CHAPTER 1
INTRODUCTION

Edible films and coatings, such as wax on various fruits, have been used for centuries to prevent loss of moisture, enhancing shelf life and to create a shiny fruit surface for aesthetic purposes. These practices were accepted long before their associated chemistries were understood, and are still carried out in the present day. The term, edible film, has been related to food applications only in the past 50 years. There are ancient reports that spies’ instructions were written on edible films, so that if they were captured, they could easily destroy their secrets by eating them. In most cases, the term film and coating are used interchangeably to indicate that the surface of a food is covered by relatively thin layer of material of certain composition. However, a film is occasionally differentiated from a coating by the notion that it is a stand-alone wrapping material, whereas a coating is applied and formed directly on food surface itself. As recently as 1967, edible films had very little commercial use, and were limited mostly to wax layers on fruits. During intervening years, a significant business grew out of this concept (i.e., in 1986, there were little more than ten companies offering such products, while by 1996, numbers grew to 600 companies). Today, edible film use has expanded rapidly for retaining quality of a wide variety of foods.

Most food consumed comes directly from nature, where many of them can be eaten immediately as we take them from the tree, vine or ground. However, with increased transportation distribution systems, storage needs, and advent of ever larger supermarkets and warehouse stores, foods are not consumed just in the orchard, on the field, in the farmhouse, or close to processing facilities. It takes considerable time for a food product to reach the table of the consumer. During time-consuming steps involved in handling, storage and transportation, products start to dehydrate, deteriorate, and lose appearance, flavor and nutritional value. If no special protection is provided, damage can
occur within hours or days, even if this damage is not immediately visible.

Huge post-harvest losses of fruits and vegetables are a matter of grave concern for any country whose economy is agriculture based. But this is a general phenomenon happening in almost every developing country. Fruits and vegetables are highly perishable commodities that require to be handled with much care to minimize losses. Because of their high moisture content horticultural crops are inherently more liable to deteriorate especially under tropical conditions. They are biologically active and carry out transpiration, respiration, ripening and other biochemical activities, which result in quality deterioration. Losses during post harvest operations due to improper storage and handling are enormous and can range from 20-50 percent in developing countries (Kader, 1992). During peak seasons when horticultural crops arrive in plenty at the market, prices slump bringing the farmer less profit. These stocks are carelessly handled due to lack of appropriate storage and transport facility. There should be enough processing industries to utilize the surplus. Moreover the varieties available need to be suitable for processing. Here agriculture may be characterized as disjointed. Production is not linked with marketing. With perishable crops like fruits and vegetables, storage, packaging, transport and handling technologies are practically non-existent in most developing countries. Hence considerable amount of produce is wasted. Every crop is worthy of its investment only when it is utilized completely without losses. The quality of the harvested fruits and vegetables depends on the condition of growth as well as physiological and biochemical changes they undergo after harvest. Fruits and vegetable cells are still alive after harvest and continue their physiological activity. The post harvest quality and storage life of fruits appear to be controlled by the maturity. If the fruits are harvested at right maturity their quality is excellent.
The main components of our everyday foods (e.g., proteins, carbohydrates and lipids) can fulfill requirements for preparation of edible films. As a general rule, fats are used to reduce water transmission; polysaccharides are used to control oxygen and other gas transmission, while protein films provide mechanical stability. These materials can be utilized individually or as mixed composite blends to form films provided that they do not adversely alter food flavor. A major objective in preparing films for many foods (e.g., fresh fruit and vegetables) is to ensure that the generated films afford physical and chemical properties necessary to maintain transmission of various gases and liquids at the same rates as they occur within their native systems. Chemical structures of the three major components used to prepare films differ widely, and therefore attributes that each component contributes to overall film properties are different too.

Even though the package performs significant functions for extending shelf life of foods, the conventional packaging materials also poses serious problem of environmental pollution if they are non-recyclable. It is estimated the packaging materials generate approximately 30 per cent by weight of municipal waste. Out of 30 per cent packaging waste, 13 per cent is due to plastic materials which are not biodegradable. Increasing environmental issues, awareness among consumers and growing market of convenience foods have augmented the need for development of packaging material which is easily recyclable or preferable edible. Because of these environmental aspects of packaging materials, edible films and coatings offers alternative of eco-friendly packaging system. Edible coatings produced from bio-origin can partially or totally replace some of the synthetic packaging films and thus can reduce use of these conventional synthetic materials.
Films from various sources of protein, such as corn, milk, soy, wheat and whey, have been used for years, their major advantage being their physical stability. It should be mentioned, however, that most of these protein sources are in fact mixtures of various proteins comprising a range of molecular weights. When selecting protein for use in an edible film, consideration should extend beyond just protein functionality and GRAS status. In general, value of proteins as moisture barriers is low, and they also do not adequately control transfer of oxygen, carbon dioxide and other gases that are important to stability of various foods. Their major advantage is their structural stability, which makes it possible to hold a required form. Cross-linking can also occur in proteins where the isoelectric point is dependent on interaction of the amino and carboxylic groups of the protein. Thus depending on protein composition, permeability can also be altered. It was reported that depending on the pH of solution from which the film was cast, properties (e.g., color, texture, tensile strength) were markedly different (Gennadios et al. 1993; Gontard et al. 1992.)

The primary advantages of polysaccharide films are their structural stability and ability to slow down oxygen transmission. As a general rule films which do not provide protection against water transmission often have desirable properties in preventing oxygen transmission and vice versa (Banker 1966). Resistance to gas transmission can be so effective for polysaccharide films that it can be a challenge to manipulate. For example, permeability for oxygen in high amylose starch films was found to be virtually zero despite addition of plasticizers that were known to increase gas permeability (Mark et al. 1966). Therefore, in spite of their shortcomings with regard to water permeability, polysaccharides can be used to protect food from oxidation. Another interesting role of polysaccharide films is to act as “a sacrificing agent” instead of as a barrier.
Since most polysaccharides and other hydrophilic materials provide low protection against water transmission (i.e., they are highly hygroscopic), they may be applied as relatively thick films at food surfaces to intentionally absorb water and provide temporary protection against further moisture loss (similar to how a surfer’s wet suit takes in water, but provides protection). Carrageenan, a sulfated polysaccharide of d-galactopyranosyl units was found to form a structured gel, which acted as sacrificing agent (Glicksman 1982, 1983). Thus the coated product itself does not lose significant moisture until the sacrificing agent or film itself is dehydrated. If a surfactant is added to the coating, surface water activity can be altered without altering water content inside.

Waxes and fats are the oldest known edible film components. While most waxes are of natural origin, synthetic acetylated monoglycerides have similar characteristics and have been used with the blessing of the FDA in edible films for meat, fish and poultry. Originally, lipid coatings were applied by simply pouring molten paraffin or wax over citrus fruits. This process slowly gave way to adding a thin shiny layer by applying small amount of various wax through dipping or spraying. The hydrophobic fruit surface, which also protects against abrasion during transportation, adds an aesthetic appearance. At the same time, thin wax coatings still allow some breathing to occur. They are excellent barriers to water transmission, while still slowing or altogether preventing other gas migration. Wax will affect oxygen and carbon dioxide transmission, and thus, can result in unwanted physiological processes, such as anaerobic respiration. This process in turn, will diminish quality of the product, resulting in softening of tissue structure, alteration of flavor, delay of ripening, and promotion of microbiological reactions (Eaks and Ludi 1960). In case of horticultural products with minimal respiration such as root vegetables, thick layers of wax are less harmful and can be used (Hardenburg 1967).
It was reported that water vapor transmission through fatty acid monolayers decreased logarithmically as length of the fatty acid hydrocarbon chain increased, though this effect was not indefinite *(LaMer et al. 1964)*. However, there is disagreement about the most efficient chain length.

Respiration plays a very significant role in the post harvest life of the fruits. In most fruits the rate of respiration increases rapidly with ripening as in climacteric fruits when senescence and deterioration of the fruits begin. To extend the post harvest life of the fruits and delay ripening, its respiration rate should be reduced as far as possible. Ethylene, produced by some fruits as they ripen, promotes additional ripening of produce. Thus an understanding of the factors which influence the rate of respiration and ripening is indispensable to developing appropriate post harvest technologies.

Recently edible films have been developed to extend the shelf life of fruits and vegetables. This environment friendly technology wraps the film closely around the fruit preventing respiration and transpiration, thus slowing down senescence. Studies have shown that these films can be incorporated with nutrients or preservatives and are functional in various ways. With demand for more natural foods, bio-preservatives are being added to the films making it more wholesome for the consumer.

Ideal edible film should have the following characteristics:

- Contain no toxic, allergic and non-digestible components.
- Provide structural stability and prevent mechanical damage during transportation, handling, and display.
- Have good adhesion to surface of food to be protected providing uniform coverage.
- Control water migration both in and out of protected food to maintain desired moisture content.
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• Provide semi-permeability to maintain internal equilibrium of gases involved in aerobic and anaerobic respiration, thus retarding senescence.
• Prevent loss or uptake of components that stabilize aroma, flavor, nutritional and organoleptic characteristics necessary for consumer acceptance while not adversely altering the taste or appearance.
• Provide biochemical and microbial surface stability while protecting against contamination, pest infestation, microbe proliferation, and other types of decay.
• Maintain or enhance aesthetics and sensory attributes (appearance, taste etc.) of product
• Serve as carrier for desirable additives such as flavor, fragrance, coloring, nutrients, and vitamins. Incorporation of antioxidants and antimicrobial agents can be limited to the surface through use of edible films, thus minimizing cost and intrusive taste.
• It should be easily manufactured and economically viable

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important and widely cultivated vegetables in India and according to FAO the annual production of tomato in India was 4,800 MT. There is increasing evidence that diet can play an important role in human health by providing important substances that increase the body defense system against several diseases. Tomato is a major contributor of carotenoids (especially lycopene), phenolics, vitamin C and small amounts of vitamin E in daily diets (*Khachik et al* 2002). Results from the epidemiological studies showed that tomatoes and tomato products may have a protective effect against various forms of cancer, especially prostate cancer and cardiovascular diseases (*Barber and Barber*, 2002). Since tomato is highly perishable it encounters several problems in its transportation, storage and marketing (*Ben and Susanlurie*, 1986).
Owing to lack of information on appropriate post harvest treatments, packaging, temperature etc, the fruits not only lose their quality but also encounter a substantial post harvest loss. In tropical countries a loss of 20-50% \textit{(Kader, 1992)} between harvesting, transportation and consumption of fresh tomato has been reported by \textit{Aworth and Olorunda (1981)}. Even though some research efforts have helped to increase the production of tomato to some extent, the purpose of obtaining maximum profit will be served only if the increased production is supplemented with the similar efforts to minimize the post harvest losses and enhance the shelf life. The tomato is now grown worldwide for its edible fruits. Proper harvesting determines the nutrient contents as well as storage durability of any fruit. It is normally harvested at different maturity stages, such as green mature stage, half ripen stage and red ripen stage. It is a climacteric fruit, having respiratory peak during their ripening process. Being a climacteric and perishable vegetable, tomatoes have a very short life span, usually 2-3 weeks after physiological maturity. An increase in the storage life and improvement of tomato fruit quality is really desirable.

Papaya (\textit{Carica papaya L}) is the fifth most important crop in India, which is cultivated in about 80 thousand ha of land and production of 2686 thousand MT with average productivity of 33.4 MT ha\textsuperscript{-1} in 2007-08 (Indian Horticulture Database, 2008). The fruits are excellent source of vitamin A (2020 IU/100 g) next to Mango (2500 IU/100 g) and also a rich source of other vitamins like thiamine, riboflavin, nicotinic acid and ascorbic acid. Papayas (100 g) contains 9\% of the Dietary Reference Intake (DRI) for Cu, 6-8\% of DRI for Mg, but less than 3\% DRI for other minerals \textit{(Wall, 2006)}. Unfortunately papaya fruit has not caught the fancy of the consumers as much as it deserves mainly because of it’s odor which is not highly appealing and thus limits it’s commercial exploitation at processing level.
Edible films are being used for a variety of purposes within a multitude of food systems, even though this fact might not be fully realized by consumers. The shiny surface of an apple in a supermarket is not provided by nature. Some candies are coated with shellac to increase product shelf life and provide desired glaze. Medicine pills are often coated to prevent crumbling, to hide any bitter or undesirable taste before swallowing, and to provide controllable timed-release of medications. Table 1.1 provides an informative, and non-comprehensive list of examples of commercial edible coatings.

Table 1.1 List of Commercially Used Edible Coatings

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name</th>
<th>Main Component</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FreshseeI™</td>
<td>Sucrose esters</td>
<td>Extending shelf life of melon</td>
</tr>
<tr>
<td>2</td>
<td>Fry Shield™</td>
<td>Calcium pectinate</td>
<td>Reduces fat uptake during frying fish, potatoes, and other vegetables</td>
</tr>
<tr>
<td>3</td>
<td>Nature Seal™</td>
<td>Calcium ascorbate</td>
<td>Apples, avocado, carrot, and other vegetables</td>
</tr>
<tr>
<td>4</td>
<td>Nutrasave™</td>
<td>N,O-Carboxymethyl chitosan</td>
<td>Reduces loss of water in avocado, retains firmness</td>
</tr>
<tr>
<td>5</td>
<td>Opta Glaze™</td>
<td>Wheat gluten</td>
<td>Replaces raw egg based coating to prevent microbial growth</td>
</tr>
<tr>
<td>6</td>
<td>Seal gum, Spray gum™</td>
<td>Calcium acetate</td>
<td>Prevents darkening of potato during frying</td>
</tr>
<tr>
<td>7</td>
<td>Semperfresh™</td>
<td>Sucrose esters</td>
<td>Protect pome fruits from losing water and discoloration.</td>
</tr>
<tr>
<td>8</td>
<td>Z*Coat™</td>
<td>Corn protein</td>
<td>Extends shelf-life of nut meats, pecan, and chocolate covered Peanut</td>
</tr>
</tbody>
</table>
Thus the present research work was undertaken with following objectives

a. To formulate composite edible coating for fresh tomato and papaya.

b. To study effect of edible coating on physico-chemical, properties of tomatoes and papayas stored at ambient and refrigerated conditions.

c. To study effect of edible coating on textural properties of tomatoes and papayas stored at ambient and refrigerated conditions.

d. To study effect of edible coating on microbial properties of tomatoes and papayas stored at ambient and refrigerated conditions.

e. To assess suitability of edible coating as a means of carrier of preservative.

f. To optimize the composition of soy protein isolate based edible film.

g. To study the physical, mechanical and barrier properties of protein based edible film.