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Application of edible coatings in chili (*Capsicum annuum* L.) to increase shelf life of the fruit

Ramandeep and Deven Verma

Abstract
The post-harvest losses are more prominent in horticulture crops. Post-harvest management techniques are helpful to prevent the produce from different losses and also helps in increasing the availability of the produce all over the world. Reduction in shelf life one of the most important losses in horticulture produce. Edible coatings such as Neem oil, Chitosan, Gum arabic and Clove oil are highly efficient in preventing post-harvest losses. It also reduces the losses during transportation such as it prevents cuts and wounds occurred during the transportation of produce from coating place to consumers. Neem oil increases the shelf life of produce and protect it from inoculation of different pests and diseases by acting as a barrier against them. Edible coating increased the shelf life of produce up to 15 days after application. After the application of edible coating in chili crop shelf life is increased from 7 to 10 days. The income of the farmers enhanced up to 10 to 12% by applying edible coating over horticultural produce. Edible coating induces the low rates of fruit respiration which leads to increase in shelf life of fruits which are covered with edible coating. The shining or outer appearance of produce is enhanced due to coating which makes products looking more shiners as compared to uncoated products. In this paper different aspects of edible coating based on its efficiency and compatibility are considered for prevention of farmer's produce to enhance the economic growth of farmers.

Keywords: Post-harvest losses, quality, edible coating, respiration, management techniques, shelf life, pest and diseases, barrier

Introduction
Chili (*Capsicum annuum* L.) belongs to solanaceae family that is grown as a cash crop throughout the year. Chili is one of the most important vegetable crop grown in tropical and subtropical regions. Chili is widely used as a flavoring and condiment in world because of their color, taste, aroma and also due to pungency. Chili is rich source of vitamin-C, capsaicin and antioxidants which helps to prevent cancer, stomach ulcer, weight loss, scurvy disease, cardio-vascular diseases such as high blood pressure, heart attack and also help in maintaining immunity. It is also abundant source of vitamin-A which help in preventing scurvy disease. Chili is most important ingredients of Malaysian cuisine.

Chili contains about 88% of water, 1.3 gram of carbohydrates and protein is about 0.3 grams. About 100 gram serving of chili pepper contains 40 calories, 9 gram of total carbohydrates, 2 gram of protein, 1.5 gram of dietary fiber, 7mg of sodium 5g of sugar, 40gram of vitamin-C, 0.34 gram of potassium, 6 gram of Iron, 6 gram of magnesium, 1 gram of calcium and 15 gram of vitamin B6 (USDA, 2021). Capsaicin is important component present in green chili which is responsible for pungency in chili pepper. Capsanthin is a compound which is responsible for red Color of chili pepper. Red chili pepper also contains lycopene, a red carotenoid pigment which has strong antioxidant properties.

Chili is very essential crop as according to industrial use as well. Chili s used in various industries such as food, confectionery, cosmetics and pharmaceuticals. Chili is used for making pickles, chutney. Red chili is used in dried form as well as in powder form. Red hot chili known as Byadagi chiles is used in manufacturing of lipsticks. Chili is used as pain relief agent because of their ability of inhibiting pain messengers. Extracts of chili are used for reducing the pain of arthritis, head burn, headache and neuralgia. It helps in boosting immune system and also help in lowering the cholesterol. Chili pepper is very helpful in curing intestinal parasites. Chili compound oleoresin is used for Manufacturing of pepper spray which is utilize as Self-defence by the women.

Globally chili is grown in an area of around 20.20 million Hectare with total production of 37.62 million tonnes. India is largest producer of chili with production of around 13.76 million tonnes every year followed by china which produces around 3 million tonnes. India contributes about36.57 percent in total world's production (Fao, 2013). India ranks first in terms of area and production of chili and 2nd in terms of productivity in the world. Area and production of chili in India during the year 2014-2015 is 774 million hectare and 1492 million tonnes (Horticulture Statistics Division Dac&fw, 2014). Major chilli growing countries are as follows: India, China, Romania, Maynmar, Pakistan, Thailand, Nigeria, Bangladesh, Vietnam, Mexico, japan, etc. In India, Andhra-Pradesh is largest producer of chilli followed by Telangana, Karnataka, West- Bengal, Madhya- Pradesh, Orrisa etc. India also ranks first in terms of export value. India exports highest quantity of chili about 347000MT in the year 2014-2015(Spices Board satistics, 2015-2016). Indian chili and other chilli products such as pickle, dried chillies, oleoresins are more acceptable in international market which helps in achieving the goals of higher export rate than other countries. Major Countries to which chilli is exported on large scale are Vietnam, Malaysia, Thailand, Sri Lanka.

Despite of their contribution for the nation in context of production and export value, more than 30-35% chili produce is deteriorated due to lack of post-harvest handling and diseases like anthracnose is also main factor of post-harvest loss. Post-harvest losses are very important factor that make the chili crop unprofitable in most parts of the world. Total post-harvest losses in chili are about 28.6% and 38.7% of initial product weight in dry and wet season respectively. About 6.7-17.1% occurs during Marketing (S Shil *et al*. 2018) [1]. Therefor Post-harvest Management is required for maintaining post-harvest life of chili. Various types of chemicals had been used to increase shelf life of vegetables but in this review paper, role of edible coating such as guar-gum, gum Arabic, chitosan, neem oil, clove oil, carnauba wax, aloe-vera gel, neem oil, clove oil, calcium chloride, spermidine and salicylic acid has been studied.

Edible coating are soluble formulations which creates covering on outer surface of vegetables that coating help in reducing rate of transpiration, moisture content. Reduced rate of transpiration helps in reducing weight loss of vegetable. The basic purpose of edible coating is to make barrier between transpiration and respiration. Vegetables are very perishable in nature that's why we need edible coating to enhance shelf life of vegetables. Three types of edible coating are as follows: Hydrophilic (polysaccharides-based coating), hydrophobic (lipid and wax-based coating) and hydrocolloids. Edible coating is applied in wide range vegetables (carrot, tomato, chili, radish, potato, turnip). Now a days edible coating is in trend and day to day its demand is increasing because it is edible in nature, non-toxic in nature, Bio-degradable in nature and cost effective as compared to other synthetic coating.

Different types of coating materials used in vegetables are as follows

Aloe-vera gel

Aloe-vera gel is obtained from leaves of aloe-vera plant that gel has some medicinal properties like antioxidant, anti-bacterial properties.

In present time aloe-vera gel has become popular and used in many beverages, facewash, shampoo, soaps etc. apart from this, aloe-vera gel is used as edible coating for vegetables because it has anti- bacterial properties which helps in reducing bacterial, moulds, yeast growth. Coating of Aloe-vera gel also help in reducing in rate of respiration, ethylene production rate, polyphenol oxidase and peroxidase activity. Aloe-vera gel acts ad barrier between internal and external atmosphere by this way coating helps in reducing rate of respiration in fruits vegetables.

Treatment of aloe-vera gel with grapes fruits shows that coating help in preventing loss of moisture, firmness, control respiration rate and maturation of fruit and delay oxidative browning and also help in reducing growth of micro-organism.

Brown seaweeds are used for extracting alginates compound. Alginate coating acts as good oxygen barriers and also help in preventing lipid oxidation. In minimally processed carrots alginate are able to reduce weight loss and microflora counts.

Faramitha *et al*. (2022) [4] conducted an experiment to evaluate the effect of aloe-vera gel and chitosan coating on quality attributes of red chili. Red chili was treated with different concentration of chitosan (1, 1.5, and 2%) and aloe-vera gel (5 and 10%) and stored at room temperature for 15 days. chitosan at 2% concentration and aloe-vera gel at 10% were found effective in showing minimum decaying of red chili (43%). Chitosan and aloe-vera gel-based coating has strong antifungal properties which helps in inhibition of mycelial growth of *Colletotrichum capsici* up to 52%.

Khatri *et al*. (2020) [5] carried out an experiment with chitosan and aloe-vera gel as edible coating in tomato (*(Solanum lycopersicum)* for increasing the shelf life of tomato fruits. They studied the effect of chitosan and aloe-vera gel on the biochemical and anti-oxidative properties of tomato. Tomato fruits coated with chitosan and aloe-vera gel or in combination of both. Treated fruits showed gradually increased in total soluble sugar, lycopene content, total phenolic content and slowly decrease in vitamin-Ccontent and titratable acidity during cold storage. Chitosan and aloe- vera gel treatment in combined form found to be effective in extending the shelf life of tomato fruits up to 42 days.

Chitosan

Chitosan (2-amino-2-deoxy-β- d-glucan) has strong antimicrobial and anti- fungal properties that help in controlling fruit decay. It is natural compound which is obtained from outer skeleton of Shellfish.

Chitosan is biodegradable and non-toxic in nature. Chitosan is polysaccharides- based edible coating. Chitosan can form clear film on the outer surface of vegetables which helps in reducing respiration rate by regulating the permeability of carbon-dioxide and oxygen.

Chitosan coating also helpful for delaying the ripening in vegetables. Chitosan coating also effective in reducing weight loss, fungal infection, wilt in bell pepper, cucumber and tomatoes.

Muthmainnah *et al*. (2019) [6] conducted an experiment to study the effect of chitosan and gum Arabic for controlling the respiration rate and vitamin-c content in green chili. Both chitosan (0%, 1%, 1.5%, 2%) and gum arabic (0%, 5%, 10%, 15%) was used in different concentration and three replications (R1, R2, R3) for each treatment. The coated fruits were stored at room temperature (28 °C) for 15 days. Chitosan with 1.5% concentration and gum Arabic with 10%

showed best results. At 15 days respiration rate in chili fruit decreased up to 42-62%. But Chitosan at 1.5% concentration shows lowest decrease in respiration rate (51.78%). After 15 days of storage vitamin-c content was decreased 72-98% in chili fruits. Chitosan at 1.5% slowing down decrease in vitamin-c content as compared to uncoated chili fruits.

Limchoowong *et al.* (2018) [8] conducted an experiment in which they had used iodate- coated chitosan as edible coating in chili fruits. this coating helps in preventing thyroid cancer which helps in improving public health. Chili fruits was coated with chitosan-iodate at 1.5□m concentration. Chili fruits were dipped in chitosan- iodate solution for 5-7 min. chitosan-based coating had no effect on anti-oxidant properties of chili. Iodate concentration was determined by spectrophotometer at 620nm. Chitosan based coating increased shelf life of chili fruits up to 15- 20 days.

K. Divya *et al.* (2018) [9] examined the effect of chitosan as edible coating on the various vegetable such as chili, brinjal, tomato. Chitosan has antifungal and anti-oxidant properties so they studied the effect of chitosan against various plant pathogens such as *Pytophthora infestans, Collectotrichum acutatum, Rhizoctonia solani and Fusarium oxysporum.* Vegetables were coated with chitosan at 1%, 2%,3%, 4%, 5% concentrations. Chitosan at 3% concentration showed the best results by decreasing the weight loss in vegetables than control vegetables which helped in increasing the shelf life of vegetables.

Meitha *et al*. (2022) [7] investigated the effect of chitosan for maintaining the post- harvest life of spinach. Spinach leaves was treated with chitosan at 0.1% and 0.5% (w/v) concentration, 1% acetic acid and distilled water as control. The spinach leaves were examined for physiological, morphological and molecular parameters on 0 and 3 days at room temperature. Chitosan at 0.1% concentration showed best result by slowing down the process of decaying of spinach. This is only possible by inhibition of bacterial growth.

P. Jitareerat *et al*. (2017) [10] investigated the effect of chitosan as edible coating against the anthracnose disease in chilli variety 'jinda' causal organism of anthracnose disease in chili is *Colletotrichum gloeosporioides.* Chili pepper fruit were coated with chitosan at 1.2% and 1.6% concentration. Chitosan at 1.6% showed best results than chitosan at 1.2% by delaying the disease development and weight loss but it causes fruit fermentation. Chitosan at 1.2% helps in reducing rate of respiration and ethylene production which help in increasing the shelf life of chili fruits, but it had no effect firmness loss and color changes.

Gum Arabic

Gum Arabic is a soluble fiber obtained from acacia tree (*Acacia senegal* L.) which is grown in sub- Saharan Africa. Gum Arabic is used as emulsifier, thickening agent and also used as coating material because it is film forming compound. Gum Arabic coating is found to effective in increasing in shelf life of tomato, cucumber.

Sreejit Valiathan *et al*. 2018 [11] studied the effect of composite edible coating on green chilli.

In this study, composite edible coating is made with combination gum Arabic (5%), glycerol (1%), thyme oil (0.5%) and tween 80 (0.05%) and fresh green chilli is dipped in solution of edible coating for 1, 3,5 minutes at room temperature which help in preserving the shelf life of chilli. Result from this study is that coated chillies shows less loss in weight, phenolic acid production, capsaicin production and higher retention of ascorbic acid, total chlorophyll content, colour, firmness and have good organoleptic properties than un-coated chilies. Shelf life of coated chilli is also increased up to 12 days where as uncoated chilli is at 6 days.

Ghannam *et al*. (2021) [12] investigated the effect of Gum arabic as Edible Coating for Improving Postharvest Quality of Potato Tubers. The objective of this study was to study the effect of gum arabic at 10% concentration as edible coating combined with glycerol 1% and CaCl2 1% on potato tubers stored at 8 °C and 30±5 °C for 35 days. They had analyzed the following observations: pH, total soluble solids (TSS), weight loss percentage and total counts of bacteria, molds and yeast.

Gum arabic composite coating increases the shelf life of potato tubers up to 32 days while uncoated fruit decayed on 25 day which were stored at 8 ^{0}C. potato tuber samples which were stored at 30±5 °C and coated with gum arabic composite coating maintained their shelf life up to 30 days without any decaying of potato.

Kannaujia *et al*. (2019) [13] investigated effect of gum arabic and fruwash coatings on postharvest quality of summer squash (Cucurbita pepo). In this experiment they had studied the effect of gum arabic (5, 10 and 15%) concentration and fruwash as edible coating stored at 10 °C for minimizing moisture loss on the summer squash. Gum arabic at 10% concentration showed best result by minimizing water loss and colour retention in terms of Lvalue than fruwash coated fruit and control. Proline content in gum arabic coated samples at 10% concentration (235.05₹ g/g fruit weight) was 68% higher than control (140.06₹ g/g fruit weight).

Paladugu *et al*. (2017) [14] investigated the effect of gum arabic nano formulation as edible coating on physiochemical changes in tomato. they had developed gum arabic nano formulations by low energy approach method. They had applied Gum arabic at 1, 1.5 and 2% concentration as edible coating in semi matured tomatoes fruits and fruits were stored at 32°C and relative humidity 35- 42% for 28 days. they had analyzed the following observations: physiological loss in weight, titratable acidity (TA), total soluble solids (TSS), Vitamin-c content. Gum arabic at 1.5% concentration showed the best result by increasing the shelf life of greenish- yellow tomatoes up to 14 days.

Guar-gum

Guar-gum is obtained from seed cluster bean plant (*Cyamopsis tetragonoloba*). Guar gum is polysaccharide based edible coating.

It is used as edible coating in various vegetables like cucumber, tomato and bell pepper, red chilli etc.it is also known as galactomannan.

It is used as thickening agent in food industry due to its different physiochemical properties, high availability, low cost and biodegradability.

Ruelas-Chacon *et al*. in 2017 [15] studied the effect of guar gum as an edible coating on tomato for increasing shelf life and post-harvest quality of Roma tomato.

In this study, tomato is coated with 1.5% guar gum with glycerol 15% at 22±2 °C and 40% relative humidity for 20 days. Result from this study is that coated tomato fruit shows less loss in weight, less loss of total acidity, firmness and decrease in respiration compared to control.

Cinnamon oil

Cinnamon oil is extracted from leaf or of cinnamon tree by steam distillation method. Cinnamon oil extracted from Cinnamomum cassia tree known as cassia cinnamon and cinnamon oil that is extracted from Cinnamomum verum known as Ceylon cinnamon. It has antifungal, antibacterial, antidiabetic and antioxidant properties.

Cinnamon oil is used as basic ingredient in sugar-free gum, hard candy, tea. Cinnamon oil also helps in maintaining blood sugar level because it has antidiabetic properties.

Cinnamon oil is also used in making baking products such as pastries, cakes, etc. cinnamon oil is used in manufacturing of toothpaste, mouthwash, soaps, facewash and body lotion. It is also used as fragrance in room spray and candles.

Apart from this, it is also used as edible coating in various fruits and vegetables. Cinnamon oil coating is very effective against Colletotrichum Capsici which causal organism of anthracnose in chilli because it has antifungal properties.

Asgar Ali *et al*. in 2014 studied the effect of the propolis extract and cinnamon oil as edible coating against anthracnose of chilli under cold storage. They used propolis extract 5% and cinnamon oil 0.1% and combination of cinnamon oil with 5% gum Arabic. Coated chilli fruit stored in cold storage at temp of 13±2 °C (80–90% of relative humidity for 28 days.

Result shows that propolis and cinnamon oil coating individually showing fungal growth but combination of both propolis and cinnamon oil with gum Arabic shows very good effect against *Colletotrichum capsici* with 100% inhibition of mycelial growth and spore formation.

Bee wax

Bee-wax is naturally occurring wax which is produced by worker bees (*A. mellifera)* in their beehives. Glands which are under the abdomen of worker bee secrete this wax which is then utilized for construction of honey comb. The wax is produced by eight gland which is present in abdomen segment of worker bees.

When honey is collected from beehives and refined, bee wax remained as by-product. Bee wax consists of fatty acid ester, types of long chain of alcohols.

Bee wax is hydrophobic in nature. bee wax is food grade wax which is white in colour when it is freshly prepared later changes to yellow colour because of presence of propolis and pollen colourants. Propolis and pollen colourant are responsible for odour of bee wax.

Bee wax is crystalline in structure which mainly depend upon storage. Hardness is main characteristics of bee wax.

Bee wax is insoluble in water and soluble in organic solvents like ether, acetone, xylol, benzene, chloroform and tetra chloromethane. Bee wax is purified by using hot water extraction, centrifugation and steam extraction. It has anti-inflammatory, anti-viral, anti-bacterial properties.

Bee wax is mostly used for manufacturing cosmetics products such as skin cream, soaps, foundation and lotions. Bee wax is also used for manufacturing the candles. Bee wax is used as a coating for cheese for sealing out the air which gives protection spoilage. Bee wax is also used as food additive in very small quantity which acts as glazing agent that help in preventing the water loss. Apart from this, it is used as edible coating in fruits and vegetables. It is not used individually as edible coating because it causes hardness to fruits and vegetables. It can either be used chitosan, cinnamon oil or clove oil. Bee wax is always used in small quantity.

Shompoo Yimtoe *et al*. (2014) [17] investigated the effect of beewax coating with cinnamon oil or clove oil for increasing the shelf life of sweet peppers. Sweet pepper fruits were coated with beewax with 1.4% cinnamon oil or clove oil and fruits were stored at room temperature (27 ± 2 °C) or low temperature (10 ± 2 °C) for 15 days and 30 days respectively. They compared cinnamon oil coating with clove oil and thiobutacin anti-biotics. the result from this study suggested that coated sweet pepper fruits showed less loss in weight and had less plate count as compared to control. cinnamon oil coating had greatest effect against fungal and bacterial growth of Colletotrichum gloeosporioides, Colletotrichum capsici and Erwinia carotovora, beewax coating combined with 1.4% cinnamon oil and clove oil preserved the quality and increased the shelf life of sweet pepper fruits up to 12 days at room temperature and 30 days in low temperature storage.

Calcium chloride

Calcium chloride is an inorganic substance with chemical formula CaCL2. Calcium chloride is white crystalline solid in ambient conditions and it is soluble in water. It is obtained by neutralizing hydrochloric acid with calcium hydroxide. This compound is widely used for dust control and de- icing. Calcium chloride is used as firming agent in canned vegetables. Cacl2 is used in the production of activated charcoal. It is Used as a sterilant for male animals.

Santosh Kalauni *et al*. (2020) [18] investigated the effect of different Storage conditions and Sanitizer treatments on the postharvest life of sweet pepper fruits var. California Wonder. This study was conducted at Chitwan District, Nepal. This study was conducted in two factorial Randomized Complete Block Design (RCBD) with three replications. They had used 0.1%, calcium chloride, 10%, Neem extract, 10% aloe-vera gel and 0.02% sodium hypochlorite as treatments and treated samples were stored under Evaporative Cooling (EC) and Ambient conditions. They had recorded the following observations: Physiological loss in weight (PLW), Total soluble solids (TSS), vitamin-c, Titratable acidity (TA), spoilage percentage and shelf life of fruits. Result from this study was suggested that samples which were stored in evaporative cooling chamber showed lowest physiological loss in weight (13.19%) as compared to samples stored at ambient temperatures (21.61%) and control. sweet pepper showed the lowest Spoilage percentage (41.1%), the longest Shelf life (13.8 days), the highest TSS (3.16□Brix) and Vitamin C (53.7 mg/100g) in evaporative cooling chamber. Sodium hypochlorite treated samples showed the lowest Spoilagepercentage (37.5%) and physiological loss in weight (14.69%). Aloe-vera gel treated samples showed the highest TSS (3.63□Brix), Vitamin C (52.8 mg/100 g) and the longest Shelf life (13.33 days). the result from this study implies that shelf life of sweet pepper fruits was extended when stored at evaporative cooling chamber and treated the samples with aloe-vera gel and sodium hypochlorite.

Sathiyaseelan *et al*. (2021) [19] conducted an experiment to study the effect of calcium chloride, chitosan and tea tree oil nano emulsions as coating materials for increasing the shelf life of red bell pepper. In this study, red bell pepper was stored at 4 ^{0}C for 21 days. they had observed that calcium chloride coated fruits abled to retain the total phenolics content (89.89 mg/g of GAE), antioxidant activity (> 80%) and flavonoid content (5.12 mg/g of QE) as compared to control samples. result from this study suggested that cacl2

and tea tree oil nano emulsions as edible coating had maintained the shelf life of pepper fruits up to 18 days. calcium chloride also helped to control fungal and bacterial growth.

T.V Ramana Rao *et al*. (2011) [20] performed an experiment to study the effect of calcium chloride (Cacl2) and salicylic acid (SA) on the physiochemical properties and anti-oxidative activities of sweet pepper. sweet pepper fruits were treated with calcium chloride at 1.5% concentration and salicylic acid at (1 mM and 2 mM) concentration and treated fruits are then packed in polythene bags which were stored at 10 ^{0}C and 25 ^{0}C for 18 days. they had recorded the following observations: total soluble solids (TSS), acidity (TA), shelf life and pH at 0,9,18 day.

Result from this study suggested that calcium chloride at 1.5% concentration slowed down the ripening in sweet pepper fruits which were stored at 10 ^{0}C and increased the shelf life of pepper fruits up to 71 days without any decaying and off-flavour of sweet pepper fruits than control.

A.R da costa paixao (2020) [21] carried out an experiment to evaluate the effect of exogenous application of pectin methyl esterase (PME) and calcium chloride (Cacl2) in green chili pepper (*Capsicum annuum* L.) var. yolo wonder for increasing the shelf life of green pepper. this study was conducted at department of agronomic engineering, Federal university of Sergipe, Brazil. In this study calcium chloride at 7% concentration and pectin methyl esterase at 7% concentration was applied on green chili pepper by vacuum infusion technique. Green pepper fruit which was infusion by water used as control. They had recorded the following observations such as total soluble solids content, pH, Total acidity, peel colour, fruit firmness, fresh mass and PME Activity. best result from this study was that calcium chloride at 7% concentration preserved firmness of green pepper fruits and also maintained the physiochemical properties of green chili pepper. Cacl2 and PME applied in combined form did not Maintained the firmness of green pepper fruits.

Suthar and panigrahi *et al*. (2021) [22] studied the effect of calcium chloride (Cacl2) and gallic acid (GA) for increasing the shelf life of bottle gourd (*Lagenaria siceraria). this* study conducted on anti-oxidant capacity, viability and sensory evaluation present in bottle gourd fruits. They had used cacl2 and GA in equal combination of 1:1 □M, 2:2 □M, 3:3 □M, and 4:4 □M. result from this study was suggested that cacl2 and GA in all combination increased the shelf of bottle gourd fruit up to 21 days while control bottle gourd remained last for 14 days. the best result was showed by combination of cacl2 and GA at 2:2µm concentration. Cacl2 and GA in all combination showed valuable result by slow down the ripening process which thus increased the shelf life of bottle gourd fruits.

Salicylic acid

Salicylic acid is an organic compound with chemical formula of $C_7H_6O_3$. salicylic acid is obtained from bark of willow tree (Salix sp.) from which it gets its precursor and metabolite for aspirin (acetyl salicylic acid). It is used in manufacturing of medicine and cosmetics products such as soaps, facewash, acne- products, face-creams. vegetables such as broccoli, tomato, cucumber, cauliflower, zucchini, radish, mushrooms, brinjal and chili peppers are rich source of salicylates.

Manli Luo *et al*. (2020) [23] investigated the effect of salicylic acid and trisodium phosphate on the bell pepper at 4 ^{0}C for 25 days. salicylic acid and trisodium phosphate increased the fatty-acid desaturation efficiency. Result from this study suggested that salicylic acid and trisodium phosphate applied in combined form reduced chilling injury in bell pepper fruits.

Kumar and Thakur *et al*. (2017) [24] investigated the effects of salicylic acid, calcium chloride and hydrogen peroxide on postharvest life of bell pepper fruits. This study was conducted in Postharvest Physiology Laboratory, Department of Food Science and Technology, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, solan (HP). Bell pepper fruits were treated with salicylic acid at 1000,2000,3000 ppm for 5 min, calcium chloride at 0.5, 1,.5% for 5 min and hydrogen peroxide at 5,10,15 mM for 30 min and bell pepper fruits were stored at 10±2°C and 90- 95% RH for 28 days. result from this experiment suggested that bell pepper fruits treated with hydrogen peroxide at 15mM concentration showed reduction in spoilage percentage than other treatments and controls. salicylic acid at 1000 ppm showed less decrease in dry matter and maintained the capsaicin content in bell pepper fruits. Calcium chloride at 1.5% maintained the titratable acidity and vitamin-c content which helped to increase the shelf life of bell pepper fruits. The best result was showed by calcium chloride at 1.5% and salicylic acid at 1000 ppm by maintaining postharvest quality and minimizing the spoilage in bell pepper fruit during 28 days of storage.

Zahra Ghahremani *et al*. (2021) [25] investigated the effect of salicylic acid and calcium lactate as foliar spray on the shelf life of brinjal. They had applied the salicylic acid at 1.5mM and calcium lactate at 4mM as foliar application in the brinjal plants. Result showed that salicylic acid and calcium lactate increased the plant height and yield of brinjal crop. Salicylic acid and calcium lactate also increased the firmness and vitamin-c content which helped to increase the shelf life ofbrinjal fruits.

Yang and Zhang (2015) [26] carried out an experiment to study the effect of salicylic acid and chitosan as edible coating for reducing the chilling injury and preserving the fruit quality in cucumber. they had used salicylic acid individually and in combination with chitosan as edible coating stored at 2 ^{0}C for 14 days. result from this study suggested at salicylic acid and chitosan coating showed reduction in weight loss and respiration rate and also increased the total soluble solids, vitamin-c content and chlorophyll content than salicylic acid applied individually and control. salicylic acid and chitosan coating helped to reduce the chilling injury in coated cucumber fruit than control.

Spermidine

Spermidine is polyamine compound with a chemical formula C7H19 N3 which is found in ribosomes and living tissues which have type of metabolic functions within organisms. It was first isolated from semen. It is precursor to other polyamines such as spermine and putrescine. Spermidine is used in electroporation technique which is used for transferring of DNA into cell by using electrical impulse. Spermidine is also used as edible coating in some vegetables such as tomato, brinjal, bell pepper, chili pepper, etc.

Gaintait *et al*. (2019) investigated the effect of spermidine and putrescine as edible coating for increasing the shelf life of green bell pepper. Spermidine and putrescine were applied in various combination 10µm, 10µm plus, 20µm 20µm plus, 30µm 30µm plus om the bell pepper fruits and treated fruits were stored at 4 ± 1 °C for 40 days. results from this study

suggested that spermidine and putrescine treated samples and control showed decrease in titratable acidity, chlorophyll content, protein content and catalase and peroxidase activity proline content, antioxidant, 1,1- diphenyl-2-picryl-hydrazyl were increased in spermidine-putrescine treated samples. Spermidine at 20µm and putrescine at 20µm was proved to effective for preserving the shelf life of green bell pepper for up to 40 days of storage.

Ghosh *et al*. (2021) [28] investigated the effect of putrescine and chitosan on the shelf life of Capsicum annuum L. (cv. Tejaswani). They had used putrescine at 100µm concentration and 1% chitosan as edible coating to study the effect of both on total soluble solids, color, firmness, water loss and vitamin-c of the chili fruits. Result from this study suggested that Putrescine and chitosan coating altered oxidative metabolism present in chilli fruits by reduction in the level of O2 and H2O2 content. Treated chili fruits had more anti-oxidant activity than control. putrescine and chitosan coating increased the shelf life of chili fruits.

Mario G. Ferruzi *et al*. (2010) carried out an experiment to study the effect of polyamines on the fruit ripening and decaying in tomato fruit. They had studied the effect of spermidine, putrescine and spermine on the antioxidant activity and lycopene content of tomato fruits. Spermidine treated fruits showed reduction in shrivelling and delayed the decaying in treated tomato fruits than control. Spermidine and putrescin had increased the shelf life and also reduced the fruit decaying in tomato fruits.

Carnauba wax

Carnauba wax is obtained from leaves of carnauba palm *Copernicia prunifera* which is grown in some states of brazil. It is also known as brazil wax and it is also called as queen of waxes. Carnauba wax consists of fatty acid esters 80-85%, fatty alcohols 10-16%, acids 3-6% and hydrocarbons 1-3%. It is non toxic and hypoallergenic. It is insoluble in water and ethanol.it is used as thickening, emulsifying, softening agent.

Carnauba wax is used as hardener for other waxes and also used to increase the melting point of wax mixtures. It is used as key component of furniture, leather polishes. It is also used in manufacturing of car polishes. It is also used for making lipsticks and balms. It is also used in manufacturing of various types of cosmetics products such as face- creams, deodorants, make-up product and sunscreen. In food industry it plays a vital role as it is used in manufacturing of chewing gum and candies. It is also used as edible coating in fruits and vegetables. Carnauba is used to maintain post-harvest quality in eggplant (Singh *et al*., 2016) [36] and guava (Germano *et al*., 2019) [35].

Clove oil

Clove oil is an essential oil which is extracted from flower buds of clove tree (S*yzygium aromaticum)* and family Myrtaceae. Clove oil has strong anti-oxidant and anti- fungal properties. It is used as flavoring or fragrance agent in toothpaste, soaps and other cosmetics products. It is used for pain relieving and to promote healing. Clove is widely used as spices in India.

M. Hassan *et al*. (2021) [32] conducted an experiment to study of the effect of pre harvest application of clove extract and potassium silicates as foliar spray which affects the postharvest life of hot pepper. Hot pepper was cultivated in two summer-season in the year 2017 and 2018 and potassium silicates and clove extract were applied as foliar spray. The fungal infection of *alternaria alternata* was examined as postharvest resistance in hot pepper fruits. The result from this present study was suggested that clove extract and potassium silicates reduced the disease severity of Alternaria fruit rot in hot pepper and also increased the shelf life of hot pepper by maintaining the flavonoid and total phenolic content.

Miriam Zermeno Ortega *et al*. (2020) [30] performed an experiment to evaluate the effect of clove and black pepper essential oil and functional extract against the Fusarium oxysporum and Aspergillus niger in tomato fruits (*Solanum lycopersicum* L.). tomato fruit were coated with clove and black pepper oil and extract at the concentration of 350, 400,450 ppm. result from this study suggested that clove and black pepper essential oil and their extract were efficient in an artificial environment at a concentration of 400 to 500 ppm after 10 days of culturing. Clove oil reduced the mycelial growth of aspergillus niger from 50 to 70% and fusarium oxysporum to 40%.

Neem oil

Neem oil is obtained from seed kernels of neem tree *(Azadirachta indica),* neem oil is yellow in color and has strong odour like garlic. neem oil is anti- septic in nature.it is used in manufacturing of many cosmetics products such as soaps, facewash and medicines. It is used as pesticides and insecticides. Now a days it is used as edible coating for various types of vegetables such as brinjal, potato, chili, tomato, sweet potato, etc.

Noor Shahira Md Yusoff *et al*. (2021) [33] conducted an experiment in which they had applied pre- harvest application of neem extract as bio-pesticide and inorganic chemical pesticide in chili production which affects post-harvest quality of chilli. they had used neem extract at 0,25,50,75% concentration and chemical pesticide on chili plants. they had observed the following pre harvest such as plant height, stem diameter, crown diameter, no of chili pods, no of flowers, pest severity and post-harvest parameters such as leaf area, fresh and dry weight of chili, color, firmness and total soluble solids. The results from this study suggested that neem extract at 25% concentration showed less pest severity and increased the pre-harvest parameters which were written above. Neem extract at 25% concentration increased the firmness and leaf area of chili as compared to control and other concentration of neem extract.

Mohammad Zahirul Islam *et al*. (2018) [34] examined the effect of neem oil, Trichoderma and anti- biotics on the decaying of cherry tomatoes by bacteria and fungi. They had measured the biochemical reaction of few bacterial strains such as *Rahnella aquatilis, Microbacterium oxydans, Pseudomonas panacis, Gordonia sputa, and Escherichia coli* in cherry tomatoes. They had also analyzed the bacterial reaction and anti-fungal properties of neem oil and trichoderma in cherry tomatoes. the neem oil and Trichoderma helped to reduce the fungal growth of *aspergillus niger* in cherry tomatoes.

Conclusion

Edible coating is in trend because it is non-toxic in nature and it can efficiently increase the shelf life of vegetables. The coating in horticultural produce increases the shelf life of product which directly increases the economy of farmers.

Products which are coated with edible coating having the more aroma and better taste as compared to uncoated produce. The quality of the coated vegetables and fruits enhanced. Shining of the fruits is increased due to coating. The neem oil and gum Arabic having the superior when different types of coating are applied on fruits. The average shelf life is enhanced 3 to 4 days more and the coating of gum Arabic increases shelf life 5 to 6 days whereas neem oil increases 4 to 6 days after the application of coating. Carnauba wax induces the thicker layer of edible coating which reduces the sweetness of fruits. Activity of ethylene and the enzymes present over the surface of fruits is reduced. It is also notices that the mycelial growth is reduced in coated fruits. Respiration rates is low of those fruits which are affected by pest attack and wounds when these fruits are coated with edible coating.

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