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Studies on Preservation of Fruits and Vegetables by Active Packaging

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ABSTRACT

In the Department of Food Technology, Guru Jambheshwar University of Science and Technology, the current investigation entitled 'Studies on Minimum Processing and Preservation of Fruits and Vegetables through Active Packaging' was carried out during 2007-2011. The study was carried out in order to prepare minimally processed fruit and vegetable products and prolong their shelf-life through the use of active packaging technology. By following the best unit operations, the measures for the preparation of minimally processed fruits and vegetables (apple, banana, orange, tomato, cauliflower, and spinach) were standardized. Oxygen, carbon dioxide, humidity, ethylene scavengers and chitosan-based film forming solution for coating were optimized for further study treatments under active packaging. Their effects on minimally processed products at RT were observed, while RT and AT reacted well to all commodities. Furthermore, qualitative, bio-chemical, physiological and enzymatic reactions have been observed in both fresh-cut and whole fruits and vegetables. Chitosan coating, followed by ethylene and moisture scavenging treatments, was found to be the most effective.

Keywords: *Vegetables, Fruits*

INTRODUCTION

India has only emerged as the world's second largest producer of fruits and vegetables next to China, and our country is designated as the world's "fruit and vegetable basket" in terms of total area and production. India currently produces approximately 71 million tonnes of fruit and 133 million tonnes of vegetables over an extensive area of 6 and 8 million hectares, respectively (NHB, Indian Hort. Database 2010). According to Baisya (2009), world fruit and vegetable production amounts to 550 million tonnes and 910 million tonnes, respectively, and India produces approximately 64 million tonnes of fruit and 126 million tonnes of vegetables annually, representing approximately 12 and 14% of world production, respectively.

Fig. 1.1: Fresh fruits and vegetables

Fruits, which are extremely nutritious, are an important part of the human diet, but have a very limited shelf life after harvest. When they age, they become very fragile and more vulnerable to damage, which makes them extremely perishable. In India, due to spoilage, about 30 percent of the total production is wasted. In order to resolve post-harvest fruit losses, there is an urgent need to develop technologies (Surendranathan, 2005), as these raw materials die due to their harvest, storage, grading, transport, packaging and distribution. Since fresh horticultural products have limited shelf-life at ambient temperature from a few hours to a few weeks, packaging is not only necessary for food preservation and safety, but is also assumed to maintain a multifunctional role by serving as a symbol of value added, food quality and assurance, and ultimately a tool for convenient storage marketing (FAO, NHB 2000). Food packaging is mainly intended to protect food from potential microbial or other contamination, including oxygen, water vapour and light, and also plays an important role in assessing the shelf life of a food.

Storage gas composition is one of the most critical package-related parameters that could affect post-harvest metabolism and post-processing degradation, and each fruit and vegetable requires a different and often very specific gas composition ratio to optimise its shelf life, while gas concentrations depend on the temperature and period of storage (Argenta et al., 2004). The main drivers of progress in food packaging technology in recent years are perhaps due to the increased demand for minimally or lightly processed foods. Minimal processing involves operations such as washing, sorting, trimming, peeling, slicing or chopping and avoiding browning that affects the freshness of fruits and vegetables. Fresh fruits and vegetables are products that are minimally processed and modified with or without washing by peeling, slicing or chopping (FDA, 2007). These products are processed from fresh fruit and vegetables that, even after processing, remain metabolically active and undergo processes of ripening and senescence. Most fresh-cut fruits and vegetables are typically eaten fresh and before consumption, a non-thermal method of preservation is applied. The shelf life of these items is very limited because of these minimal manufacturing activities, even though maintained at the optimal storage conditions of cooling and humidity (Abadias et al., 2008). Ideally, packaging materials for minimally processed goods should have greater gas and ethylene permeability, or contain gas absorbers to cope with high respiration and output of ethylene.

Fig. 1.2: Minimally processed fruits and vegetables

In this study, Active or smart packaging techniques are proposed for better quality retention and shelf-life extension of fresh as well as minimally processed (MP) products of fruits and vegetables. The term ‘active’ reflects to perform some role other than providing an inert barrier to external conditions. “Active packaging (AP) is an innovative concept that can be defined as a mode of packaging in which the package, the product and the environment interact to prolong the shelf-life or enhance safety or sensory properties, while maintaining nutritional quality of the product” (Suppakul et al., 2003). This type of packaging plays an additional role in maintaining the quality of minimally processed produce as compared to traditional packaging systems which are specifically designed to control produce’s deterioration reactions by utilizing active ingredients that have been deliberately included in the packaging material or the headspace of the package (Day, 2008) by inhibiting the growth of pathogenic and spoilage microorganisms, preventing and/or indicating the migration of contaminants, and displaying any package leaks present, thus ensuring food safety. Currently, most active packaging technologies for fruits and vegetables depend on sachet technology, which contains the active ingredients inside small bags that are placed in the food package and these bags are usually permeable to gases but impermeable to the in-sachet contents (Ozdemir and Floros, 2004). Potential technologies being used in active packaging are O2 scavenging, ethylene absorbing, CO2 scavenging/emitting, moisture/humidity regulating, antimicrobial or antioxidant releasing and taint removal systems.

OBJECTIVES OF THE RESEARCH WORK

1. To standardize the technique of preparation of minimally processed products from fruits and vegetables.

2. To study and compare the application and uses of various active packaging ingredients on whole (fresh) as well as minimally processed (MP) products of fruits and vegetables.

APPLICATIONS OF ACTIVE PACKAGING TECHNOLOGIES/SYSTEMS

It is possible to divide active packaging systems into active scavenging systems (absorbers) and active releasing systems (emitters). Unwanted compounds such as oxygen, excess water, ethylene, carbon dioxide, stains and other unique food compounds are extracted by scavenging systems, while releasing systems deliberately add compounds such as carbon dioxide, water, antioxidants or preservatives to packaged foods. The aim of both absorption and release systems is to increase shelf life and/or improve food quality. Through the use of O2, CO2 and ethylene scavengers inside the package, changed atmospheric conditions are generated within the packages by the product itself and/or by active modification techniques.

Table 1.1: Types of active packaging systems

Type of AP	Ingredients/Substances used	Application	Function
O_2 absorbing	Powdered iron oxide, ascorbic acid, glucose oxidase-glucose	Dried fruits, potato chips, fruit tortes, nuts	Inhibit lipid oxidation, mould growth and discolouration
CO_2 absorbing /emitting	Activated charcoal, iron powder-calcium hydroxide, ferrous carbonate-metal halide	Fruits, vegetables, ground coffee and cheese	Absorbs CO_2 produced to prevent package swelling
Moisture absorbing	Silica gel, diatomaceous earth	Dry products, fruit and vegetables	Control moisture
Ethylene absorbing	Activated charcoal, silica gel, zeolite, Fuller's earth	Whole and MP fruits and vegetables	Control fruit & vegetable ripening
Antimicrobial releasing	Sorbates, benzoates, propionates, silver salts, ethanol, peroxide, sulfur dioxide	Fruits, vegetables dry apricots, bakery products and cheese	Inhibit microbial growth
Antioxidant releasing	BHA, BHT, TBHQ, ascorbic acid, tocopherol	Ready-to-eat dry cereals	Inhibit lipid oxidation

The presence of oxygen in food packages can cause many degrading food reactions that can lead to the production of off-flavor and off-odor (e.g. rancidity due to lipid oxidation), colour changes (e.g. pigment oxidation), nutrient losses (e.g. vitamin C oxidation) and can promote microbial growth, resulting in substantial decreases in food nutritional value and shelf life. It also has a major impact on the rate of respiration and the production of ethylene in breathing foodstuffs such as fruits and vegetables. Oxygen scavengers are active additives used in the packaging system to absorb excess oxygen that remains after the container has been sealed, resulting from the respiration of the product, reducing O2 and the permeability of the package. In order to reduce the rate of these rotting and spoiling reactions in foodstuffs, it is therefore necessary to monitor oxygen levels in food packages.

High levels of carbon dioxide (CO2) typically play a beneficial role in slowing microbial growth on surfaces of meat and poultry and in delaying the breathing rate of fruits and vegetables as this gas is more permeable than oxygen through many plastic films used for food packaging, most of the CO2 inside the package usually permeates through the film; if the package has a high CO permeability.

On the other hand, commercial CO2 scavengers use the sachet technology either by using CO2 absorbers or absorbers suitably named as CO2 controllers when applied within the package, when CO2 concentration increases in some foods due to deterioration or respiration reactions and excess CO2 may adversely affect the product (anaerobic metabolism, reduction of pH and colour and flavour) (Brody et al., 2001). In order to suppress microbial growth and prevent foggy film formation, control of excess moisture inside the food packages is necessary. Water accumulation within is more pronounced due to the poor permeability of the fruit package to water vapour, and thus, the excess water deposition within a fruit package typically occurs due to the constant transpiration of the fresh produce, temperature variations in the food packages' high equilibrium relative humidity. Silica gel, calcium oxide and other natural clays are the most widely used moisture scavengers. Ethylene is a growth stimulating hormone that, by increasing the respiration rate of climacteric fruits and vegetables, accelerates maturation and senescence and also accelerates the rate of chlorophyll degradation in leafy vegetables and fruits.

Therefore, the removal of ethylene gas from the headspace of the package delays senescence and preserves the product's appropriate visual and organoleptic consistency. The most popular, cheap ethylene scavenger consists of silica-embedded potassium permanganate that is typically stored in sachets put within the packet. Over the past ten years (Cooksey, 2001), research in the field of antimicrobial food packaging materials has greatly increased as an alternative approach for the protection of unwanted microorganisms on food by adding antimicrobial stances in or coated onto packaging materials (Han, 2000). Direct application of antimicrobial substances to the surface has minimal benefits because the active substances are neutralized or easily dispersed through the food mass from the surface. The use of packaging films containing antimicrobial agents may also be more beneficial if high concentrations are maintained where slow migration or the action of the agents on the surface of the product requires them (Quintavalla and Vicini, 2002). The key potential food applications for antimicrobial films include meat, fish, poultry, bread, cheese, fruit, vegetables and beverages, which, by increasing the shelf life of foods, may play an important role in reducing the risk of pathogenic contamination.

POST-HARVEST QUALITY ENHANCEMENT IN FRUITS AND VEGETABLES

During growth, maturation, ripening and storage, fruits and vegetables undergo biological, chemical and bio-chemical changes. Maintenance of post-harvest quality depends on various factors such as optimum maturity harvesting, harvesting process, proper handling, microbial load minimization and adequate ambience in terms of suitable temperature and relative humidity during storage and transport (Rai et al., 2002). Workneh and Osthoff (2010) investigated some of the post-harvest handling techniques and factors influencing the quality of fruits and vegetables, including the temperature of disinfection, packaging and storage, and found that pre- and post-harvest procedures have an impact on the quality of the product after harvest, which should be measured from the point of view of quality improvement, maintenance and consumer protection. Surendranathan (2005) identified 'fruit ripening' as a physiological process involving the induction/acceleration of a variety of metabolic processes, most of which are enzymatic ally regulated, and he further mentioned that the major changes in degradation occurring during ripening are chloroplast destruction, chlorophyll breakdown, organic acid catabolism, pectin compound inactivation, bronchoplastic breakdown, Thus, he visualized the urgent need to develop technologies to solve post-harvest fruit losses by achieving viable technology and adding alternative value to consumers through the production of creative consumer-interest products. Major efforts have been made in recent years to grow several post-harvest packages in India and abroad to minimise post-harvest losses in fruit and vegetables (Arya, 2004).

However, due to their greater susceptibility to water loss, cut surface browning, higher respiration rates, increased ethylene biosynthesis and action along with microbial growth, the rapid growth of MAP (Modified atmospheric packaging) for the preservation of fresh-cut (minimally processed) products is of great interest (Lange, 2000).

MINIMAL PROCESSING (MP) OF FRESH-CUT FRUITS AND VEGETABLES

In the ready-to-use (RTU) vegetable industry, tremendous growth has largely been attributed to increased demand for fresh, nutritious and convenient foods. Mehyar and Han (2010) suggested that most fresh-cut fruits and vegetables are normally consumed before consumption by fresh and non-thermal preservation methods; thus, due to the increased demand for better quality, fresh and convenient food items, there is an increased consumption of these products. Consumers have also become critical for the use of synthetic additives to preserve food or improve characteristics such as color and flavor, as stated by Bruhn (2000), while Kader (2002) stressed that customers typically judge the quality of fresh-cut fruit at the time of purchase on the basis of appearance and freshness. Ohlsson (2002) indicates that minimal techniques of processing have arisen to meet the challenge of replacing conventional preservation methods while preserving nutritional and sensory consistency. Fresh-cut products are described by the International Fresh-cut Produce Association (IFPA) as fruits and vegetables that have been trimmed and/or cut into 100% usable product that is bagged or pre-packaged to provide high nutrition, comfort and flavour while preserving customer freshness.

Ahvenainen and Hurme (1994) suggested that fresh fruit attracts consumers because they are fresh, nutritious, low-priced and ready-to-eat, so a wide range of MP fruits has been produced and referred to as 'easy' and 'convenient' products that can benefit from the healthy image of the fruit. Manvell (1997) described MP as non-thermal technologies for processing food in a way that guarantees food safety and preservation and retains as much as possible fresh-like characteristics of fruits and vegetables, while Jongen (2002) added that these products satisfy the need of consumers for 'fast' and 'convenient' products that maintain their nutritional value, retain a natural and fresh c The microbiological, sensory and nutritional shelf-life of MP vegetables or fruits should be at least 4-7 days, but ideally longer, up to 21 days depending on the market, according to Ahvenainen (1996); the loss of ascorbic acid and carotene is the key limiting factor of nutritional quality and he further claimed that the development would change as a result of peeling, grating and shredding. Minimal processing practises alter the integrity of fruits, resulting in changes in product quality such as browning, production of off-flavor and breakdown of texture, and the presence of microorganisms on the fruit surfaces may compromise the safety of fresh fruits (Rojas-Grau et al., 2009). MP output deteriorates due to faster biochemical changes and microbial spoilage, which can lead to deterioration of the product's color, texture and flavor (Varoquaux and Wiley, 1994) and several cells are ruptured during peeling/grating operations, and intracellular products such as oxidising enzymes are published.

CONCLUSIONS

In the Department of Food Technology, Guru Jambheshwar University of Science and Technology and CCSHAU, Hisar (Haryana) during 2007-2011, the current investigation entitled 'Studies on minimal processing and preservation of fruits and vegetables through active packaging' was conducted. The goal of the research was to standardize and maintain the steps for the minimal processing of fruits and vegetables by applying the principle of active packaging. The findings obtained during the study course are summarized below: 1. On the basis of sensory assessment ratings, proper cutting shapes of fresh-cut fruits and vegetables were adopted and scored highest for the most approved types of minimal processing, i.e. vertical peel slices in apple, horizontal peel slices in banana, orange intact fragments, tomato horizontal slices, medium-sized cauliflower florets and spinach trimmed. 2. It can be summarized that for MP apple, banana, tomato, cauliflower and spinach, chatoyant coating treatment followed by ethylene scavenger and moisture scavenger treatments were the most successful among AP treatments, while for MP Orange, ethylene and moisture scavenging treatments followed by chitosan coating treatment were found to improve shelf life at refrigerated temperature.

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