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Shelf-life enhancement of fruits using pectin and starch based coating under refrigerated conditions

Gupta Prerna[1*], Kundu Priyanka[1], Sharma Richa[2] and Bhat Anju[2]

Lovely Faculty of Technology and Sciences, School of Agriculture Lovely Professional University[1], Jalandhar-Delhi GT-Road, Punjab 144411 and Sher-e-Kashmir University of Agricultural Sciences and Technology[2], Chatha. Jammu, J & K.

[*]Corresponding Author: prerna.gskuastj@gmail.com

ABSTRACT

Preservation of fresh fruits and vegetables by the use of various chemicals as well as packaging material is questionable and is strictly being monitored as far as health of humans is concerned. For this reason a possible and biodegradable approach is edible packaging. By proper utilization of waste from fruits and vegetable industry certain films and coatings can be formulated having target-based application that can be directly used on to the surface of a food product such as methylcellulose, chitosan, starch. Meeting all the quality and safety parameters edible films/coatings is a possible innovative approach for the industries as well as for the society. Extraction of these films and coatings require a comprehensive approach that includes sample preparation strategy.

***KEYWORDS**: Pectin extraction, methylcellulose, chitosan, hydrocolloids, microwave extraction*

Preservation of fruits and vegetables in fresh form by various chemicals as well as packaging material is questionable and is strictly being monitored as far as health of humans is concerned. For this reason a possible and biodegradable approach is edible packaging. The effect of oxygen, radiant energy and living organism for showing the interaction between synthetic polymers and natural environment has been observed over the past two decades (Ojeda, 2013). Synthetic polymers degrade the environment and are not easily decomposed. That’s why there is a great need to develop biodegradable plastics. Films or coatings that are edible have been used in the food industries since long to preserve the food products and do not cause any environmental hazard e.g. waxing on fruits and vegetables and or cellulose coatings on meat casing (Embuscado and Huber, 2009 and Jamie, 2012).

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Appearance is the first quality indicator on the basis of which fruits and vegetables are generally judged (Rojas-Grau *et. al*, 2007) and are one of the most challenging problems in the fresh cut fruit industry. Use of edible films or coatings are solution to overcome this (Salleh, 2013). These films and coatings not only provide additional protection but also act in the way as modified atmosphere storage. Variety of fruits and vegetables such as oranges, apples, grapefruit, cherries, cucumber, strawberries, tomatoes and capsicum etc. are a success in terms of edible coatings (Kumar and Sethi, 2018).

HISTORY

During the early 12th century fruits used to be wax coated by dipping (Krochta and Mulder-Johnston, 1997). Dipping method helps in retarding water transpiration rate in many fruits like lemons and oranges and was practiced in China. According to them wax-coated fruits could be stored longer than non-waxed fruits. Later on in 1930 hot-melted paraffin wax used commercially as a source of edible coating on fresh fruits like apples and pears. Then coating made up of fats was used. This process of using fats is called "larding" and was practiced in England. Now-a-days "Sausage casing" material made of gelatin (a protein source) is also used with a film thickness of 2.5 mm. In fact oils, waxes and celluloses have shown similar effects (Bahnasway and Khater, 2014) of spoilage prevention and freshness retention in case of fruits and vegetables. Edible coatings that are usually prepared with natural polymers are non-phytotoxic, tasteless, odorless, cost- effective, economical, biodegradable and are readily available (Zaragoza *et al*., 2018 and Dhall, 2012 and Tharantharn, 2003). An edible polymer generally acts as a substitute for synthetic plastics and can be used in various food applications (Siracusa, e*t al.*, 2008). The polymer is generally a mixture of sucrose fatty acid esters (SFAE), sodium carboxymethyl cellulose and mono- and di-glycerides. SFAE an emulsifier helps in retarding fruit ripening. These mixtures have been made commercially available since 1980 under the trade name "TAL Pro-long" and "Semper fresh" (Lau and Meheriuk, 1994). An example of this is coating of zein on tomato that prevented change in color, weight loss and maintained firmness during storage as observed by Park *et al.* in1996.

NEED FOR EDIBLE FILM

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Films and or coatings are thin layered material that can be consumed and provide barrier to oxygen, microbes and moisture in food. Different type of materials having good mechanical properties such as celluloses, starch, pectin, lipid, chitin and chitosan were used to extend the shelf life and to provide shiny appearance to fresh fruits and vegetables (Rossman, 2009 and Puri, et *al*., 2012). A general thickness of less than 0.3 mm has been recorded (Kader, 2002).

HARMFUL EFFECT OF SYNTHETIC PLASTICS

The U.S National Institute of Health Researchers called synthetic polymers as " rapidly increasing, long term threat". Problems like food imitation, persistant organic pollutants, production pollution, landfill accumulation is pertinent with the ongoing use of synthetic plastics (King, 2018).

- Four workers died of liver cancer in 1974, at the British Food Goodrich Company's Poly Vinyl Chloride (PVC) plant. The major reason for death was the exposure of workers to chlorine gas that was added to PVC to give the plastic its strength, flexibility and resistance to temperature.
- In 1972, Washington posted an article by saying, "humans are just a little plastic now" because of the presence of phthalates like DEHP that was found in blood samples of people who were getting exposed to plastics everyday. Thus, edible films and coatings help to reduce plastic waste and the ill effects caused by them.

TECHNOLOGICAL IMPLEMENTATION OF EDIBLE FILM:

Approximately around 50% of the fresh produce gets deteriorated during harvesting, handling, transportation and storage owing to their perishable nature. Edible Coatings/films can be applied either to whole fruit and/ or on fresh-cut pieces (Takahashi, *et al*., 2010) with a great success. Some examples are:

Fruits	Vegetables
Oranges, apples, grapefruit, cantaloupe, cherry, papaya, lemon, strawberry, mango, peaches, Fresh-cut apples and pears	Tomato, cucumber, capsicum, minimally processed carrots Fresh-cut potatoes, cabbage, tomato slices, onion and lettuce.

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Table 1: Successful implementation of edible coating on various food products

Materials for EF/ EC	Food involved	Sources
Cassava starch	strawberry, tangerine	Bersaneti *et al*., 2016, Thomas *et al*., 2016
Combination of corn starch with beeswax and pectin	raspberry, oranges	Adriana et al., 2015 and Perez-Gallardo *et al.*, 2012
Chitosan coating	asparagus, pomegranate, broccoli, Sliced apple, cantaloupe, papaya, carp, sausage	Qiu *et al.*, 2013, Ghasemnezhad *et al*., 2013, Alvarez *et al*., 2013, de Britto and Assis, 2012, Bai et al., 2002, Zhang *et al.*, 2012 and Krkic *et al*., 2012
Pectin film and coating	melon, peachs, mango, cantaloupe, sapota, fried potato chips	Ferrari *et al*., 2013, Ayala-Zavala *et al*., 2013, Moalemiyan *et al*., 2012 and Garmakhany *et al*., 2012
Caseinate	pineapple	Talens *et al*., 2012
Alginate	Mushroom, Cherry, Minimially processed carrots	Jiang, 2013, Diaz-Mula *et al*., 2012
Gelatin	persimmon, chilled hake	Neves *et al*., 2012 and Lacey *et al*., 2012
Aloe vera based edible coation	tomatoes	Athmeselvi *et al*., 2013
Red algae	Bacon, Cheese	Shin *et al*., 2012

Utilization of edible coating for shelf life enhancement

Methyl Cellulose Coating on Strawberries: Coating reduces the rate of decay along with the length of storage in case of strawberries. Methyl- cellulose (MC) coating reduces the rate of decay up to 29.6% after 11 days of storage that increased

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up to 87.5% without any coating material at 4^0C. The percent loss of weight in control sample was 10.37% higher than the MC-treated fruit (Nadim *et. a*l, 2014).

Chitosan Coating on Mushroom: Chitosan coating (up to 2%) in mushrooms helps in lowering the enzymatic effect and microbial count as well during storage at 4^0C for up to a period of 15 days. Discoloration is delayed by controlling polyphenol oxidase (PPO), peroxidase, catalase, phenylalanine, ammonia lyase and laccase, as well as total phenolic content activity. Activity of cellulase, total amylase and α- amylase is also greatly reduced (Hesham, 2007). Ibrahim *et al*., in 2017 used chitosan coating with lemon grass and thyme essential oils to improve the quality and to extend the shelf life of strawberries. The results showed that coating helped in maintaining firmness, total acidity, ascorbic acid and overall acceptability of strawberry fruits under both ambient and refrigerated conditions for up to a period of 4 and 15 days respectively. Although no change on total soluble solid content was observed under both the conditions.

Pectin Coating on Melon: Use of calcium lactate showed a beneficial effect on maintaining the firmness of melons. Also change in cellular structure, mechanical damage and microbial stability was maintained for up to a period of 14 days (Kanse, 2017). Also combination of calcium lactate dip and pectin coating and or association of osmotic dehydration and pectin coatings proved to be a good alternative for fresh-cut melons thereby reducing the fruit respiration rate, maintaining the overall sensory and nutritional characteristics for up to 14 days (Ferrari e*t al*., 2018).

FILM FORMING MATERIAL

Edible coatings having hydrophobic groups are either lipid-based or waxes, and the other hydrocolloids or hydrophilic group, such as polysaccharides-based, protein-based or combination of both and alginate (Dhanapal *et. al*, 2012 and Silva, 2013). The non-chemically synthesized coatings are mainly divided into three classes: a) Hydrocolloids, b) Lipids like fatty acids, acryl glycerides and waxes (Galus and Kadzinska, 2015) and c) Composites like protein-protein, polysaccharides-protein, lipid-polysaccharides. However the protein and polymer based material shows less tensile strength because of their strong energy density (Pascal and Lin, 2013). Sometimes surfactants and or plasticizers are also used as coating material. The

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function and performance of coating material mainly depends on its mechanical, physical and color retaining property, which controls gas transfer and moisture loss of fruits and vegetables (Pan *et al*, 2011).

PECTIN

Pectin is the methylated ester of polygalacturonic acid present in the primary cell wall of the plant. It is commercially extracted from citrus peels and apple pomace under mildly acidic conditions. Citrus pectin is light cream or light tan in color. Henri Braconnot first isolated it in 1825. Pectin is generally divided into two major groups on the basis of its degree of esterification. Pectin has a tendency to form gel due to its three dimensional network that can be used in various food formulations, pharmaceutical industry and for promoting health (Tharantharan, 2003). Globally pectin demand is increasing due to its enormous contribution in food industry has gone from 30,000 to 60,000 tonnes per year and is increasing every day (Sundar, *et al*., 2012). Brazil is one of the largest producers of pectin followed by Denmark and Mexico. Now-a-days microbes are also used as a source of pectin extraction.

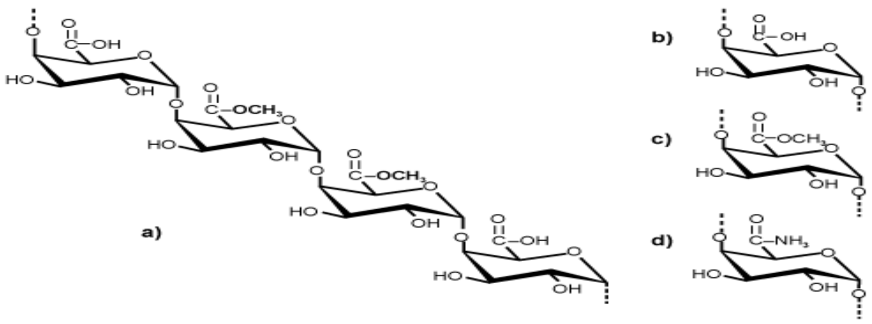

Figure 1: (a) A repeating segment of pectin molecule and functional groups; (b) carboxyl; (c) ester; (d) amide in pectin chain.

EXTRACTION METHODS FOR PECTIN

Acid extraction of pectin: Use of strong mineral acid solution is one of the most commonly used extraction method for pectin (Warriner *et al*., 2009). Acids used are citric acid, hydrochloric acid, sulphuric acid and nitric acid. Pectin is generally a hetero hemicellolose enriched in galacturonic acid. Strong acid strength (i.e decreasing pH of 1.0, 1.5, 2.0 and 2.5) plays an important role in increasing the galacturonic acid content at temperature 65ºC for 30 minutes. This results in the formation of a jelly-like material called pectin, which was further centrifuged. And

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further dried in a hot air oven at 40ºC for 20 minutes (Yu and Sun, 2013).The highest yield of pectin was obtained as the strength of extractant was increased up to pH 1.

Enzymatic extraction: The cell wall of the plant contain various degrading enzymes like polygalacturonase, hemicelluloses, protease, cellulose, α-amylase, xylase, b-glucosidase, endopolygalacturonase, pectinesterase having minimum pectinolytic activity and are used to hydrolyze the non- pectin plant cell wall components in enzymatic extraction of pectin (Xian-Chun and De-Lin, 2012). Sometimes microbial mixed enzymes are also used due to their ability to degrade and to modify the physicochemical properties of pectin (Lin and Zhao, 2007).

MICROWAVE EXTRAXTION METHOD: 100grams of the powdered sample of 0.4 mm particle size was mixed with acetic acid sodium acetate buffer. The extraction was then carried out in microwave-assisted synthesis reaction instrument under atmospheric pressure. The mixture was then allowed to cool under room temperature conditions and a certain amount of the compound enzyme i.e. 80% pectin acid enzyme and 20% Aspergillus enzyme then was added (Tiwari, *et al*., 2017). Centrifugation was then carried out at 4000 rpm for 10 min and the supernatant was then placed in water bath for 5 min at 85ºC to inactivate the enzymes. This process of cooling, precipitation and centrifugation was repeated until pure pectin is extracted. The pectin so obtained was then dried in a vacuum oven at 50 ºC for 2 hours (Prasad and Batra, 2015).

APPLICATIONS OF PECTIN

1) Pectin and its derivatives helps in increasing the viscosity and volume of stool so that it can be used to treat constipation and diarrhea.

2) It helps in lowering blood cholesterol level by increasing the fecal cholesterol, fecal fat, sterols and bile acid (Youssef *et al*., 2015).

3) In cosmetic products and acidic beverages, pectin acts as a stabilizer. It is also used in hair tonics, body lotions, shampoos, deodorants and toothpaste and as specialty medical adhesive such as colostomy device (Dhanpal e*t al*, 2012).

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4) Pectin can also be used in confectionary and jellies to give a good gel structure and clean bite (Smith, 2003). Syneresis in jams and marmalades and the rate of digestion by immobilizing food components in the intestine can be reduced.

5) The mouth-feel and pulp stability in juice -based drinks can be improved up to a certain extent.

STARCH

Starch is one of the most common polysaccharide obtained from cereal grains such as wheat, maize, rice etc. Potato and other tubers and legumes are also good sources of starch. Starch is a homopolymer composed of polysaccharides components of which one is water- soluble linear amylose and the other is water insoluble branched amylo-pectin. Amyloses are good source for film and coating material (Rodriguez *et. al*, 2006). For e.g. coatings and films obtained from corn starch or potato starch are highly stable for long- term preservation. These films and coatings are biologically absorbent, semi-permeable to oxygen and carbon-dioxide. In general starch derivatives are broken down with the help of amylase and the final product is dextrin (Satyanarayana and Chakrapani, 2011).

CONCLUSION:

Edible films and coatings are highly effective in improving the quality and extending the shelf life of fresh food products under different storage conditions. Physico-chemical and phyto-chemical components like weight loss, firmness, total soluble solids, total acidity, ascorbic acid, anthocyanin content, microbiological growth (total bacterial, yeasts and molds counts) and overall acceptability of the product is greatly influenced and enhanced by edible coating. Moreover these films and coatings are non-toxic by nature and are therefore completely reliable. They also prevent the use of increased amounts of preservatives on to the surface of food product higher doses of which might lead to certain allergic reactions in the human body.

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