_2, and ethylene.

✓ It improves appearance and mechanical handling to maintain structure and colour of Fruits and Vegetables.

✓ Edible coating contains active components such as antioxidants, vitamins etc., they enhance nutritional composition of Fruits and Vegetables without affecting its quality.

✓ These coatings provide a protective covering on Fruits and Vegetables and enhance their shelf life.

3. Edible Coating Applied on Different Fruits and Vegetables:

Fresh fruits and vegetables are highly perishable and approximately 50% fresh produce are deteriorated during harvest, handling, transportation and storage. Edible coatings play a very important role to handle this situation. Edible Coatings are applied on whole and fresh-cut fruits and vegetables [24, 107]. Fruits and vegetables which has been coated are-

Fruits: Edible coated fruits are Orange, Apple, Grapefruit, Cherry, Papaya, Lemon, Strawberry, Mango, Peach etc. and fresh-cut Apple, fresh-cut Peach, fresh-cut Pear etc.

Vegetables: Tomato. Cucumber, Capsicum, Cantaloupe and minimally processed Carrot, fresh-cut Potato, fresh-cut Cabbage, fresh-cut Tomato slices, fresh-cut Onion, Lettuce.

Figure 1: Edible coated fruits and vegetables [3].

4. Classification of edible coatings:

Edible coatings are having hydrophobic group, for example lipid-based or waxes, and hydrocolloids or hydrophilic group, for example polysaccharides-based, protein-based or combination of both groups to improve function of edible coating [101]. Edible Coatings are not chemically synthesised and it is natural. It is generally used for good appearance and preservation of fruits and vegetables. The main advantages of edible coating are its edibility, non-toxic nature and cost effective as compared to other synthetic coating [76]. Edible coating materials are generally made up of polysaccharides, proteins and lipids [71]. The edible coatings are mainly divided into three classes; these are following- [23].

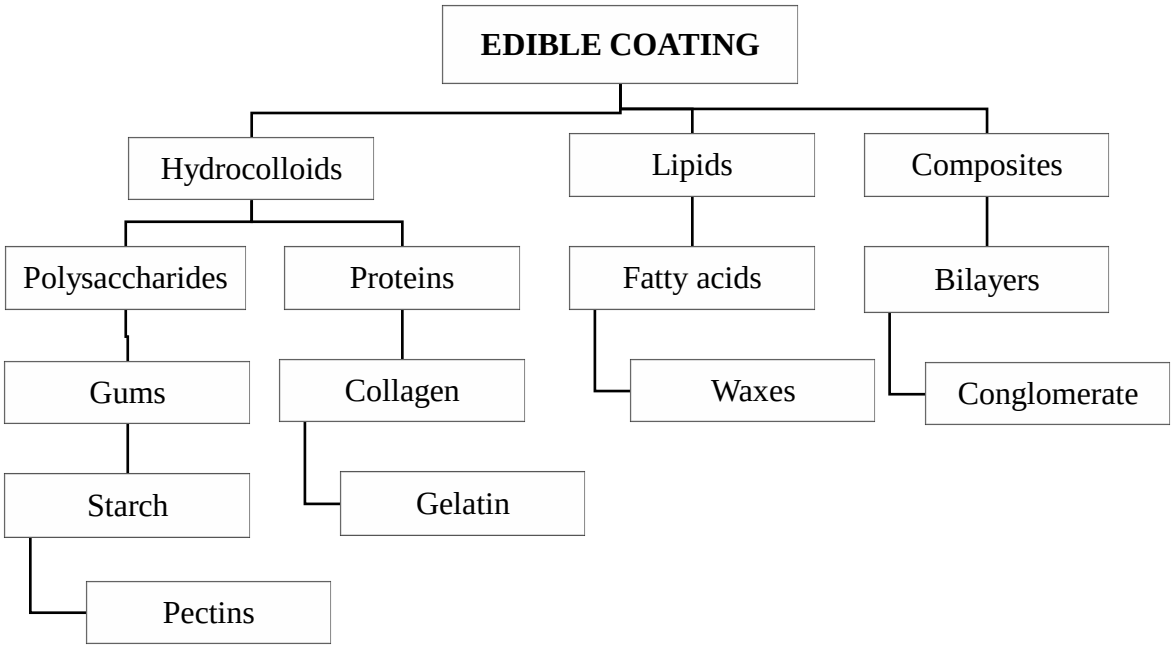
❖ Hydrocolloids: e.g., polysaccharides, proteins and alginate.

❖ Lipids: e.g., fatty acids, acryl glycerides and waxes.

❖ Composites: e.g., protein/protein, polysaccharides/protein, lipid/polysaccharides

Edible coating materials are produced with a variety of natural substances such as polysaccharides, protein, lipids by the addition of surfactants and plasticisers. The function and performance of edible coating mainly depends on its mechanical, barrier

and colour properties, which control the gas transfer and moisture loss of fruits and



vegetables [49].

Figure 2: Different types of Edible coating [49].

❖ **Hydrocolloids:** Hydrocolloids are originated from animals, vegetables, microbial or synthetic, they are hydrophilic polymers. They have hydroxyl group and may be poly-electrolytes such as Alginate, Carrageenan, Pectin, Carboxy Methyl Cellulose, Xanthan gum and Gum Arabic. Today, hydrocolloids are used in wide range as a coating forming solution to coat and control the colour, texture, flavour and shelf life of fruits and vegetables [102]. Generally, all hydrocolloids are partially or completely dissolve in water and principle use of this is to increase the viscosity of the aqueous phase (continuous phase) i.e., gelling agent thickness [10]. They act as an emulsifier due to this stabilising effect. The hydrocolloids are divided into two classes-

➢ Polysaccharide-based,
➢ Protein-based,

➢ **Polysaccharide-based**: The most common polysaccharides used for edible coating of fruits and vegetables are chitosan, starch, alginate, cellulose, pullulan, carrageenan, gellan gum etc., [37]. Polysaccharides based edible coatings having poor moisture barrier properties, it is water soluble. But it contain moderately low O_2 permeability. Mostly, polysaccharides based edible coatings are applied on fresh and minimally processed fruits and vegetables, by creation of modified atmosphere condition to reduce their respiration rate. Its improved mechanical handling property and additives carrying capacity [8, 33].

Polysaccharides give crispiness, hardness, compactness, thickening quality, adhesiveness and viscosity to a variety of edible coatings. Polysaccharides are made up of polymer chain, having excellent gas barrier properties, resulting in desirable modified atmosphere that extend the shelf life of the fruits and vegetables without forming anaerobic conditions [10]. These coatings are given below-

•Cellulose Derivative:

Cellulose is easily found in nature. It is made from long chain of anhydro-glucose polymer. Cellulose is reacted with alkali, then it is treated with appropriate chemical reagent and then it forms substitute of cellulose chain of anhydro-glucose monomers. This pro cess has been done under controlled conditions (62). The substitution reagents are given below-

a.Methyl cellulose- formed by chloromethane,

b. Hydroxypropyl cellulose (HPC)- substitute reagent is propylene oxide,

c. Hydroxypropyl Methyl Cellulose (HPMC)- mixed substitution of chloromethane & propyl oxide,

d. Methyl ethyl Cellulose (MEC)- mixed substitution of chloromethane & chloroethane,

e.Carboxy Methyl Cellulose (CMC) - monochloroacetic acid.

Methyl Cellulose, HPMC, HPC, CMC films or coatings contain film forming characteristics [62].

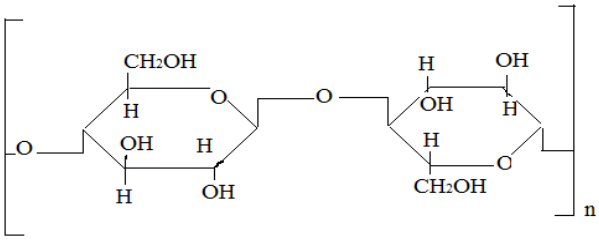


Figure 3: Structure of Cellulose [62].

Cellulose derivatives are made from polymer chain of two repeating unit of anhydro-glucose or β-glucopyranose residue attached through 1, 4-glucosidic linkage. In this chemical structure, 'n' indicates the no. of glucose monomers of polymerisation. The DS (Degree of substitution) are defined as, the average no. of –OH group substituted per anhydro-glucose unit. Generally the modified cellulose derivative edible coatings and films give colourless clear solution, odourless and tasteless. It is having good resistant property of oil and fats and soluble in water and partially permeable to moisture and gas transmission [44]. The mechanical barrier property of cellulose edible coating and films are based on molecular weight of cellulose, that is the higher molecular weight of cellulose the excellent barrier properties [46]. Methyl Cellulose has good moisture barrier property as compared to others and it is lowest hydrophilic [42].

These modified cellulose derivatives are found in granule and powder form; it is hygroscopic in nature [62]. However, cellulose derivative coatings and films have poor gas and water barrier properties. Polysaccharides derivatives are hydrophilic in nature that's why they have poor mechanical properties.

• **HPMC:** Hydroxypropyl Methyl Cellulose is commonly used for edible coating. It is non-ionic water soluble macromolecule, is capable to form gel on heating [104]. HPMC is by product of propyl oxide and chloromethyl [62].

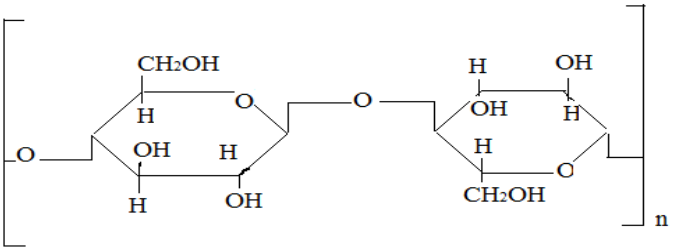


Figure 4: Structure of HPMC [62].

The Hydroxypropyl methyl cellulose is divided in two regions, one region contain Methoxy group and this region is hydrophobic in nature, and other region have Hydroxy

Propyl group that are hydrophilic in nature. HPMC are soluble in cold water and after dissolve in water it gives different viscosity characteristics solution, it's totally depend on their degree of polymerization and substitution. The different types of HPMC are found in market, which contain different viscosity and different molecular weight.

•Starch Derivatives:

Starch is the most common polysaccharide. Starches are obtained from cereal grains such as wheat, maize, rice etc., and cereal grains are belong to Poaceae family. Potato and other tubers, legumes are also good source of starch [100]. Starches are composed of anhydro-glucose units. Starch is a homopolymer composed of polysaccharides components- one is water soluble amylose and second is water insoluble amylo-pectin. On the other hand the amylose are a linear or unbranched chain of D-glucose (1-4 linkage) and the amylopectin is a branched chain of glucose (1-6 linkage). Amylose are good starch derivatives for film and coating material [79] coatings and films of high amylose corn starch or potato starch are contained high stability during long period preservation. These chains are held by the help of glucosidic linkage. Starch derivatives are breakdown by the help of amylase and the final product is dextrin [79, 86]. Starch amylose for example corn starch is excellent source for coating and film production [52]. Corn starch based films and coatings demonstrated of physical characteristics resemble to plastic films and coatings, they are tasteless, odourless and colourless and non-toxic. It is biologically absorbent, semi-permeable to oxygen and carbon-di-oxide.

Chitosan:

Chitosan is derived from chitin, it is an edible polymer. Chitin is mainly found in crustacean animal shells. Chitosan is the most common non-toxic and natural product after cellulose for formation of edible coating [88].

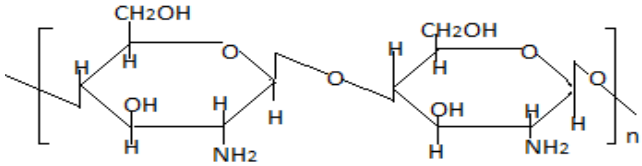


Figure 5: Structure of Chitosan [48].

Chitosan having good character feature without addition any type of additive and antioxidants such as it contains good O_2 barrier and CO_2 permeation and antimicrobial activity against microorganism. Chitosan has excellent mechanical properties. Viscosity of chitosan is very high similar to the natural gums [73]. Chitosan are made up of transparent and clear coatings, increase shelf life of fruits and vegetables. Its coating are normally smooth, shiny, cohesive and without cracks on surface [77].

Gums:

Mostly all gums are polysaccharides it consists of sugars. Gums are used for preparation of edible coating on fruits and vegetables because of its texture capability. Generally, gums are divided into three parts-

a.Exudate gums (e.g., gum Arabic)

b. Extractive gums (e.g., guar gum)

c. Microbial fermentation gums (e.g., xanthan gum).

Gums are soluble in water. Xanthan gums are prepared by microbial extraction by fermentation process. It is rapidly spread in water due to this high viscosity are found readily in cold and hot both stages. A mixture of gum Arabic, guar gum and xanthan gum are used to form equal coatings with good adhesion property in wet batters [56]. In

mesquite gum formation a coating by the addition of a little quantity of lipid, it shows excellent water barrier property [56].

Alginate:

Alginate is obtained from brown seaweed, which is related to the Pheophyceae family. Alginate contains salts of Alginic acid. Alginate having a linear chain copolymer of D-mannuronic acid L-guluronic acid monomers, the chemical formula of alginate is $(C_6H_8O_6)$ n. It is found in white, yellow, fibrous powder form. Alginate is commonly used in form of Sodium alginate this is extracted from brown algae. Alginate contain excellent barrier for moisture and water vapour [83].

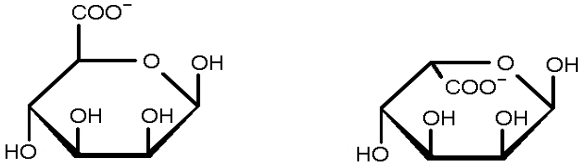


Figure 6: Alginate monomers, β –D-mannuronate & α- L-guluronate [25].

Alginate maintains good properties useful in food application [66]. It has a unique colloidal property, which contains stabilising, thickening, suspending coating or film producing gel forming and stabilising emulsion [78]. Alginate coating materials are made by the use of divalent cations such as Ca, Mg, Mn, Al etc.; it is used as gelling agent. Alginate has some desirable properties including reduction of shrinkage, moisture retention, colour and odour of food. Strong edible coatings or films are made from alginate and present formally poor water resistance due to own hydrophilic nature [14].

Pectin:

Pectin is a group of polysaccharides which is derived from plant; it is naturally found in fruits and vegetables. Pectin is good for low moisture fruits and vegetables but is not a good moisture barrier [12]. It is a heterogeneous group of acidic polysaccharides. It is commonly found in peel of citrus fruits and apple pomace. The structure of pectin polysaccharide are very complex, are made up of β-1, 4-liked-galactouronic acid residues [22]. Pectin is a complex polysaccharide; it composed from 1, 4- linked d-galactouronic acid residue. HMP (High Methoxy Pectin) are excellent pectin compound for producing good film and coating. The mixture of citrus pectin and high amylose starch provided a pliable film and coating. These are stable at the temperature of 180˚C; pectin is dissolved in poly vinyl alcohol [28].

Carrageenan:

Carrageenan is water soluble polymer; it contains a linear chain of partially sulphated galactans, which have ability to forming coating or film material forming. Carrageenan is a sulphated polysaccharide, extracted from cell wall of different red seaweeds belongs to the family Rhodophyceae [41]. Carrageenan coatings or films form a gelation mechanism during moderate drying process lead to a 3-dimansional network form by polysaccharide double helical and to a solid coating or film after solvent evaporation [41].

Agar:

Agar gum are obtained from red seaweed Rhodophyceae family, it is a galactose polymer. Agar is hydrophilic colloidal in nature it contains a mixture of agro pectin and agrose [83]. It is used widely in microbiological media to give firmness. Agar forms a strong gel melting point for above the initial gelation temperature [64]. Agar gels are set on cold temperature and melt on high temperature. Because of their capacity to form hard gel at low concentration and of its extraction [93]. Agar is widely used in food industry.

➢ **Protein-Based Edible Coating:** Protein based edible coatings are derived from animals and plants. The plant based protein edible coating material are milk protein casein, whey protein, zein (from maize), gluten (from wheat), soy protein etc. and the animal based protein are egg albumen, collagen etc., [10]. Protein based edible coating consist excellent barrier properties for aroma, oil and oxygen and it gives strength but it is not effective barrier for moisture [44, 59]. The reason of its excellent barrier property for oxygen is its tightly packed hydrogen bonded structure [13]. Protein based edible coating has good O_2 barrier property at low relative humidity. Protein based coating are not good barrier for water vapour due to its hydrophilic nature but it consist good organoleptic and mechanical properties [45].

•**Casein and Whey Protein:**

Casein is a milk protein, it is found in the form of micelles consisting all casein species. One micelle is containing 104 peptides; its molecular weight is about 105 kda. Casein is commonly used in preparation of emulsion because it is amphipathic in nature and containing hydrophilic and hydrophobic ends. Caseinate is the most common casein product; this is easily dissolved in water. Casein could be mostly used for edible coating because casein edible coatings are easy to form. This is because of their open secondary structure [55].

•**Zein:**

Zein proteins are obtained from maize, made from corn gluten flour. Zein protein is immiscible in water, it dissolved in aq. Alcohol, glycol esters. Zein protein having good film and coating producing, adhesive and binding properties. Corn-Zein protein is effective to prevent colour change, firmness, weight loss and it increases shelf life of fruits and vegetables, it has good barrier property to O_2. Corn-Zein coating and films having excellent barrier property to water vapour, about 800 times higher than other edible coatings and wrapping films. All properties of zein coatings depend upon coating thickness [70].

❖**Lipid Based Edible Coating:** The lipid based edible coatings are used from many years for preservation of fruits and vegetables. They provide shiny and glossy appearance to food. Most common lipid based coating materials are carnauba wax, bees wax, paraffin wax, and mineral or vegetable oil. Lipids are having good water barrier capacity [61]. Wax coatings contain very good moisture barrier properties as compare to other lipid based coating and non-lipid coating. Oil, fat and wax based coatings are not easily applied to the surface of fruits and vegetables because of its greasiness and thickness and it gives rancid flavour [83]. Combination of lipid and polysaccharides, protein are used in coating material improve their barrier properties. Most common lipid based coating materials are as follows-

➢ Waxes
➢ Lacs
➢ Fatty acids and alcohols
➢ Acetylated glycerides
➢ Cocoa-based material

This classification is based on the chemical nature of molecules such hydrocarbon chain, polar compound, chain length, no. of acetylation and unsaturation etc., [21].

❖**Composites Based Edible Coating:** Composites or Multicomponent films and coatings contain combination of protein, polysaccharides and lipid based material. This is used to enhance and improve mechanical strength, moisture and gas barrier properties of edible coatings and films [74, 83]. According to Han *et al.,* [37], composites are divided into two categories given below-

- Bilayer composites
- Conglomerates

The bilayer composites consist two layers combined with same or different coating materials such as protein/protein, polysaccharides/protein, lipid/lipid, lipid/polysaccharides etc., [30, 75, 105]. In this type of coating materials include Sucrose, propylene, monoglycerides, proteins, water, waxes and fatty acids [83].

Table No. -1, Edible coating of fruits and vegetables.

S.no	Fruit and vegetables	Used Edible coating	References
1.	Fresh-cut Apple	Sodium Alginate, Gellan Gum, Sunflower oil. Whey protein concentrate, WPI & WPP.	[80] [92]
2.	Blueberry	CMC, Chitosan, Monoglycerides, Sodium alginate, Calcium casienate.	[26]
3.	Tomato	*Aloe vera* gel	[6]
4.	Grapes	*Aloe vera* gel.	[15]
5.	Mango	Chitosan, *Aloe vera.* Tapico flour, Sago flour, Soy protein. Chitosan.	[16] [87] [1]
6.	Apple	Neem oil, Marigold flower extract, Guar gum & *Aloe vera.* Soybean gum, Paraffin wax, Jojoba oil & Arabic gum. WPC, SPI, Alginate, Carrageenan.	[17] [5] [31]
7.	Fresh-cut Pineapple	Pectin & Alginate.	[51]
8.	Strawberry	Sodium Alginate & Calcium Alginate gel. Arabic gum & Arjan gum Psyllium mucilage. Chitosan & Tragacenth. Linseed mucilage extract, Chitosan. Pectin, PVA, Starch, Soy protein, Gluten.	[57] [103] [35] [18] [106]
9.	Cantaloupe	*Aloe vera* gel. Pectin, Chitosan.	[108] [29]
10.	Banana	PVA, CMC, Tannin.	[50]
11.	Guava (fresh-cut)	*Aloe vera* juice.	[63]
13.	Pistachio	Chitosan and *Aloe vera* gel.	[98]
14.	Orange, Tomato, Mango, Papaya, Guava, Mushroom.	Veg. oil, Cellulose gum, Emulsifier.	[65]
15.	Potato	Chitosan, WPC, Coconut oil.	[85]
16.	Papaya	Chitosan, *Aloe vera,* Papaya leaf extract.	[53]
17.	Plum	CMC, Pectin.	[68]
18.	Sapota	*Aloe vera* juice,	[67]
19.	Pumpkin, Carrot, Radish, Cantaloupe, Cucumber.	Chitosan, calcium salt.	[94]
20.	Cucumber	Gum Arabic Powder. Beeswax, High Methoxy Pectin,	[39] [58]

		Sorbitol, Emulsifier. Chitosan, *Aloe vera*. Paraffin wax. Sodium Alginate, Starch, Glucose, Sucrose, Chitosan, Sorbitol, PVA.	[2] [7] [109]
21.	Apple, Potato, Cucumber.	Potato starch, Guar gum, Pea starch.	[32]

- **Plasticizers:** Plasticizers are mixed in solution of edible coating for increase mechanical property. These contain low molecular weight, it is mixed with protein coating material for enhance and change its structural ability [45, 91]. Water is also natural and effective plasticizer. The most common plasticizers added in coatings are Glycerol, fatty acids, Sorbitol, propylene glycol, sucrose polyethylene glycol and monoglycerides [45, 44, 91].

5. Applying Methods of Edible Coating:

Edible coatings should be applied on fruits and vegetables by different methods. These methods are-

a) Dipping
b) Brushing
c) Extrusion
d) Spraying
e) Solvent casting

The dipping method is used widely for applying edible coatings on fruits and vegetables, in this method Fruits and Vegetables are dipped in coating solution for 5-30 sec. [99]. It is easy to apply on mostly fruits. While Brushing method gives good result, Edible Coatings applied on generally, Beans and highly perishable Fruits and Vegetables such as strawberry, berries. Other three methods spraying, extrusion and solvent castings are also used in food industry. Extrusion method depends on thermoplastic properties of edible coatings; it is best technique for applying of EC for industrial purpose as compared to other methods [99].

➢ **Advantages:** Advantage of edible coatings are included [34, 65, 69].

o Edible coatings improve retention of acids, colour, flavour and sugar.
o Maintain quality of fruits and vegetables during storage.
o Reduce weight loss and firmness loss.
o Decrease polymer packaging and waste.
o Edible coatings can be consumed along with fruits and vegetables, they contain health beneficial nutrients.

➢ **Disadvantages:** Edible coatings have some disadvantages [27, 70].

o Thick coating can prohibit Oxygen exchange, causes off- flavour development.
o Edible coatings have good gas barrier properties which causes anaerobic respiration due to this normal ripening process is disturbed in fruits and vegetables.
o Some edible coatings are hygroscopic in nature, which helps to increase microbial growth.

6. Herbal Edible Coatings: A New Concept:

Herbal edible coating is a new technique for food industry. It is made from herbs or combination of other edible coatings and herbs, most common herbs used in Edible coatings are such as *Aloe vera* gel, Neem, Lemon grass, Rosemary, Tulsi and Turmeric. Herbs have antimicrobial properties, it consists vitamins, antioxidants and essential minerals [20].

As recently *Aloe vera* gel is widely used in coating on Fruits and Vegetables, because of its antimicrobial property, it also reduces loss of moisture and water. Ginger

essential oil, clove bud oil, turmeric neem extract, mint oil, other essential oil and extracts are also used in edible coating of Fruits and Vegetables. Herbs are natural source of vitamins, minerals, antioxidants, beneficial for health act as a nutraceutical and medicines [15, 54, 63].

7. Conclusion:

Edible coatings are used from many years for storage of Fruits and Vegetables in food industry. Different coating materials are used for coating such as hydrocolloids, waxes, protein. Researchers have produced new edible coatings; it is safe and environment friendly and safely eaten with Fruits and Vegetables. According to this review, Edible Coatings extends shelf life, reduce water and moisture loss, delayed ripening process and also prevent microbial growth specifically in fresh fruits and vegetables. In edible coating, recently a new concept has been introduced and it is herbal edible coating. It gives better results and health benefits. Herbal edible coated Fruits and Vegetables contained nutrients and act as medicines.

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