ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

REVIEW ARTICLE

Post Harvest Losses of Fruits, Vegetables and Its Safety-A Review

Puttalingamma .V
Defence Food Research Laboratory, Mysore, Karnataka, India.

Manuscript Info

Manuscript History:

Received: 11 November 2014
Final Accepted: 22 December 2014
Published Online: January 2015

Key words:

Post harvest losses, Edible Coatings, Carnauba Wax, nisin, shelf life, Fruits and Vegetables

Corresponding Author

Puttalingamma .V

Abstract

Vegetables are highly perishable agricultural commodities due to high moisture content and higher metabolic activities. The post-harvest losses recorded during previous decades are alarming. Spoilage of fruits & vegetables mainly occur due to microbial attack, auto-oxidation and insect pest attack. As a result, about 25 to 30 per cent of the production is lost after harvest due to improper handling, storage and microbial contamination. As processing technology is a young science in India, the aim of this work is to review the existing knowledge about the way in which minimally processing along with edible coatings like carnauba wax and nisin can improve the shelf life of salad vegetables during storage at room temperature as well as at low temperature. With the simple non expensive technique the vegetables produced may be preserved for longer periods; also to make the vegetables available to consumers in a form of closer to fresh produce. These newer approaches aimed at preserving both the freshness and nutritive value of vegetables have revolutionized the vegetable processing technologies, but have not yet been widely adoptable owing to lack of infrastructure and unfavourable economics for small scale operations.

INTRODUCTION

SCOPE AND IMPORTANCE OF EXTENDING THE SHELF LIFE OF FRUITS AND VEGETABLES:

India grows a wide range of fruits and vegetables due to varied agro-climatic conditions. As per the NHB (2011) report, the production of fruits is 72.28 million tons and that of vegetables about 133.54 million tons. During 2012-13 India produced 81.285 million metric tons of fruits and 162.19 million metric tons of vegetables in India exported fruits and vegetables worth Rs. 8760.96 crores, but in India we process only 1.5% to 2%. Post harvest sources of contamination include fecal matter, processing equipment, transport contamination, insect, dust, rain water, ice, storage temperature, kind of food involved, kind of microorganisms present, packaging materials, apart from normal surface flora (Burnett et al**.**, 2001, Vishwanathan et al., 2001). These microorganisms lead to various types of spoilage of vegetables (Puttalingamma et al., 2012). Gram-negative bacteria flora like *Erwinia* and *Pseudomonas* are major microorganisms which causes spoilage of vegetables. These spoilage organisms thrive and multiply faster at ambient temperatures and high humidity. Many of these spoilage organisms multiply even at lower temperatures during refrigeration. Refrigeration of vegetables for long period results in spoilage due to the growth of Psychrotrophic bacteria, they are capable of surviving and multiplying in refrigeration temperature (Burnett et al., 2001, Vishwanathan et al., 2001).

PHYSICAL CAUSES FOR VEGETABLE LOSSES

Vegetables after picking and before processing are "alive". Physical and chemical changes takes place after harvest and continue during storage periods (Salunkhe et al., 1998 Raffaele Porta, et al., 2013). Major physiological changes ensuing post harvest period are:

1. **Loss of moisture:** Loss of moisture leads to rapid shrivelling and loss of crispness. Plant tissue become mushy and eventually inedible, it leads to loss of soluble carbohydrate and reduction in weight. Moisture loss from surface initiates immediately after harvest and continue during storage or transportation period (Verma et al., 2000).
2. **Loss of stored energy:** Vegetables are living tissues, respiration that occurs during post harvest period require energy. The stored carbohydrates are degraded for the purpose of energy supply.
3. **Loss of food constituents:** Moisture loss during storage is the major factor responsible for nutrient loss. The most labile nutrients that are lost are vitamins.
4. **Fiber development:** In vegetables such as beans, knolkhol and carrot, pectin degradation takes place as a result of moisture loss. The tissues become hard and fiber development takes place.
5. **Root and shoot development:** Certain vegetables like beans, potatoes and root vegetable develop such parts during storage.
6. **Loss of nutritional important pigments:** Chlorophyll, Carotenoids, Lycopenes and Xanthophylls are degraded during storage**.** The extents of loss are proportional to period of storage and hostile atmosphere.
7. **Overall Quality:** Owing to the losses described above, the stored vegetables have poor overall quality.

CONTAMINATION OF VEGETABLES AND PATHOGENIC BACTERIA

Vegetables are exposed to various types of contaminants. They generally contain heterogeneous microflora, total microbial population depends on the field organisms and other bacteria encountered. Hence galaxies of pathogens that form surface microflora of vegetables are, *Salmonella, Aeromonas hydrophila, Listeria monocytogenes.* Association of vegetables with the outbreaks of human Listeriosis is often reported. L. monocytogenes have been isolated from cabbage, cucumber, radish, tomatoes, salad vegetables, beans sprout etc. (Karen et al., 2002; Wells et al., 1997 and Francis et al., 1999).

EXTENDING SHELF LIFE OF VEGETABLES

Protection of fresh produce should commence from the field before harvest. Various types of physical damages occur during handling of the products. After the harvest, immediately they were dumped in to trucks, corners of the rooms, baskets etc. Most important are surface injuries like cuts and creaks i.e. impact injuries that contribute to deterioration of the horticulture produce. Microorganisms grow rapidly on such surfaces and lower its nutritional value. Some of the intrinsic factors such as moisture, temperature, nutrient components are important factors for consideration. Microorganisms need water in an available form to grow on food products. Control of moisture content in foods is one of the oldest exploited preservation strategies.

METHODS OF VEGETABLE PRESERVATION

Methods of food preservation have been known for thousands of years. Preserved foods have even been discovered from ancient Greek periods. The techniques of food preservation can be separated into two groups: physical and chemical methods.

Physical methods: Preservation such as canning and freezing rely on killing the microorganisms present, or at least stopping their growth for long enough to allow the food to be safely consumed. Other physical methods include drying, applications of gamma irradiation, ultraviolet or high intensity white light, ultra high pressure and filtration. Cold storage is most common method employed in commercial establishments for storage of vegetables and fruits.

Use of chemicals: Chemical preservatives work either as direct microbial poisons or by reducing the pH to a level of acidity that prevents the growth of microorganisms. A number of food-processing techniques have been developed to prolong the shelf-life of vegetables.

Two commonly used preservative chemicals are:

Inorganic preservative: Salts like sodium chloride, hypochlorite, nitrite, sulphites, boric acid, borates, alkalies, metals like – silver, halogens like chlorine, iodine, H_2O_2, gases like ozone etc.

Organic preservative: Lactic acid, citric acid, benzoates, parabenzoates, sorbic acid, acetic acid, propionic acid, sugar, alcohols, spices, wood smoke etc.

- Sulphites are commonly used to prevent the browning of fruits and vegetables after they've been peeled, and to prevent fungal spoilage.
- Benzoate is also used in preservation. It acts as inhibitor for the growth of yeast and moulds.

Recent methods of preservation

Technological advancement has lead to the development of different technologies in preservation. The objective of such process is to provide food in a form which is near to the fresh product.

Minimally processing of vegetables: Consumer's preference for fruits and vegetables with fresh like quality and conveniences have lead to a new category of foods called minimally processed fruits and vegetables. Minimally processed vegetables have demand in super markets and rapid extension is seen among the consumer. Minimal processing is also defined as surface treatments such as sorting, trimming, washing, peeling, chlorinating, slicing etc. Minimal processing includes a wide range of technologies for preserving short shelf-life vegetable and fruit products while minimizing processes that alter freshness characteristics, this improve quality of the product and extend shelf-life (Karen et al., 2002, Buck et al., 2003, Walcott et al., 2003, Maria et al., 2008).

The concept of ready to use food has created a demand for minimally processed vegetables. Minimally processed vegetables offer a variety of advantages for the consumers i.e. minimal processing is a state of art technology, which maintains fresh like fruits and vegetables in a processed and packed form. The common practices are to wash the fresh produce in potable water several times (2-3 times). This treatment reduces one to two log cycles of surface microorganisms, soil debris as well as, pesticides and insecticides from foods. This should be followed by treatment with surface sanitizers. The known sanitizers are potassium permanganate, sodium hypochlorite and chlorine. However with the advent of new surface application technologies, surface coating of vegetables with a variety of pesticides/fungicides with antioxidants and waxes are in vogue. Nevertheless these techniques are based on age old concepts of preservation. As early as 12th century citrus fruits were processed by coating them with carnauba wax (Kaplan, 1986). This method is based on the "hurdle concept" of processing vegetables. Several microbial growth-limiting technologies are utilized for preservation rather than applying a single extreme treatment. Further by combining gentle bactericidal and bacteriostatic technologies, a greater reduction of microbial load in the product may be achieved as against applying a single extreme treatment. Fresh and minimally processed (MP) fruits and vegetables are often considered to be among the most healthful and safe foodstuffs available.

Irradiation as a preservative technology: Irradiation is yet another established process with clearly documented safety and efficacy. Its efficacy stems from the fact that it does not increase the temperature of the product; it can be used during post packaging. However its application is restricted to only to onion, potatoes and cauliflower.

SURFACE COATING OF VEGETABLES

This is one of the post harvest technology to extend shelf life of vegetables. Edible coating with nontoxic substances which acts as a barrier to gases and water vapors are used. Some fruits and vegetables carry a natural waxy coating called cuticle, (layer of cutin) which acts as a barrier for gas and moisture exchange thereby protects from microbial growth. In combination with wax emulsion water-based coating provides good protection against post-harvest losses (Sebti et al., 2002).

Methods of coating application

Different methods for application of surface coatings are practiced.

Dip coating methods: dipping of fruits and vegetables into a tub or tank containing coating materials is a common practice. This method is applied for meat, fish, poultry, fruits and vegetables. Most perfect methods for fruits and vegetables with unequal surface.

Spraying: is performed in a more uniform and thinner manner than dipping method. Spraying, unlike dipping is more suitable for applying a film to only one side of a food to be covered.

Casting: is accomplished by controlled thin spreading or by pouring to a controlled thickness. Coating materials are applied with sterilized brash on the surface of the vegetables.

Wax coating

Different types of waxes are used, however combination of wax with, antioxidants, fungicides, antimicrobials and other chemicals are preferred. Wax coating was used on citrus fruits in China in 12th and 13th

centuries; they noticed that the wax coating prevented water loss (Hardenburg, 1967; Coma et al., 2001). Carnauba wax and oil in emulsion has been also used for coating fresh fruits and vegetables (Kaplan, 1986). Carnauba, candelilla, rice bran wax and natural plant wax, bees wax are commonly used.

Bio-preservatives

Nisin is an antibiotic and is an accepted preservative in milk and milk products like cheese. Nisin is produced by *Lactococcus lactis*, however, the latest application in food as a preservative is the tender coconut water in cans and sachets.

ANTIMICROBIAL SUBSTANCES FROM LAB

The protective effects exhibited by LAB are due to production of a variety of metabolites. The various metabolites elaborated by LAB and their effects on target organisms is presented in Table - 1.

Table 1. : Metabolic products elaborated by LAB and their antimicrobial properties

Products	Target organisms
Organic acids Lactic acid Acetic acid	Putrefactive effect on Gram- positive and negative bacteria, clostridia, fungi and yeast.
Hydrogen peroxide	Pathogens and spoilage organisms in milk, meat and their products.
Enzymes Lactoperoxidase with H_2O_2	Pathogens and spoilage bacteria-Milk and dairy products.
Lysozyme	Spoilage microorganisms, mainly Gram-positive bacteria.
Low molecular metabolites – Diacetyle Reuterin [3-oH –propionaldhyde]	Gram positive and negative bacteria, yeast and moulds, protozoa and pathogens.
Bacteriocin- Nisin	Food and water borne pathogens, Gram-positive bacteria and spore formers. Antagonistic effect on LAB.
Others	Gram positive bacteria, antimicrobial spectrum according to producer strains and bacteriocin type.

Charumati Mishra et al., (1996)

Nisin is a natural antimicrobial peptide. It is also approved as a natural food preservative by more than 50 other countries as well the Food and Agriculture Organization/World Health Organization and the European Union. The Nisaplin brand of nisin is certified kosher; as well Lactic acid bacteria (LAB) produce a high diversity of different bacteriocins (Puttalingamma et al, 2006). Many LAB bacteriocins have been characterized biochemically and genetically, while certain aspects of these compounds are still unknown. Delves-Broughton (2005) have reported that the heat resistant spores of *Bacillus* spp. are able to survive. Pasteurised soups with Nisin at levels of 2.5–5.0 mg/L is effective at preventing or delaying outgrowth of psychroduric spoilage *Bacillus* spp. during prolonged storage. Nisin is also used in canned dairy puddings containing semolina and tapioca. Uses of nisin to control spoilage lactic acid bacteria have been identified in beer, wine, alcohol production and low pH foods such as salad dressings (FDA, 1998, Cooksey et al., 2000, Natrajan et al., 2000a).

Nisin was used as a food preservative because:

1. Nisin is non-toxic
2. The producer strain *L. lactis* is regarded as safe (food-grade)
3. There is no apparent cross-resistance related to therapeutic antibiotics
4. It is degraded immediately during digestion
5. It is heat stable at low pH

Table 2: Nisin as a permitted additive in different countries

Country	Food in which nisin is permitted	Max level [IU/g]

Australia	Cheese, processed cheese, canned tomato	No limit
France	Processed cheese	No limit
Peru	Any food	No limit
UK	Cheese, canned foods, clotted creams	No limit
US	Pasteurized processed cheese spreads	10,000
Russia	Processed cheese, canned vegetables	8000
Netherlands	Factory cheese, processed cheese, cheese powder	800
Italy	Cheese	500
Mexico	Any food	500
Argentina	Processed cheese	500
Belgium	Cheese	100
India	Cheese, Tender coconut water	10 mg / Lit 1500 mg / Kg

Ref no –127 gazette notification

Nisin is used in canned foods mainly for the control of thermophilic spoilage. It is mandatory in most countries that low acid canned foods (pH>4.5) receive a minimum heat process of $F_0 = 3$ to ensure the destruction of *C. botulinum* spores (Delves-Broughton et al., 2005).

Conclusion

All over India people are suffering from nutritional losses and acceptability determination as well due to the drastic methods of processing and preservation. Coating improves product appearance, colour, crispness, flavour, nutritive value, juiciness, texture, etc. Till now, many of the coating operations are done by batch processing. Safety of food product should be maintained in the coating operations. Many of the coating materials are high in cost and some of the coating operations are also higher cost. Moreover it can also help in increasing shelf life of fruits and vegetables in room temperature as low temperature. Nisin is known bactericidal compound from lactic acid bacteria exhibited antagonistic effect against the pathogens (Thomas et al., 2000, Haiping et al., 2002).

Nisin is heat stable and active at low pH, which makes it a good candidate for a natural food preservative. Indeed, it is used in this capacity in many different food products worldwide. Wax coating retards ripening process, reduces chilling, mechanical injury and decay. Small amounts of wax coating may be used on some fruits and vegetables to prevent dehydration and improve the appearance of apples, bell pepper, cucumber, grapes, lemons, lime, orange etc. Nisin incorporated into wax emulsion and applied on the vegetable surface to extend the shelf life of fresh vegetables, giving promising results (Natrajan et al, 2000a, Hanseh et al., 1994). Among all the methods, minimally processing is a non radiation method where no heat treatment is involved, which is well suited for vegetable preservation without losing flavour, colour, texture, eye appeal. With this simple non expensive technique the vegetables produced may be preserved for longer periods; also to make the vegetables available to consumers in a form of closer to fresh produce. These newer approaches aimed at preserving both the freshness and nutritive value of vegetables have revolutionized the vegetable processing technologies, but have not yet been widely adoptable owing to lack of infrastructure and unfavourable economics for small scale operations.

ACKNOWLEDGEMENT

Authors are thanks full to Director DFRL Dr**.** Batra H.**V**, for providing the necessary facility and encouragement.

REFRENCES

1. Buck, J.W., Walcott, R.R. and Beuchat, L.R. (2003): Recent trends in microbiological safety of fruits and vegetables. Plant management network., (1) 0121-01.

2. Burnett, S.L. and Beuchat, L.R. (2001): Human pathogens associated with raw produce and unpasteurized juices, and difficulties in contamination. J. Indust. Microbial. Biotechnol., 27: 104-110.
3. Charumati Mishra and John Lambert (1996): Production of antimicrobial substances by probiotics. Asia Pacific J. Clin. Nutr. 5: 20-24.
4. Coma, V., Sebti-I pardon, P., Deschamps, A., & Pichavant, F.H. (2001): Antimicrobial edible packaging based on cellulosicether, fatty acids and nisin incorporation to inhibit *Listeria innocua and Staphylococcus aureus*. J. Food Protection. 64(4):470-47.
5. Cooksey, K. Utilization of antimicrobial packaging films for inhibition of selected microorganism. In: Risch SJ, editor.(2000): Food packaging: testing methods and applications. Washington, DC: American Chemical Society.p 17 - 25.
6. Delves-Broughton, J. Nisin as a food preservative. (2005): Food Australia 57 (12). 525-627.
7. FDA. Nisin preparation: Affirmation of GRAS status as a direct human food ingredient Fed. Reg. (1998): 53:11247.
8. Francis, G. A., & O'Beirne, D. (2002): Effects of vegetable type and antimicrobial dipping on survival and growth of Listeria innocua and E. coli. International Journal of Food Science and Technology, 37(6), 711.
9. Haiping, Li and Daniel J. O'Sullivan.(2002): Heterologous Expression of the *Lactococcus lactis*, Bacteriocin, Nisin, in a Dairy *Enterococcus* Strain. Applied and Environmental Microbiology, 2002, p. 3392-3400, Vol. 68, No. 7.
10. Hanseh, J N. Nisin as a model food preservative. (1994): Critical review, Food sci and nutri, 34(1):69-93.
11. Joss Delves- Broughton. (2007): Senior Application Specialist, Danisco, UK (Courtesy of the Egg Forum 2007). Use of Nisaplin® as a preservative in pasteurised liquid egg products. Publication date: 24/09/2007.
12. Kaplan, H.J. (1986): Washing waxing and colour adding in fresh citrus fruits. WF Wardowdki S Nagy and W. Grierson.Eds. AVI, Pub. Co. Eds Westport. CT; 379.
13. Karen, M. Schuenzel and Mark. A. Harrison. (2002): Microbial antagonists of food borne pathogens on fresh, minimally processed vegetables. J. of Food Protection. 65(12): 1909-1915.
14. Maria Vargas, Clara Pastor, Amparo Chiralt, D. Julian McClements, and Chelo Gonzalez-Martinez. (2008): Recent Advances in Edible Coatings for Fresh and Minimally Processed Fruits. Critical Reviews in Food Science and Nutrition. 48:496-511.
15. Natrajan,N., Sheldon, B.W (2000a): Efficacy of nisin coated polymer films to inactivate *Salmonella typhimurium* on fresh broiler skin. J Food Prot. 63(9):1189 –1196.
16. Puttalingamma,V and Khyrunnisa Begum (2012): An approach of conventional coating method to minimize spoilage and sensory quality of cucumber and capsicum. International Journal of Science Innovations and Discoveries. 2 (6), 511-518.
17. Puttalingamma,V., Khyrunnisa Begum and A.S. Bawa. (2006): Antimicrobial Peptides-New Weapons Against Enteric Pathogens. Pakistan Journal of Nutrition.5 (5): 432-435, 2006.
18. Raffaele Porta., Giovanna Rossi-Marquez., Loredana Mariniello., Angela Sorrentino., C. Valeria, L., Giosafatto., Marilena Esposito and Prospero, Di, Pierro.(2013).Edible coating as Packaging Strategy to Extend the Shelf-life of Fresh-Cut Fruits and Vegetables. Journal of Biotechnology & Biomaterials. 3:4,1-4p.
19. Salunkhe, D.K. and Kadam, S.S. (1998): Ed. Hand book of vegetable science and technology Production, composition, storage and processing. Marcel, Dekker, INC, New York.
20. Schillinger, U., Beeker, B., Vignolo, G. and Holzapfel, W.H. (2001): Efficacy of nisin in combination with protective cultures against *Listeria monocytogenes* Scott A in tofu. Int. J. of Food Microbiol**.,** 71: 159-168.
21. Sebti, I., Ham Pichavant, F., & Coma,V. (2002): Edible bioactive fatty acid-cellulosic derivative composites used in food-Packaging applications. J. of Agricultural and Food Chemistry., 50(15): 4290-4294.
22. Thomas,B., L.V., Clarkson., M.R. and J. Delves – Broughton.(2000): Natural food antimicrobial system. A.S. Naidu (Eds.), CRC Press, London, W.D.C. Chapter 18 (Nisin), 463-524.
23. Thompkinson, D.K. and Singh, A.K. (2000): Natural Food Preservation Systems. Indian Food Industry, Sept. 19: 330-339.
24. Verma, L.R. and Joshi, V.K. (2000): Post harvest technology of fruits and vegetables. Indus Publishing Co., New Delhi.
25. Vishwanathan, P., Randhir - Kaur. (2001): Prevalence and growth of pathogens on salad vegetables, fruits and sprouts. Int. J. Hygiene and Environ. Health., 203(3): 205-213.
26. Walcott, R.R and Beuchat, L.R. (2003): Recent trends in microbiological safety of fruits and vegetables. Plant management network, (1) 0121-01.