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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 2746-2752

www.thepharmajournal.com
Received: 14-04-2022
Accepted: 19-06-2022

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Effect of hydroxypropyl methylcellulose and methylcellulose-based edible coatings on storage life and quality of horticultural crops: Review

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Abstract
Nowadays fruits and vegetables are extremely demanded within the market owning to their nutritionary worth. Fruits and vegetables have short shelf life due to their perishable nature. About 30% of fruits and vegetables are affected or damaged by insects, microorganisms, pre and post-harvesting conditions throughout transport and preservation. The edible coating is an efficient method to resolve this problem. Hydroxypropyl methylcellulose (HPMC) and Methylcellulose (MC) are principally accustomed to increasing fruit gloss and extending the shelf life of horticultural crops. HPMC and MC delay ripening, decrease the rate of respiration, have barrier properties, and are environment friendly. Application of the semipermeable edible coating like HPMC and MC reduces moisture loss which increases the storage life of the horticultural commodity and reduces postharvest decay of fruits, vegetables, and ornamental. This review article explains HPMC and MC application for maintaining the post-harvest life of horticultural crops.

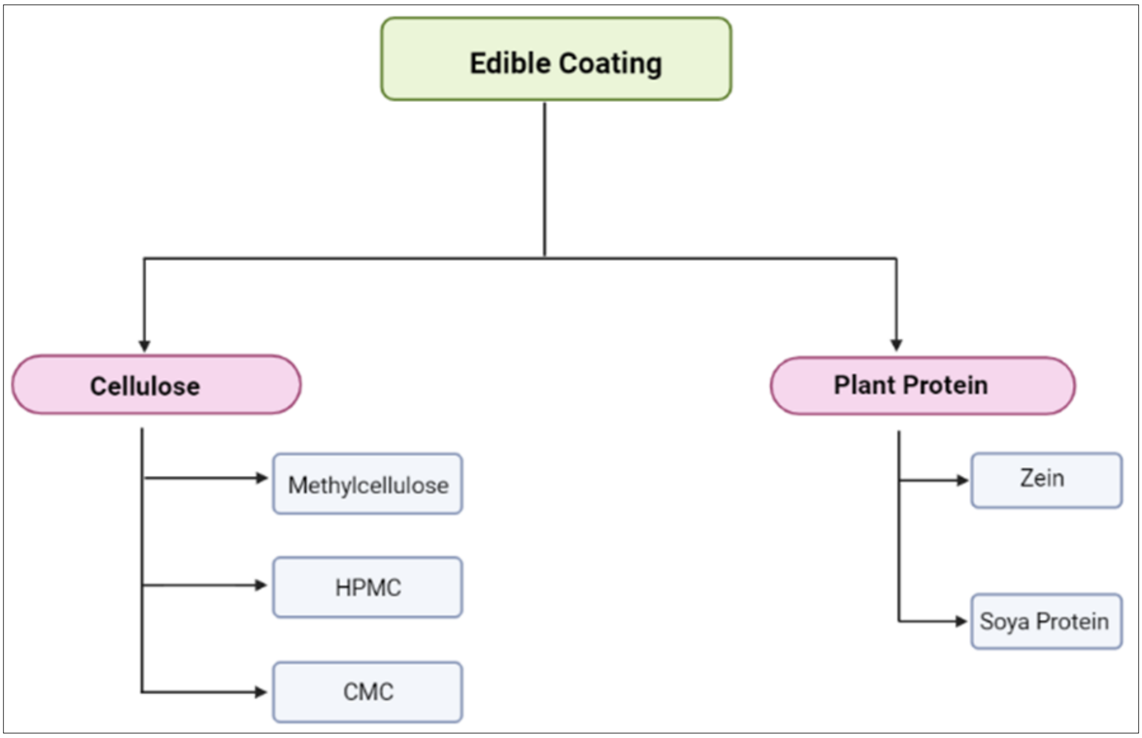
Keywords: Edible coating, hydroxypropyl methylcellulose, methyl cellulose, storage, shelf-life

1. Introduction

Fruits and vegetables are crucial components of a daily diet and have been increasingly popular among the general public in recent years. They are a storehouse of nutrients that are quickly destroyed by biotic and abiotic stresses, including vitamins, critical minerals, antioxidants, bio-flavonoids, dietary fibres, and flavouring compounds. Since fruits and vegetables are highly perishable, there are significant losses following harvest from microbes, insects, respiration, and transpiration. The internal elements are the species, cultivar, and its growth stage, whereas the external factors are the atmospheric composition, such as the ratios of oxygen, carbon dioxide, and ethylene, temperature, and stress factors.

Edible coatings and films can be applied directly to the surface of fruits, vegetables, and other food products, whereas edible film is utilised as a packaging material for wrapping (Aguirre-Joya *et al*., 2018) [1]. To achieve a thin protective layer, the coating materials could be sprayed or dipped onto the food product (Yousuf *et al*., 2018; Thakur *et al*., 2019) [66, 57]. Edible coating is made of non-toxic, biodegradable ingredients. The application of the biopolymers-based edible coating on food products serves as a barrier layer against solute exchange, water migration, aroma changes, and gas diffusion (Sabbah *et al*., 2019, Krge *et al*., 2020) [53, 23]. Various forms of biopolymer matrix, including polysaccharides, proteins, lipids, and composite materials, are used to create edible materials.

In the food processing industry, edible coating/film offers a stable quality for food products with market safety, nutritional value, and an affordable cost of manufacturing (Bhardwaj *et al*., 2019) [6]. It keeps the food products' quality standards, appearance, and shelf life intact. Due to its potential barrier properties, (fruits, vegetables, baked goods, dairy products, etc.) regulate the enzymatic activity, and protect against moisture and gas transport, lipid oxidation, and organismal spoilage.



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Maintenance of fruits and vegetable quality has been achieved by using some edible coatings supported by hydrocolloids (gums), like chitosan, MC, and HPMC and alginate (Valero *et al*., 2013) [62]. Edible coatings such as HPMC and methylcellulsoe act as physical barriers on the fruits and vegetables surface decreasing water vapor, respiration rate and, transpiration. HPMC is non-ionic water soluble supermolecule, is capable to form gel on heating (Y. Yoguchi *et al*., 1995) [67]. The different types of HPMC are found in the market, which contain different viscosity and different molecular weight. Edible coating such as HPMC materials usually created of polysaccharides, proteins and lipids (Pascall *et al*., 2013) [45]. HPMC and MC provide shiny and gloss appearance of horticultural crops. Hydroxypropyl methyl is approved as a direct artificial additive for the aim of film former, stabilizer, thickener and suspending agent. Methylcellulose it contains moderately low oxygen porosity. Methyl cellulose and HPC is mostly transparent, tasteless and odorless. Methyl cellulose and is thermo reversible gels which melt on heating (William. 2006) [24]. MC decreases polymer packaging and waste. Methylcellulose can be consumed together with fruits and vegetables, they contain health beneficial nutrients. The E number of methyl cellulose as food additive is E461. Methylcellulose as a gel, has the distinctive property of setting once hot and melting once cold (Blumenthal *et al*., 2004) [7]. MC improves retention of acids, colour, flavor, and sugar. This review article covers the use of HPMC and MC to extend the post-harvest shelf life of horticultural crops.

2. Post-harvest application of HPMC and MC

Post-harvest application of HPMC has been tested on several crops plum, apples, mandarin, citrus, and rose. Navarro-Tarazaga *et al.* (2011) [40] investigated on post-harvest application of HPMC and lipids has been shown to reduces weight loss and retains the firmness of different citrus fruit cultivars. Likewise, (Pe´rez-Gago *et al*., 2002) [46] reported that edible coating creates creation of a semipermeable barrier to gas exchange and water vapor in fruits and vegetables. HPMC and MC reduces respiration rate and moisture loss, delays produce senescence. Similarly, (Valencia Chamorro *et al*., 2008) [58] reported that the water vapor permeability (WVP) of HPMC- lipid films the addition of food preservatives. Skin firmness decreased very rapidly in the case of control fruits as compared to coated fruits. The HPMC- plasticizer phase consisted of three elements HPMC to at least one-half alcohol (dry basis) and this quantitative relation was unbroken constant throughout the study. (Maftoonazad *et al*., 2008) [30] reported methyl cellulose decreases transpiration and respiration rates as a result of coatings being considered responsible for the preservation of quality and increasing shelf life of peaches. Likewise, (Krochta. 2008) [39] investigated coatings containing protein or polysaccharides alone do not act as a barrier. Similarly, (Guerra *et al*., 2009) [33] reported that storing plums at 0-1ºC and 90-95% relative humidity will extend the postharvest life of fruits.

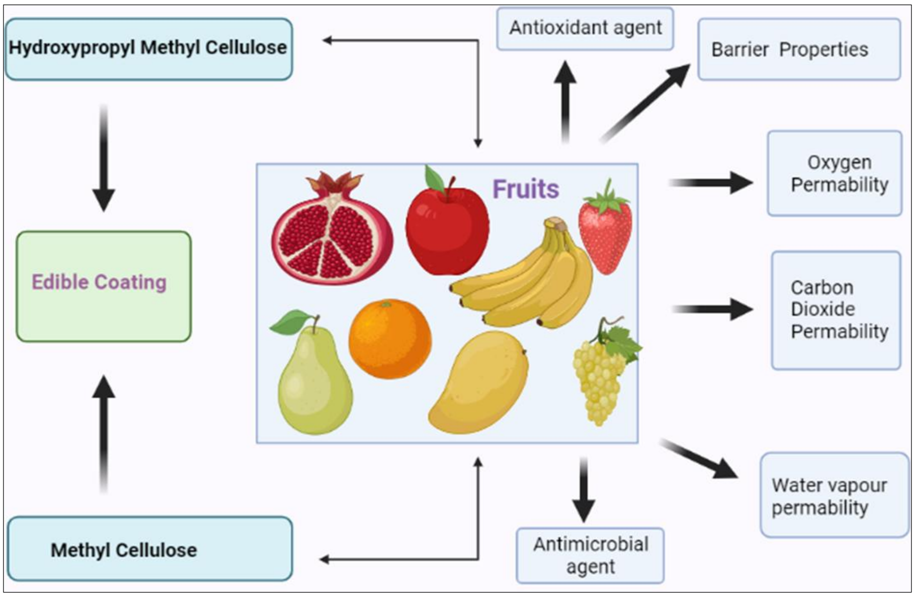

Table 1: Post-Harvest Application of HPMC in Fruits

Crop	Conc.	Effect of Post-Harvest application	Reference
Citrus (*Citrus limon*)	HPMC (5%)	Control Penicillium molds	Valencia Chamorro *et al.* (2008) [58]
Mango (*Mangifera indica*)	HPMC (1%)	Delay of fruit ripening	Baldwin EA *et al.* (1999) [5]
Plum (*Prunus domestica*)	HPMC (1%)	Improves the moisture barrier	M. B. Perez-Gago *et al.* (2003) [31]

Table 2: Post-Harvest Application of MC in fruits

Crop	Conc.	Effect of Post-Harvest application	Reference
Apricot (*Armeniaca vulgaris* Lam.)	MC (3%)	Improved the fruit quality and decreases in water and Vitamin C loss during storage	Ayranci and Tunc (2004) [3]
Beans (*Phaseolus* spp)	MC (3%)	Decrease of weight loss	Ayranci and Tunc (1997) [3]
Cherry Tomato (*Solanum lycopersicum var. cerasiforme*)	MC (3%)	Extended the postharvest life by the reducing of gray mould.	Fagundes *et al.* (2014) [15]
Green Peppers (*Capsicum annuum*)	MC (1%)	Improved the fruit quality and decreases in water and Vitamin C loss during storage	Ayranci and Tunc (2004) [3]
Sweet Cherry (*Prunus avium*)	MC (1%)	Improved fruit quality and bioactive compounds during storage	Díaz-Mula *et al.* (2012) [11]
Strawberry (*Fragaria* × *ananassa*)	MC (1%)	Delayed in Senescence	Vargas *et al.* (2006b) [63]

3. Response of HPMC and MC on important horticultural crops

3.1 Apricot
In apricots, postharvest application of MC improves fruit quality and reduces water and vitamin C loss during storage (Ayranci and Tunc., 2004) [3]; similarly, MC combined with Stearic acid considerably reduces water loss during storage (Ayranci and Tunc., 2004) [3].

3.2 Avocado
In avocados, postharvest application of MC with a mixture of glycerol dramatically enhanced shelf-life reduced color changes in skin and flesh, and delayed senescence (Maftoonazard and Ramaswamy 2005) [29].

3.3 Cherry Tomato
In Cherry tomatoes, postharvest application of HPMC with a combination of Zein significantly delays color changes throughout storage at 20 °C by making a modified atmosphere in the fruit (Zhuang *et al*., 2003) [68].
Similarly, at 20 °C, postharvest application of HPMC with a combination of beeswax and sodium benzoate effectively inhibits the Alternaria black spot (Fagundes *et al*., 2013) [14], HPMC+ Beeswax, on the other hand, maintains firmness for a long time, minimizes weight loss, and maintains quality features (Fagundes *et al*., 2015) [16].

3.4 Citrus
In citrus, Postharvest application of HPMC to 'Ortanique' and 'Chemenules' mandarins considerably minimizes weight loss (Valencia-Chamorro *et al*., 2010) [60]. HPMC, on the other hand, creates a consistent film and coating that increases the shelf life of citrus fruit by minimizing weight and firmness loss as well as respiration rate (Valencia-Chamorro *et al*., 2011; Contreras-Oliva *et al*., 2011, 2012) [61, 8]. Similarly, HPMC combined with beeswax effectively maintains firmness for a long time, preventing weight loss and maintaining qualitative characteristics (Contreras-Oliva *et al*., 2012) [9].

3.5 Grapes
Postharvest application of HPMC dramatically reduces fruit respiration, maintains firmness, and avoids water loss through hydrophobicity in grapes (Sanchez-Gonzalez *et al*., 2011) [54].

3.6 Green pepper
Postharvest application of MC with a combination of Stearic acid and glycerol to green peppers dramatically improved

fruit quality, reduced moisture loss, and reduced water and vitamin C loss during storage (Ayrunci and Tunc, 2004) [3].

3.7 Guava
In Guava, postharvest application of HPMC with a combination of beeswax resulted in an increase in ascorbic acid (Vit. C), which inhibits O_2 and CO_2 exchanges, resulting in delayed fruit ripening and maturity, which are good moisture barriers (McGuire & Hallman., 1995) [32], maintained the postharvest quality of guava (Vishwasrao and Ananthanarayan., 2016) [65], increased gas permeability and shelf-life of 'Pedro Sato' guavas (Formiga *et al*., 2019) [17].

3.8 Mango
Postharvest application of HPMC combined with beeswax lowers transpiration, off-flavors, and fresh weight loss in mangoes, maintaining the quality (Klangmuang and Sothornvit, 2018a) [22]. Similarly, the combination of postharvest application of MC (2%) + HPMC (4%) reduced the weight loss in mango fruit under ambient storage conditions (Hoa *et al*., 2001) [20].

3.9 Oranges
Postharvest application of HPMC to 'Valencia' oranges effectively maintains firmness (Valencia-Chamorro *et al*., 2009) [59]; similarly, HPMC with a combination of beeswax significantly maintains firmness for long periods, reduces weight loss, and maintains qualitative characteristics (Contreras-Oliva *et al*., 2012) [10]. Vapor between the fruit and the surrounding atmosphere lowers the rate of respiration and moisture loss, delaying the onset of productive senescence (Navarro-Tarazaga *et al*., 2007) [37].

3.10 Papaya
Postharvest application of HPMC in combination with Carnauba wax significantly improves the fruit quality in papaya (Miranda *et al*., 2019) [34]. Similarly, HPMC + silver nanoparticles had a higher content of ascorbic acid in cold-stored papaya fruit (Vieira *et al*., 2020) [64].

3.11 Peaches
Postharvest application of MC with a combination of alginate significantly reduces transpiration and respiration rates in peaches, preserves the quality, and increases shelf life (Maftoonazad *et al*., 2008) [30].

3.12 Plum
In plums, postharvest application of HPMC significantly lowers cell softening and delays ripening processes due to normal enzymatic activity (Navarro-Tarazaga *et al*., 2011) [40], retaining fruit firmness, lowering weight loss, internal breakdown, respiration, and decay rates (Navarro-Tarazaga *et al*., 2008) [39].

3.13 Pomegranate
Postharvest application of HPMC coating maintained higher values for sensory attributes in cold-stored pomegranate and less spoilage was observed in coated fruits, similarly, HPMC with a combination of lipid-based coating had higher total acidity during storage (Millo *et al*., 2021) [12].

3.14 Strawberry
Postharvest application of MC coating delayed the spoilage in strawberry fruit for up to 11 days during cold storage (Nadim *et al*., 2015) [35], and MC with a combination of chitosan delays senescence (Vargas *et al*., 2006b) [63].
Similarly, postharvest application of HPMC (1%) + sodium alginate (0.5%) coating has a higher content of total phenols in cold-stored strawberry fruit (Liu *et al*., 2021) [28], likewise, HPMC (1%) + CH (1%) coating had the greatest impact on the restriction of PME activity in strawberry fruit at the end of storage (Gol *et al*., 2013) [18].

3.15 Tomato
In tomatoes, postharvest application of HPMC significantly delays color changes in tomatoes during storage at 20º C by creating a modified atmosphere in the fruit (Zhuang and Huang, 2003) [68].

4. Conclusion
HPMC and MC have shown an impact on horticultural crops as extended shelf life by providing a modified atmosphere through the selective gas permeability without adverse effects on fruit sensory quality, reduced weight loss, and decay acts as a moisture barrier. HPMC and MC edible coating is antioxidant and antimicrobial agent. Hydroxypropyl methylcellulose and Methylcellulose edible coating gives further protection to fresh fruits and provide high-quality horticultural produce for the consumers and reduce post-harvest losses, especially for perishable fruits, vegetables, and ornamentals.

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