ISSN Print: 2664-844X
ISSN Online: 2664-8458
IJAFS 2025; 7(1): 109-113
www.agriculturaljournals.com
Received: 02-11-2024
Accepted: 07-12-2024

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Aloe vera: A novel natural edible coating for post-harvest application on fruits and vegetables: A review

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DOI: https://doi.org/10.33545/2664844X.2025.v7.i1b.246

Abstract
Now a days, fruits and vegetables have high demand in market because of its nutritional value but they are highly perishable as they contain 80-90% water by weight. About 30% fruits and vegetables are affected by insects, microorganisams during transportation and storage. Therefore preservation of fruits and vegetables is a big challenge for the present world to counteract that edible coating is a best option as an effective method. Edible coating can be defined as thin layer of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings to provide a barrier to moisture, oxygen and solute movement for the food commodity. It extend the shelf life of fresh fruits and vegetables by reducing moisture and solute migration, gas exchange, respiration and oxidative reaction rates as well as by reducing or even suppressing physiological disorders. This review article revealing the *Aloe vera* gel preparation, compostion, mechanism, as well as advantageous effect of natural edible coating such as *Aloe vera* gel on physico-chemical properties of fruits and vegetables.

Keywords: Fruits and vegetables, nutritional value, perishability, water content, preservation

Introduction
India is the 2nd largest producer of fruits and vegetable in world among that India witnessed nearly 4.6 to 15.9% losses in fruit and vegetables annually, and nearly 33% of post-harvest losses due improper handling, storage facility as well as microorganism's spoilage. The post-harvest losses annually affect the livelihoods of nearly one-third of the population, the majority of whom are small holder farmers. Reducing these losses can not only improve farmers' incomes but could also encourage more consumption of this highly nutritious fruit and vegetables in a region where per capita consumption is only half of the recommended level.

Consumers around the world demand for food of high-quality, without chemical preservatives, and an extended shelf life. Therefore, an increased effort has been made to develop new natural preservatives and antimicrobials (Lin *et al*., 2007) [14]. Many storage techniques have been developed to extend the marketing distances and holding periods for commodities after harvest. Different preservation methodologies have been developed. One method of extending post-harvest shelf life is the use of the edible coatings (Baldwin *et al*., 1995) [3]. Edible films and coatings have received considerable attention in recent years because of their advantages including use as edible packaging materials over synthetic films. Therefore preservation of fruits and vegetables is a big challenge for the present world to counteract that edible coating is a best option as an effective method.

Edible coating
Edible coating can be defined as thin layer of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings to provide a barrier to moisture, oxygen and solute movement for the food commodity.

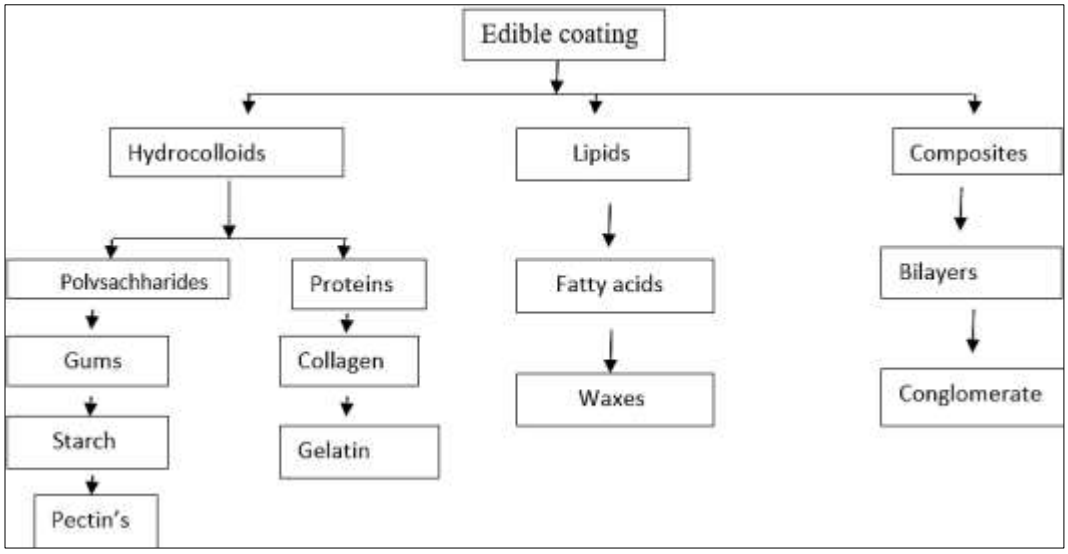
It extend the shelf life of fresh fruits and vegetables by reducing moisture and solute migration, gas exchange, respiration and oxidative reaction rates as well as by reducing or even suppressing physiological disorders.

Action of edible coatings
Fruits and vegetables continue to respire even after harvest and use up all the oxygen within

the produce and carbon dioxide accumulates within the produce because it cannot escape as easily through coating. Eventually the fruit and vegetables will shift to partial anaerobic respiration that requires less oxygen (1-3%). With less oxygen, the production of ethylene is disrupted and physiological loss of water is minimized. Thus, the fruits and vegetables remain firm, fresh and nutritious for longer period and their shelf life almost doubles.

Different types of edible coating

Components used for the preparation of edible films/coatings can be classified into three categories: hydrocolloids (Such as proteins and polysaccharides), lipids (Such as fatty acids, acylglycerol, waxes) and composites (Donhowe and Fennema, 1993) [7].



- **Polysaccharides:** used for edible films or coatings include cellulose, starch derivatives, pectin derivatives, seaweed extracts, exudate gums, microbial fermentation gums and chitosan (Krochta and Mulder-Johnson, 1997) [13]. Polysaccharides are generally very hydrophilic resulting in poor water vapor and gas barrier properties. Although coatings by polysaccharide polymers may not provide a good water vapor barrier, these coatings can act as sacrificing agents retarding moisture loss from food products (Kester and Fennema, 1986) [12].
- **Lipid films:** Lipid compounds utilized as protective coating consist of acetylated monoglycerides, natural wax, and surfactants. The most effective lipid substances are paraffin wax and beewax. The primarily function of a lipid coating is to block transport of moisture due to their relative low polarity.

Paraffin wax is permitted for use on raw fruit and vegetable and cheese. Carnauba wax is an exudate from palm tree leaves (*Copoernica cerifera*). Beewax (White wax) is produced from honeybees. Candelilla is obtained from candelilla plant. Mineral oil consists of a mixture of liquid paraffin and naphtheric hydrocarbon (Hernandez, 1994) [11].

Composites: Consisting of a blend of polysaccharides, protein, and/or lipids. This approach enables one to utilize the distinct functional characteristics of each class of film former (Kester and Fennema, 1986) [12].

Composites are divided into two categories

Bilayer composites b. Conglomerates

Properities of edible coating

- The coating should be water resistant so that it remains intact and covers a product adequately, when applied.
- It should not deplete oxygen or build up excessive carbon dioxide. A minimum of 1-3% oxygen is required around a commodity to avoid a shift from aerobic to anaerobic respiration.
- Improve appearance, maintain structural integrity, imrove mechanical properties, carry active agents (Antioxidants, vitamins. etc.,) and retain volatile compounds
- It should be easily emulsifiable, non-sticky or should not be tacky, and have eual drying performance.

Herbal edible coatings

Herbal edible coating is 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. 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.

Fruits which has been coated are:

Orange, Apple, grape fruit, cherry, lemon, strawberry, Mango, peach etc. and fresh-cut apple, fresh-cut peach, fresh-cut pear.

Aloe vera

Botanically *Aloe vera* L. originated in South Africa and South America, belongs to Family Liliaceae. More than 300 species are available in Aloe genus, traditionally being used therapeutically from roman times. The word Aloe derived from the word Arabic "Alloeh" or the Hebrew "Halal" meaning "bitter, shinny substance". *Aloe vera* is known as "plant of immortality" by the Egyptians due to its beneficial effect on human health.

3.1 Constituents of *Aloe vera* gel: *Aloe vera* gel contains 2 parts which contain anthraquinone glycosides, aloin, aloe-emodin, barbaloin and soft, colourless innenr gel parenchyma.

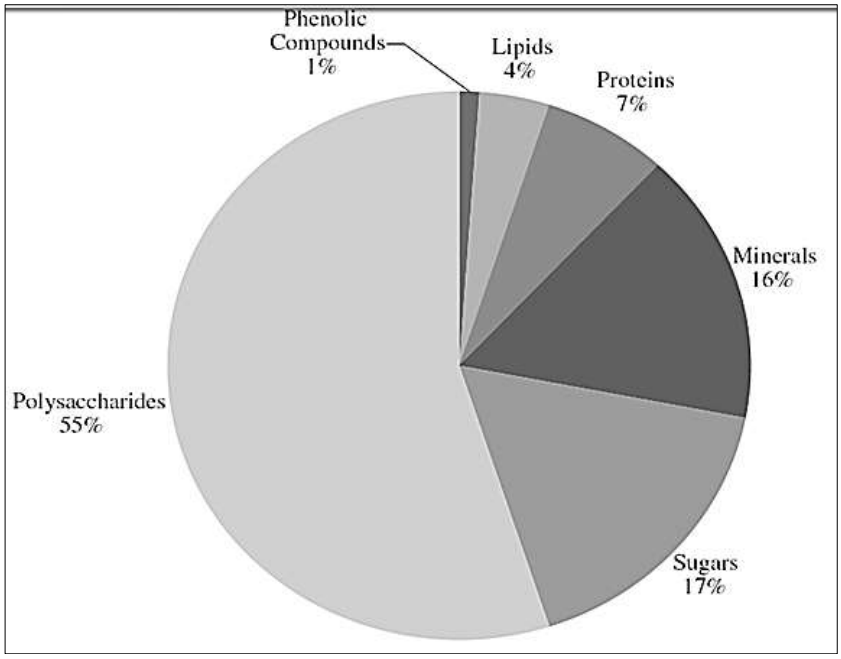


Fig 1: Chemical composition of aloe vera gel (on dry weight basis)

Preparation of *Aloe vera* gel

Harvest mature sound, undamged, mold/ rot free and matured (3-4 years) leaves in order to keep all the ingredients in full concentrations. wash with mild chlorinesolution (25%) then separate gel matrix from outer cortex of leaf later grind the colorless hydro-parenchyma in blender or commercial high speed tissue crusher at room temperature (25 ^{0}C). Filter to remove the fibers and to obtain fresh *Aloe vera* gel. To this add Ascorbic acid (1.9-2.0 g/L) to avoid browning reaction, to improve the flavour of *Aloe vera* gel juice and to stabilize the juice and also add citric acid (4.5-4.6 g/L) to maintain pH at 4. Pasteurize at 70 ^{0}C FOR 45 for 45 min or @ 85-95 ^{0}C for 1-2 min. the juice is flash cooled to 5 ^{0}C or below within 10-15 sec. This is a crucial step to preserve biological activity of the *Aloe vera* gel. To this add 1% commercial gelling agent to improve viscosity & coating efficiency. Stored in amber colored bottle mainly to prevent oxidation.

***Aloe vera* Gel: A Promising Alternative to Synthetic Preservative**

A section of unscrupulous traders use carbide in fruits like bananas, pineapples, oranges, grapes, apricots, papayas, etc. to keep them fresh. They also use textile dye in papaya, pomegranate and other fruits. Harmful plant growth hormones and chemicals are also indiscriminately used in fruit orchards. to ripen faster, papaya fruits are dipped into calcium carbide and ethephone. These chemicals are highly toxic and pose great risk to consumers health. To avoid these problems *Aloe vera* is an edible, invisible, odorless and does not affect the taste of fruits and vegetables on which it is applied. It also poses no risk to human health. It holds the potentiality to preserve fruits effectively due to its anti-microbial action. By this way we can say that *Aloe vera* is a promising alternative to synthetic preservative.

Antimicrobial activity of *Aloe vera* gel: An antimicrobial is a substance that kills or inhibits the growth of microbes such as bacteria fungi, viruses, or parasites. Habeeb *et al*. (2007) [9] found that *A. vera* gel has inhibited the growth of both gram positive and gram negative bacteria Aloe gel composed of a wide range of constituents such as Anthraquinones presented antimicrobial activity against *Staphylococcus aureus* strains and against *Escherichia coli*, through inhibition of solute transport in membranes (Hamman, 2008 & Lone *et al*., 2009) [10, 15]. Emodine has been reported to be effective against several gram positive bacteria. According to Shelton *et al*. (1991) [20] *Aloe vera* gel showed good antibacterial activity against some food borne pathogenic microorganisms such as *Bacillus cereus*, *Salmonella typhimurium*, *Escherichia coli*, *Klebsialla pneumonia* etc.

Effect of *Aloe vera* gel coating on physico-chemical properties of fruit

Weight loss

Weight loss mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration. The rate at which water is lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere. Aloe gel based edible coating act as barrier, thereby restricting water transfer and protecting fruit skin from mechanical injuries (Vogler *et al*., 1999) [22]. An experiment was conducted by (Tripathi and Dubey, 2004) [21] to maintain quality and safety of table grapes by coating with *Aloe vera* gel in cold storage (1°C, 95%). Weight loss increased during cold storage and it was significantly greater in control (uncoated fruits) than in *Aloe*-coated grapes.

Aloe vera gel (100%) has been used to preserve papaya fruit at room temperature 25 °C-29 °C and 82-84% RH. All samples demonstrated a gradual loss of weight during storage. Throughout storage, the weight loss of uncoated fruit (Sample) was significantly greater than that of Aloe gel coated fruit. At the end of the storage, uncoated papaya showed 22.5% loss in weight, whereas the weight losses of

samples coated with *Aloe vera* gel was 7.93% (Brishti *et al*., 2013) [4].

Total Soluble Solid, Titrable Acidity and Ascorbic Acid

Fruits are essential for the proper maintenance of human health. Fruits are foods rich in vitamins, minerals and supply arrays of colors, flavor, texture and bulkiness to the pleasure of eating. (Tripathi and Dubey, 2004) [21] Reported that *A. vera* led to a lower increase in TSS (Total Soluble Solid) and greater TA content (Titrable Acidity) retention of coated berries, which shows that uncoated fruits presented a more pronounced maturation development than coated berries during storage periods (1 °C, 95% RH+ 4 days at 20 °C, 90% RH).

In case of Aloe coated and uncoated oranges (12 ºC, 96-98%RH), there were no significant differences in TSS and TA content of fruits during storage periods. The value of ascorbic acid content for coated oranges was found to be higher than that of uncoated fruits (Arowora *et al*., 2013) [2]. Brishti *et al*. (2013) [4] found that ascorbic acid content was higher in Aloe coated papaya fruits (86.55 mg) than the control fruits (61.10 mg) during the storage period at temperatures 25 °C-29 °C and 82-84% RH.

Respiration rate

It is known that the environmental temperature affects the fruit respiration and the respiration affects the fruit temperature in return (Luo *et al*., 2001) [16]. When the temperature around the fruit rises, the respiration increases which leads to the increase of the temperature inside the fruit. The lower the respiration rate during storage the higher the shelf life of fruits and vice versa. The *Aloe vera* gel coating has significantly reduced the breathing rate. According to Ahmed *et al*. (2009) [1] 'Arctic Snow' nectarines was treated with Aloe gel and stored at 20±1 °C to evaluate the ripening and quality attributes. Initially, *Aloe vera* gel coated and uncoated fruit did not exhibit any significant change in respiration rate. Later on, the control fruit's respiration rate increased more rapidly and exhibited a 41% higher respiration rate compared to the *Aloe vera* gel coated fruit.

Firmness

Texture is a critical quality attribute in the consumer acceptability of fresh fruit and vegetables. The rate and extension of firmness loss during storage are the main factors determining fruit quality and postharvest shelf life. Fruits softening considerably occur as a result of degradation of the middle lamella of cell wall. Changes in cell wall structure and in their composition is mainly due to joint action of enzymes hydrolases, particularly polygalacturonase (PG), pectinestarage (PE),β-Galactosidase (β-Gal), pectate lyase (PL) and cellulose (Cel).

Aloe treatment significantly reduced the firmness losses of table grapes during cold storage (1 °C, 95% RH) whereas losses of >50% were detected in control grapes after 21 days of cold storage plus 4 days at 20 °C. This may be due to the effect of *A. vera* gel on the reduction of *â*-galactosidase, polygalacturonase, and pectinmethyl-esterase activities (Nunan *et al*., 1998) [18].

Color: Visual assessment is the first impression and a key feature in the choice of fruits. Color is one of the most important visual attributes of fruits. According to Ergun *et al* (2012) [8], *Aloe vera* gel treatment delayed the green color loss on the fruit skin of apples stored at 2 °C for 6 months. Skin color of table grapes showed lower increases in Aloe treated than in control (Untreated) fruits. Table grapes are rich in anthocyanin compounds, which account for their red color. The ripening process of table grapes has been correlated to the anthocyanin content (Cantos *et al*., 2002) [5]. At the end of cold storage (1 °C, 95% RH), control fruits exhibited a redder and darker color than *Aloe*-treated ones, showing the aspect of overripe fruit, which is considered to be detrimental to color quality (Tripathi and Dubey, 2004) [21].

The modified atmosphere created by the *Aloe vera* gel coating material retarded the ethylene production rate, therefore, delaying ripening, chlorophyll degradation, anthocyanin accumulation and carotenoid synthesis thus ultimately delaying color change of fruits (Carrillo *et al*., 2000) [6].

Decay Percentage

Decay percentage was used to observe the effectiveness of coated material on fruit in retarding fruit disease. In case of *Aloe vera* coated papaya fruits, no disease signs were observed until 1 week after the beginning of the storage period. At the end of the storage period, 100% disease incidence was observed in uncoated fruits, whereas for Aloe gel coated fruits disease incidence was only 27%. This was due to the anti-microbial potentiality of coated materials which has been discussed earlier (Brishti *et al*., 2013) [4].

Aloe vera gel was successful in reducing microorganism proliferation in table grape, the effect being higher for yeast and molds than for mesophillic aerobics (Tripathi and Dubey, 2004) [21]. Interestingly, the *Aloe vera* gel coating was effective in controlling microbial growth of 'Starking' cherry and 'Crimson' table grape without incorporation of other antimicrobial compounds such as garlic oil, potassium sorbate and nisin to increase the activity. (Pranoto *et al*., 2005) [19].

Overall appearance

Overall appearance is the first impression and a key feature in the choice of fruits (Tripathi and Dubey, 2004) [21]. Found that *Aloe vera* coated table grapes (1 °C, 95% RH+ 4 days at 20 °C, 90% RH) looked shiny and attractive. The coated fruits did not produce any bad odor or off-flavor. According to the judging panel, cherry fruit coated with *Aloe vera* gel (16 days 1 °C + 2 days at 20 °C) had a better appearance than the control fruits. Control cherry fruits showed severe symptoms of dehydration and browning during storage periods. None of the judges detected the appearance of off-flavors or aromas in cherries coated with *Aloe vera* gel (Martinez *et al*., 2006) [17].

Conclusion

Aloe vera gel is an appropriate alternative to the conventional wax/other coatings with incorporated fungicides. Having natural biocidal activity, it is effective against the fruit spoiling fungi. Reduces the PLW of fruits to a greater extent due to hygroscopic nature of *acemannan*. Retards the ripening process by creation of modified atmosphere around the fruit surface as well as retains the firmness of many fruits due to its activity against cell wall degrading enzymes. *Aloe vera* gel-based coating as a

relatively convenient and safe measure, is more and more concerned in food industry in recent years. Another advantage of this coating is totally harmless to the environment.

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