

A Critical Review on Use of Edible Coating to Enhance Shelf Life of Mango

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Authors' contributions

This work was carried out in collaboration among all authors. Author PK designed the study, wrote the protocol and first draft of the manuscript. Author NKA collected the materials of the study and precise the draft of the manuscript. Author SM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Mango is a crop of economic importance for its high export potentiality and usage as fresh and processed products of many kinds. However, increase its shelf life with maintaining postharvest quality and acceptability for long period is prime concerned since mango is a climacteric crop and cannot store for more than 5-7 days after ripening at ambient condition. Low temperature storage along with controlled atmospheric condition is being practised to keep fruits fresh. Controlled atmospheric storage reduces physiological processes, delayed ripening, but, can cause off flavour, internal tissue degradation, poor colouration and other physiological disorders. With the growing consciousness on bad effect of various chemical techniques and environmental hazards emphasizes a need to develop consumer friendly and environment friendly technology to increase shelf life of mango fruits with maintaining its quality and general acceptability. Use of edible coating is now becoming popular because it is a hazard free and environment friendly approach. It has

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tremendous potentiality to prolong shelf life of mango as whole fruit or fresh cut pieces. Generally, *Aloe vera* based edible coatings with chitosan have been studied for mango. The present review organised the various study exhaustively on different aspect of postharvest physiology of mango with use of edible coating which shall benefit the researchers for future study.

Keywords: Edible coating; mango; postharvest; quality; shelf life.

1. INTRODUCTION

Mango (*Mangifera indica* L.), the “King of Fruits” is a member of family Anacardiaceae plays an important role in balancing the diet of humans by providing energy [1], minerals and vitamins. It is a crop of excellence in India and many other countries with high economic value as fresh as well as processed products. However, it has a very short shelf life and reach to respiration peak of ripening process on 3rd or 4th day after harvesting at ambient temperature being a climacteric fruit [2]. The environmental conditions (high moisture), soft textures of fruits and susceptibility to various pathogenic infections are the limiting factors to its long storage [3] which generally ranges from 4 to 8 days at room temperature and 2-3 weeks at 13°C in cold storage [4] as well as affecting the quality and acceptability [5]. Farmers also practice to harvest green mature fruits because it takes 9-12 days [6] or 12-14 days [7] to ripen with good flavour, texture and colour characteristics at 25°C. A series of biochemical reactions or metabolic activities that cause chemical changes like increase in respiration and ethylene production; softening due to textural changes of polysaccharides, chlorophyll degradation by carotenoids biosynthesis; changes in carbohydrates or starch conversion into sugars, changes in organic acids, lipids, phenolics and volatile compounds which lead fruits to attain acceptable quality after maturity [6]. Several storage techniques including low temperature storage, Controlled-Atmosphere Storage (CAS), Modified Atmosphere Storage (MAS), hypobaric storage, irradiation methods, coatings solution and other treatments has been experimented to extend the shelf life of mango fruits [8,9]. Among them, refrigeration storage is considered as the most easy and economic as well as effective method for storage with maintaining postharvest quality [10], although, it is susceptible to chilling injury when stored for long time below 13°C [11]. Controlled atmosphere is a good method to delay ripening of mango fruits by reducing physico-chemical changes [12] but, there is a chance of poor colouration, undesirable flavour and physiological disorders [13]. Development of fungicide resistance by pathogens, residual

effect of harmful chemicals used against different biotic and abiotic stress and its growing health and environmental hazards emphasizes the need of development of an eco-friendly effective consumer bioagents [14,15,16] to extend shelf life with maintaining its quality. The use of edible coating on fruit surface is now becoming popular as it is free of health hazards and environment friendly. Edible coating has tremendous potentiality to prolong shelf life of mango as whole fruit or fresh cut fruit pieces. In this article, an exhaustive review has been made on the use of various edible coatings on different aspects of postharvest physiology of mango to make a future line of thoughts for prolonging shelf life and to boost up the mango based economy.

2. EDIBLE COATING (EC)

Edible films or coating is defined as a thin layer made up of material which provides a barrier to movement of moisture, oxygen and solutes and edible in nature. The material may be a complete food coating or can be disposed as a continuous layer between food components [17]. Edible films can be formed as food coatings and free-standing films, and have the potential to be used with food as gas aroma barrier [18]. The potential of an edible coating is to maintain the quality and extend shelf-life of fresh fruits and vegetables. It prevents microbial storage which is extremely important to perishable horticultural commodities.

3. USES OF EC

Most of natural products are hazard free and thus, are taken as alternative to chemical treatment for increasing shelf life by delaying ripening as well as reducing deterioration of postharvest quality of fruits [19]. Edible Coatings (EC) act as a barrier on the fruit surface and regulate moisture loss, internal gas atmosphere and metabolic processes which help to delay fruit ripening [20]. It also minimizes the size of non-biodegradable packaging materials which is creating environmental as well as health hazards. Few examples of commonly experimented natural EC are *Aloe vera* gel in nectarine [21], pectin in mango [22] and alginate in plum [23].

The effectiveness of EC application for protection of fruits and vegetables depends primarily on controlling the wettability of the coating solutions, which affects the thickness of the film [24]. Composition of EC must be wet and spread uniformly on the surface of fruits and become coating layer up on drying that has adequate adhesion, cohesion and durability to function properly [25]. It can also act as carriers for food additives such as antioxidants and antimicrobial agents onto the surface of the food.

Edible coatings help to increase the shelf life due to creation of Controlled Atmosphere (CA) by lowering O₂ level and higher CO₂ level [26]. However, CO₂ injury, increased ethanol production and flavour problems due to anaerobic respiration have been reported due to EC [27,28]. Concentrations of flavour volatiles and or flavour quality were affected by harvest maturity, environment of CA [26] and storage temperature [29]. Use of coatings in mangoes, has another advantage and has great choice as a coating material [30]. Apart from EC, low temperature storage, use of chemical treatment for delaying ripening, irradiation, heat treatment, packaging and shrink-wrapping are methods to increase their shelf life.

4. EFFECT OF EDIBLE COATING ON PHYSICO-CHEMICAL PROPERTIES OF MANGO

4.1 Effect of EC on Weight Loss of Mango Fruits

Loss of weight of fruits is a very important issue for increasing shelf life and over all acceptability of fruits. Gum arabic reduced weight loss in tomato [31], composite coating of gum Arabic with chitosan in banana [32] and chitosan with pectin in mango was studied [33]. Carnauba wax coating which created a modified atmosphere, restricted gas exchange and moisture loss may reduce weight loss in mango fruits [34]. Loss of weight occurs generally due to transpiration process but, it depends on the gradient of water vapour pressure difference between the surrounding atmosphere and fruit surface tissue. Edible coatings act as a barrier on the fruit surface, thereby reducing water transfer, moisture loss, sealing small wounds and thus, delaying weight loss. The irradiation increased degree of deacetylation and lowered down the molecular weight of chitosan which in turn

delayed internal changes of fruit that was not much delayed by unirradiated chitosan because it had less degree of deacetylation and high molecular weight [35,36].

Use of Primafresh C was found more effective than Primafresh 31 in reducing the fruit weight loss when applied at higher concentration (20%) and it was also examined that waxing had no effect on mesocarp chlorophyll, sugar or starch content [37].

Mango fruits cv. Palmer and Keitt showed non-significant effects in external colour parameters, but coatings affected internal colour parameters when fruits coated with 1% aqueous suspension of sucrose esters [7]. Fruits coated with beeswax (9%) resulted low weight loss with good external appearance [38].

Several studies on carnauba wax or beeswax coating [34,39,40,41,42,43,44] showed that wax coatings were effective in reducing water loss in mango and did not develop any off flavours [41] thus, were preferred by consumers over uncoated fruits. Waxing markedly reduces weight loss in mango [45]. In addition, fruit loss due to diseases and physiological disorders reduced when wax coated fungicide was treated. [46] also found that waxing of mango fruits immediately after hydro-heating prevented shriveling and maintained fruit finish. Wax treatment of harvested mangoes had a marked effect in retarding ripening (by 11 days), in delaying the onset of the over-ripe stage (by 9 days) as well as in reducing weight loss [47].

Aloe vera gel has recently drawn interest as potential edible coating substances in the food industry [48]. *Aloe vera* based edible coatings prevent moisture loss and keep fruits firm, control respiration rate, delay oxidative browning and reduce microorganism proliferation in sweet cherry, table grapes and nectarines [21,49,50]. In addition to the traditional role of edible coatings as a barrier to water loss and delaying fruit senescence, the new generation coatings are being designed for incorporation and/or controlled release of antioxidants, nutraceuticals, chemical additives and natural antimicrobial agents.

This positive effect in terms of reduction of moisture loss may be due to the hygroscopic properties of *Aloe* gel which is mostly composed of polysaccharide [51] effective as a barrier against moisture loss without incorporation of

lipid thus, preventing its external transferences [52]. No study has demonstrated the use of *Aloe vera* natural plant extract based on its antifungal properties on enhancement of shelf life and quality of mango fruits before decades and thus, [53] conducted a study and found that 50-75% *Aloe vera* gel was useful to reduce weight loss when storing at 13°C.

Plastic films with selective permeability to CO₂ and O₂ are utilized to increase shelf life of mango and other fruits. These films (polyethylene, polypropylene and various polymers [54,55]) produce a microclimate around the fruit surface by increasing CO₂ concentration which helps to reduce respiration rate and other metabolic activities which reduces weight loss of fruits [56].

Gum Arabic (a polysaccharide which is natural secretion from *Acacia* species) has good properties of film forming, emulsification and encapsulation and its coating along with natamycin retains the fruit weight by delaying ripening and extending the storage life [31,57]. While, gum Arabic coating supplemented with chitosan and pectin were found to reduce weight loss in mango [33] and in banana [32]. Carnauba wax in mango is effective to reduce weight loss may be due to creation of a modified atmosphere by restricting gas exchange and moisture [34]. Mango fruit coated with Gum arabic 10% and Chitosan 1% may form a thin layer on fresh fruit [58]. A smaller loss of fresh mass throughout the storage of 'Tommy Atkins' mangoes treated with the chitosan based coating (a mass loss of 3.28%, under coated with chitosan at 1% and 3.8% weight loss while the fruits are under control [59].

4.2 Effect of EC on Firmness of Mango Fruits

Ripening of mango fruit is accompanied by textural softening of tissues during storage. Several studies confirmed that edible coating retained high firmness in mango fruit [22,60,61]. It has been observed that combined treatment of gum arabic and chitosan effectively retained high firmness of banana fruits [32], gum arabic (10%) and natamycin in shiitake mushroom [57]. Cell turgidity, changes in cell structure and cell wall composition influenced textural properties [62] related to water loss affecting turgidity of fresh fruit [58]. Reduction of moisture loss of mango by GA (10%) and Chitosan (1%) coatings depends on their capacity to work as barriers and thus, retained high firmness. Degradation of cellular

material and pectin which are responsible for the cohesiveness of the fruit and the main components of the middle lamella as well as structural elements in the primary cell wall, results in textural softening of fruits [63] which may be related to the enzymatic hydrolysis of cell wall components.

The coated fruits had higher firmness (>150 kg force), lower pulp to peel ratios (<2.0) and acidity values when compared to control and chitosan-based coatings were found much superior in prolonging the shelf-life and quality of banana and mango [60].

Chitosan and gum arabic efficiently inhibited decay incidence and maintained high firmness of fruits and overall quality of mango fruit, but had no significant effect on ascorbic acid. Thus, combined application of gum arabic and chitosan coatings can be used for extending the shelf life and maintaining quality of mango fruit during cold storage [64]. Semperfresh, a mixture of esters of mono and di-glycerides with sucrose and carboxy methylcellulose decreased loss in fruit firmness of apple fruit for 25 days [65].

The galactomannan coating was efficient in reducing weight loss and delaying softening and thus in maintaining quality of 'Tommy Atkins' mangoes for a longer period of storage at ambient temperature (25°C) [66].

Aloe vera gel (1:1) resulted in increased lightness, whereas, Semperfresh and mango carnauba reduced skin lightness of the coated fruit as compared to the control. Semperfresh and *Aloe vera* gel (100%) exhibited delayed color development as compared to the uncoated fruit, which was more prominent from day 9 of the ripening period. All coatings delayed fruit color development and loss of fruit firmness as compared to the control except *Aloe vera* gel (1:1). The fruit coated with mango carnauba remained firmer than the fruit coated with any other coating. The interaction effect between edible coatings and ripening time on subjective fruit firmness was found to be significant [67]. *Aloe vera* gels maintain the texture of fruit efficiently by reducing α -galactosidase, polygalacturonase and pectinmethyl-esterase activities [68].

4.3 Effect of EC on Regulation of Ripening of Mango Fruits

The ripening process of mango fruit involves a series of biochemical reactions, resulting into

increased respiration, ethylene production, change in structural polysaccharides causing softening, degradation of chlorophyll, developing pigments by carotenoids biosynthesis, change in carbohydrates or starch conversion into sugars, organic acids, lipids, phenolics and volatile compounds, thus, leading to ripening of fruit with softening of texture to acceptable quality [6].

Hydroxypropyl methylcellulose (a polysaccharide) delay ripening of 'Tommy Atkins' mangoes [34]. Coating with hydroxypropyl methylcellulose and zein (a plant protein from maize) as effective treatment for delaying of softening, colour development as well as to delay ripening of mature green fruit by several days. Waxing retards ripening along with slower increase in Total Soluble Solids (TSS) and sugar content, greater retention of ascorbic acid and reduce respiration rate [42].

Fruits of mango CV Haden when coated with Semperfresh and *Aloe vera* showed delay in ripening for several days [4]. Polyamine coatings delayed ripening of 'Kensington Pride' mangoes without impairing fruit quality [69]. Starch, cellulose and chitosan-based coatings on Alphonso mangoes were found to be more effective for ripening delay along with reduction of fungal infections [60]. A number of other studies have also reported chitosan coatings to delay ripening of mangoes by several days [61,70,71,72]. Methylation of the polymer showed a higher resistance to CO₂ which helps to retard ripening of climacteric fruits [73].

Change in peel color was considerably retarded by 2% chitosan while, sensory qualities of the fruits at the ripe stage were not influenced by 1% chitosan, although, the pulp exhibited changes in ripening [74]. Higher and inappropriate composition of coating materials may cause odour of fermentation due to the modification of the internal oxygen and carbon dioxide composition of the fruits.

Unripe mature fruits coated with Tal-prolong (containing sucrose esters, glycerides and cellulose) delayed ripening by 4-5 days when they were stored under ambient conditions (28-32°C) for 18 days by dipping the fruits for 2 min in a 1% suspension before storage [75]. This treatment also reduced weight loss and resulted in delay in ripening of fruits with quality attributes (freshness, texture and taste) comparable to those untreated fruits; though they had a duller yellow skin colour and gave soft green fruits of

high acidity. Pro-Long, a similar to Semperfresh also causes delay in ripening and reduce water loss and respiration rate in 'Julie' mangoes [39].

4.4 Effect of EC on Soluble Solid Concentration (SSC)

Chitosan 1% and Gum Arabic (GA) 10% efficiently reduced the rapid changes in SSC (an important maturity index for obtaining good quality) during storage period. The ratio of sugar to acid in relation to SSC plays a significant role in the determination of stage of ripening and taste of the fruit. SSC generally increased with the storage time in nectarine [21], mango [5,76], shiitake mushroom treated with gum arabic and natamycin [57] and chitosan coated mango [60,33]. Breakdown of carbohydrate into simple sugar and glucose also increased the concentration of soluble solid [60]. During the ripening process, starch hydrolyzes into simple sugars, where glucose, fructose and sucrose are dominant in ripe fruits [77] and increased activities of sucrose synthase, invertase and amylase enzyme hydrolysed the starch to sucrose during ripening [78]. Edible coating created a semi permeable film on the fruit surface and modified the internal atmosphere by increasing CO₂ and decreasing O₂ production [33]. The low respiration rate reduces the use of metabolites, resulting in lower SSC consumption and slow conversion of carbohydrates to sugars. Lower SSC in mango fruit treated with GA 10% and Chitosan 1% might be due to delay in conversion of starch into sugars and lower SSC consumption due to suppression of respiration and metabolic activity, thereby, mango fruit treated with GA 10% and Chitosan 1% reduced changes in SSC and protected the fruit from quick deterioration during storage.

4.5 Effect of EC on Ascorbic Acid Content

Ascorbic acid content decreases with ripening though, edible coatings had no significant effect on ascorbic acid content of mango fruit during storage [42]. However, ascorbic acid is quite unstable mainly due to the activity of ascorbate oxidase enzyme and the reaction with oxygen in presence of heavy metal ions and light [79]. Therefore, EC treatments might be insufficient to prevent losses of ascorbic acid in mango fruits during storage. A sharp decrease in ascorbic acid was observed in fresh-cut and whole 'Ataulfo' mango during storage for 15 days [80], in 'Brokin', 'Julie' and 'Peter' mango varieties at 12

days storage in both control and chitosan treated mango throughout the storage period [61,81].

4.6 Effect of EC on Respiration and Ethylene Production

Edible coatings reduced respiration rate in mango fruit [22,60] by *Aloe vera* gel coating in nectarine [21] and chitosan plus gum arabic in banana [32]. The modified atmosphere created by the *Aloe vera* gel coating material retarded the ethylene production rate and respiration which is a good indicator of metabolic activity and signalling for possible shelf life, therefore, delaying ripening, chlorophyll degradation, anthocyanin accumulation and carotenoid synthesis thus, ultimately delaying colour change like in papaya fruit treated with *Aloe* gel (100%) [82]. Edible coating also imparted an attractive natural-looking sheen to table grapes [19], papaya [82] which was correlated to lower changes in both skin colour and dehydration.

Mango being a climacteric fruits, sudden increase in respiration and the burst of ethylene production is the major cause of short shelf life. Gum arabic (GA) 10% and Chitosan (CH) 1% treated fruits suppressed climacteric peak and small rise in ethylene production due to insufficient permeability and accumulation of carbon dioxide which reduced ethylene and respiration rate in banana [32] and in plum fruits by alginate coating [23]. Coating forms a semipermeable membrane around the fruits that modify the internal atmosphere, thus, delays metabolic activity and possibly reduced the ethylene production. The fruit coated with Semperfresh, *Aloe vera* gel (1:1) and *Aloe vera* gel (100%) did not show any significant difference in the respiration rate as compared to the uncoated fruit. However, the application of all edible coatings, especially mango carnauba, delayed the climacteric peak in the coated fruit. The interaction between various edible coatings and ripening time significantly affected the respiration rate during the fruit ripening period.

4.7 Effect of EC on Other Fruit Quality Parameters

The effect of polysaccharide coatings on quality of fresh cut mangoes was reported by [83]. Ripe mango fruits (cv. Tommy Atkins) when treated with chlorine dioxide, 2% calcium ascorbate and 0.5% N-acetyl-L-cysteine (antioxidants) or coating solutions of 1% carboxy-methylcellulose (CMC) and 0.5% carboxy-maltodextrin (CMM), it

was seen that CMM coating was rated as the highest than others for visual quality and flavour.

The effects of different composite coating formulations based on polysaccharides on maintaining quality and an extended shelf-life of mango at $27\pm 2^\circ\text{C}$ and compared with commercial Waxol-coated and uncoated fruits [60]. The polysaccharide-based coatings retarded colour development, lowered acidity and showed greater firmness values compared to Waxol and uncoated fruits. Coatings slow down the changes on pH and titratable acidity, effectively delaying fruit senescence because the chitosan film (semi-permeable) formed on the surface of the fruit might have modified the internal atmosphere i.e., the endogenous CO_2 and O_2 concentration of the fruit, thus retarding ripening [84,85].

Chitosan films have been found useful as an alternative to synthetic packaging films in the storage of freshly harvested mangoes considering biodegradable and eco-friendly nature of chitosan [70]. Although, control atmospheric storage has been shown to extend the shelf-life of mango [86,87], it is cost prohibitive. Modified atmosphere storage was also reported to slow mango ripening, but was often accompanied by high CO_2 and off flavor [88].

The properties of different edible coatings [aqueous mango carnauba (1:1 v/v), Semperfresh (0.6%) and *Aloe vera* gel (100%)] on mango fruit ripening and quality parameters including colour, firmness, soluble solids concentrations, total acidity, ascorbic acid, total carotenoids, fatty acids and aroma volatiles of mature green mango (Kensington Pride) [40]. Among them carnauba was found as effective in retarding fruit ripening, retaining fruit firmness and improving levels of fatty acids and aroma volatiles. Whereas, Semperfresh and *Aloe vera* gel (100%) reduced fruit aroma volatile development. Chitosan induces chitinase, a defense enzyme, which catalyzes the hydrolysis of chitin, a common component of fungal cell walls, thus also preventing the growth of fungi on the fruit [89].

Permeable coatings reduce fruit gas exchange and water loss [70]. Semperfresh coating on mango cv. Haden showed higher titratable acidity, firmness and green colour whereas weight loss, Total Soluble Solids and pH were lower compared with the uncoated fruits [4], but,

Semperfresh had no effect on decay development. 'Pro-Long', a similar edible coating to "Semperfresh", has been shown to delay ripening and reduce water loss in 'Julie' mangoes [39] and also resulted in good colour and uniform ripening after 20 days of storage at 18°C [7].

The mango fruit coated with 20% *Aloe vera* gel had longer storage life than the other treatments with chitosan and carnauba wax coating and was able to ripe normally at 25°C [90]. It was also reported that 20% *Aloe vera* gel could delay fruit weight loss, skin color changes, fruit firmness and titratable acidity changes as well as respiration rate of coated fruit in comparison to the other treatments.

4.8 Effect of EC on Incidence of Decay

Coating has the ability to prevent the growth of fungi in wide horticultural produces [19]. Postharvest diseases and fast rate of ripening are the main causes of mango fruit deterioration. Due to residual effect and other health hazards, several strategies by using natural bio-preservatives have been evaluated instead of fungicides to inhibit decay development and delay the ripening process of mango fruit. Chitosan has strong antimicrobial and antifungal properties which help to control postharvest diseases [91]. Chitosan combined with 1-methylcyclopropene treatment extended the storage life of 'Irwin' mango at 10°C up to 32 days [92]. Gum Arabic (GA) in combination with calcium chloride reduced decay incidence of mango fruit during storage [93]. Similarly, polysaccharide based treatment and carnauba wax coating reduced decay in 'Tommy Atkins' mango [34]. Being a component of fungal and green algae cell walls and the skeletal of invertebrates chitosan (β -1, 4-linked polymer of 2-acetamide-2-deoxy-D-glucan) gave the best result on decreasing anthracnose disease occurrence [94]. Mango fruits coated with 1.0% chitosan had the lowest disease occurrence, since partial deacetylation of chitin resulted in induction of plant-defense responses and inhibited growth of fungi [95]. Mango fruits coated with 0.25 and 0.50% chitosan had a storage life of 9 days. However, fruits dipped in hot water for a long period showed prolonged colour change in peel and flesh [96].

Edible coatings serve many functions for all types of food products. They improve the external and internal quality characteristics of diverse commodities including reduction in

dehydration and oxidation as well as the resulting undesirable visual changes in colour, flavour and texture. Waxes and other coatings delay ripening and senescence of fresh produce and can increase the microbial stability of lightly processed mango. Coatings show promise as environment-friendly quarantine treatments because, most coating materials are produced from renewable and edible resources, thus safe and are manufactured from waste products that represent disposal problems also for other industries. Fruits are often subjected to different levels of microbial deterioration in storage conditions, mainly due to phytopathogenic fungi, which usually infect the host through wounds sustained during harvesting, handling and/or processing [97]. As reported by [98], mainly fungal disease is controlled chemically, but the use of synthetic fungicides is limited due to undesirable aspects, including the toxicological hazard to human health and slow degradation periods, which could lead to environmental problems. Research and development effort is required too and develop edible films and coatings that have good packaging performance besides being economical. The taste, color, aroma and flavor were the best for starch coating as compared with others. The total soluble solids, total carotenoids and sugar contents were also high in starch-coated fruit (Langra and Samar Bahisht Chaunsa).

Aloe vera gel is a novel edible coating since beneficial effects of this gel to human health have been reported for many cases such as reduction of cholesterol and glyceride levels, reversion of extant atheromatous cardiovascular problem and stimulation of cell regeneration as documented in Table 1. As recently *Aloe vera* gel is extensively used in coating on fruits because of its antimicrobial property, it also reduces loss of moisture and water. Herbs are natural source of vitamins, minerals, antioxidants, beneficial for health act as a nutraceutical and medicines [99,100].

In case of mango, carnauba wax or bee wax, different polysaccharide materials like Hydroxypropyl methyl cellulose, composite coating materials, chitin, chitosan, *Aloe vera* gel etc. have been found to influence the shelf-life, colour and different physico-chemical properties of the mango fruits. The impact of edible coating produced from polysaccharide and carnauba wax on mango fruit was studied by different researchers [102] and outcomes indicated that polysaccharide was less permeable to

Table 1. Classes of components of *Aloe vera* gel

Class	Compounds
Anthraquinones	Aloin/Barb-aloin, Isobarba-aloin, Aloe-emodin, Emodin, Aloetic acid, Ester of cinnamic acid, Anthranol, Chrysophanic acid, Resistannol Anthracene and Ethereal oil.
Vitamins	B1, B2,B6, A-Tocopherol, β -Carotene, Choline, Folic acid and Ascorbic acid
Enzymes	Cyclo-oxygenase, Oxidase, Amylase, Catalase, Lipase, Alkaline-phosphatase and Carboxy-peptidase
Miscellaneous	Cholesterol, Steroids, Tricylglycerides, β - Sitosterol, Lignins, Uric Acid, Gibberellin, Lectin like substances, Salicylic Acid and Arachidonic Acid
Saccharides	Mannose, Glucose, L-Rhamnose and Aldo-pentose
Carbohydrates	<i>Cellulose</i> , acetylated mannan, Arabinogalactan, Xylan, Pure mannan, pectic substance, glucomannan, Glucogalc-tomannan and Galactan
Inorganic Compunds	Calcium, Sodium, Chlorine, Manganese, Zinc, Chromium, Copper, Magnesium and Iron
Non-essential Amino acids	Histidine, Arginine, Hydroxyproline, Aspartic Acid, Glutamic Acid, Proline, Glycine and Alanine
Essential Amino acids	Lysine, Threonine, Valine, Leucine, Iso-leucine, Phenyl-alanine and Methionine

(Source: Serrano et al., 2006) [101]

respiratory gas such as O₂. Both coatings delayed ripening and improved appearance. Therefore it can be concluded that shelf life was extended by both coatings. These findings from the study can be exploited for enhancing the storage life of fruits with maintaining its physico-chemical quality and thus, enhancing its marketability and profitability.

5. CONCLUSION

Mango is one of the important economic horticultural products getting high export value. Thus, enhancement of postharvest shelf life of fresh mango is a great concerned for the growers and traders. Chemical treatments for increasing postharvest life is useful, but, threatening a hazard to health and environment. Edible coating treatments are found to be very effective to increase shelf life of mango like other fruits in fresh condition. Among these edible coating methods various researchers found that chitosan based coating with methyl cellulose, supplemented with *Aloe vera* plant extract are very potential not only to enhance shelf life but also to maintain the quality of mango. The chitosan treated mango fruits showed best behaviour throughout storage period with minimum loss of weight, shrivel, increased ascorbic acid content and able to conserve better sensory characteristics. Irradiated chitosan coating also protected the mango fruits from disease attack. This study recommends chitosan

as the best edible coating material along with *Aloe vera* gel that is very effective in improving the overall quality of mango fruits. It emerged as an effective green technology alternate to synthetic chemical treatments. It also preserves the food value of mango fresh or cut pieces beneficial to human health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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