Keeping the Quality of the Fresh Cut

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Written for presentation at the
2004 CIGR International Conference · Beijing
Sponsored by CIGR, CSAM and CSAE
Beijing, China
11- 14 October 2004

Abstract. *Fresh cut products are to be intended as horticultural products, which are prepared and handled to maintain their fresh nature while providing convenience to the user. Growth in demand has led to increased marketing of fresh fruits and vegetables in fresh-cut products form. Therefore many firms dedicated to this type of food processing have been established. Fresh-cut produce can help increase the consumption of fresh produce due to its convenience and attractive appearance and flavor. The physical damage or wounding caused by preparation increases respiration and ethylene production, which leads to increase other biochemical reactions responsible for changes in color, flavor, texture and nutritional quality such as vitamin loss.*

Development of novel approaches for assuring the quality and safety of fresh-cut produce depends on a better understanding of fresh-cut vegetable and fruit physiology, including nutrients and other functional components as affected by storage and handling. This thus requires integration of quality management techniques like sanitation, color and texture preservation and temperature management. Different methods and techniques used to maintain good quality of fresh cuts are reviewed in this paper.

Keywords. fresh cut, fruits and vegetables, sanitation

Introduction

Fresh-cut products or minimally processed horticultural products are prepared and handled to maintain their fresh nature while providing convenience to the user. The minimally processed ready-to-eat vegetable industry was initially developed to supply restaurants, hotels and other institutions and more recently was expanded to include food retailers for home consumption.

Whereas most salads and other vegetables are still prepared at home, the inclusion of minimally processed ready-to-eat vegetables has moved the preparation of these products from the consumer. The increased time and distance between processing and consumption may contribute to higher risks of food-borne illness. Although chemical and physical hazards are of concern; such as the presence of agricultural chemicals and food additives above the maximum residue limits or the presence of metals and other injurious particles; the hazards specific to minimally processed ready-to-eat vegetables reside mainly with microbial contaminants.

The term minimal processing covers a wide range of technologies and methods for preserving foods during their transport from the site of agricultural production to consumer. Consumers are increasingly demanding convenient, ready to use and ready to eat fruit and vegetables with a fresh like quality, and containing natural ingredients. Increased product safety is also much demand by producers and distributors. The fresh like products are highly perishable and actions that increase safety are important. Technologies that allow for a two or three fold extension of the shelf life are also very important to decrease the food losses.

In order to produce fruits and vegetables with greater convenience, centralized cleaning, peeling and cutting is carried out. The resultant products are often less stable due to the enzymatic activity of the cut cell walls and also to bacteriological contamination from handling during treatment. Various post-harvest treatment methods are employed to increase the biological stability and to extend the shelf life of products. In all these treatments, low temperatures and good processing hygiene are essential to maintain food safety and to achieve desired shelf life.

Methodology

The paper was entirely based on the review of secondary data obtained from different sources. These sources included, scientific papers published in different journals, information from the Internet, fresh cut magazines, consultation with relevant subject matter specialists at the Volcani center and knowledge from personal experience of the group members as well as the knowledge obtained from the course.

Quality Preservation Methods in Fresh-cuts

Washing and Disinfection

1. Washing

Vegetable contamination in the field has been recognized as a source of human infection and illness. For fresh cut vegetables and fruits that are eaten raw, there is no treatment that can be relied upon to totally eliminate contaminating microorganism. Washing with anti-microbial compounds, while important, often brings about a relatively small reduction. Eliminating the risks is difficult. Managing them is based on identifying and controlling those factors that are important in preventing contamination or limiting the growth of pathogenic microorganism.

Washing fruits and vegetables in potable water removes a portion of microbial cells. In some instances vigorous washing can be as effective as treating with water containing 200mg/l of chlorine, which generally reduces population by 10-100 folds. In washing, the temperature of the wash-water should be higher than that of the produce to minimize the uptake of micro-organism by tissues.

Prevention of contamination of fruits and vegetables at all points from the field to the plate through application of good agricultural practice, good manufacturing practice and HACCP programs is preferred to the application of chemical disinfectants after contamination has occurred.

2. Disinfection

Although disinfectants have variable effectiveness on pathogen control of fresh cut fruits and vegetables, they are certainly useful for sanitizing water to prevent contamination of produce from water reuse or water whose quality cannot be guaranteed.

3. Chlorination

Chlorination is still the most widely used sanitizer, though it is on its way out as environmental regulations has recommended its prohibition. Disinfect ion by chlorination has had many applications in harvest, post-harvest handling and marketing display of fresh fruits and vegetables for many decades. The primary uses of chlorine have been to inactivate or destroy pathogenic bacteria, fungi, viruses, cysts, and other microorganism associated with seed, irrigation water, horticultural implements, and contact surfaces – including humans, with fresh produce. Chlorination has been routinely used to treat post harvest cooling water, in post harvest treatments and during dehydration at shipping destinations.

Legally, agricultural chlorine is commercially available in four forms that have been approved for use (registered) by the U.S. Environmental Protection Agency (EPA) and by individual states such as California (California Department of Pesticide Registration).

1) Chlorine gas (Cl_2) – the least expensive but most demanding source of chlorine from a safety and monitoring standpoint. Generally restricted to use in very large operations, the use of chlorine gas requires automated, controlled injection systems with in-line pH monitoring. Chlorine gas reduces the pH of water to below 6.5. Chlorine gas is commonly used for situations were soil, plant debris, and decaying fruit or vegetables may enter early stages of washing and grading.

2) Calcium hypochlorite ($CaCl_2O_2$) – the most common source of chlorine used for disinfection of produce and produce process water. Registered formulations are 65 percent or 68 percent active ingredient (i.e.). It is available as a granulated powder, compressed tablets, or large slow-release tablets. In dry storage, calcium hypochlorite is more stable than liquid sodium hypochlorite. Phytotoxicity (bleaching or burning) of produce can occur if calcium hypochlorite granules fail to dissolve in cool wash tank water or in a hydro cooler system.

3) Sodium hypochlorite (NaOCl) – the source of chlorine commonly used in small-scale operations. It is generally used in concentrations of 5.25 percent or 12.75 percent .i e. in liquid form, because the solid forms readily absorb water from air and release chlorine gas.

4) Chlorine Dioxide (ClO_2). A yellow to red gas with 2.5 times the oxidizing potential of chlorine gas, chlorine dioxide is explosive at concentrations above 10 percent a.i. or at temperatures above 130°C (266°F). On-site generation of chlorine dioxide is also available by combining chlorine gas and sodium chlorite or sodium hypochlorite, hydrochloric acid, and sodium chlorite. The disinfecting power of chlorine dioxide is relatively constant within a pH of 6 to 10. It is effective against most microbes at concentrations of 3 to 5 ppm in clean water.

Chlorination and Post Harvest Food Safety

The source and quality of water for post harvest operations is critical to control. Potable (suitable for human consumption) water should be used for all post harvest washing, grading, and cooling operations. Contaminated water used during post harvest operations can transmit diseases that decay the produce or adversely affect human health. Several incidents of food-borne illness associated with fresh produce (green onions, parsley, cilantro, melons, leaf lettuce) have been linked to unsanitary wash water or ice or used for cooling during transportation and distribution.

1. Chlorine demand and fruit and vegetable handling

Under typical harvest operations of many fruits and especially leafy vegetables adhering soil and organic debris can be a problem and greatly reduce disinfection efficiency. Chlorine is highly reactive with leaves, soil, and any plant or vegetable matter whenever oxygen is present. Each chemical reaction reduces the amount of active chlorine in the water. Removing field soil before sending bins or palletized loads of harvested crop into flotation tanks, chemical treatment showers, or hydro coolers will greatly aide in pathogen inactivation, chlorine use efficiency, and minimize the production of chlorinated disinfection's by-products.

2. Improving chlorination efficacy: surfactants

The efficacy of chlorination on water disinfection and microbial load reduction on product surfaces may be enhanced by the use of surfactants. Typically the extent of microbial population reduction on plant surfaces is limited to a 10 to 100-fold reduction, dependent on many factors. Water films that form on very small contours on plant surfaces may prevent the chlorinated water from directly contacting target microorganisms. To increase the penetration of hypochlorous acid into plant contours and natural openings, approved detergents are added to the process water reducing water surface tension and increasing the effectiveness of chlorination in some situations. Recently, further enhancement of disinfection has been achieved by using ultrasound equipment attached to wash tanks.

3. Monitor, control, and documentation practices

Accurate monitoring, control and recording of disinfection procedures and performance are important components of a sound post harvest quality and safety program. Oxidation-Reduction Potential (ORP), measured in millivolts (mV), has recently been introduced to fresh produce packers and shippers as an easily standardized approach to water disinfection for harvest and post harvest handling. Operationally, much like a digital thermometer or pH probe, ORP sensors allow the easy monitoring, tracking, and automated maintenance of critical disinfectant levels in water systems that fits in well to a foundation of Good Agricultural Practices (GAPs) and the evolving agricultural equivalents of Hazard Analysis Critical Control Point (HACCP) programs.

4. Disinfection by ozone

Ozone finds applications in natural disinfection, water air purification systems and fresh fruits vegetables storage. Recent findings show that ozonized water keeps the quality and flavor of fruits. The hot, off-smell of chlorinated water is absent. Ozone is unsurpassed in natural control and killing of common bacteria like E. coli, Fecal Coliform, mold, and virus and deactivation of cysts.

Ozone will oxidize organic chemicals into safer elements. During the ozonation process, some compounds like ammonia and cyanide is broken down into nitrogen and water or other safe compounds. In all reactions, the main by-product after oxidation is oxygen. Ozone, if injected into the ponds will break down contaminates while oxygenating it at the same time. The waste material is more biodegradable after oxidation and safer for the environment. Ozone does not change the pH, nor does it react with the remaining organics to produce carcinogenic trihomethanes.

Ozonated water is free of algae, bacteria, cyst, mold, viruses and yeast, parasites. The taste is improved making it softer with less scale buildup in appliances and plumbing lines with no stained fixtures and less tub rings. It oxidizes organics, iron, heavy metals and other contaminates. Water without chemicals and offensive chlorine and sulfur odors is possible.

5. Irradiation

The efficacy of irradiation stems from the fact that its biocidal effect is not limited to the surface, since it penetrates the product and eliminates microorganism that present in crevices and creases, pockets and natural opening in the skin as well as the interior. Recent works on shredded carrots, pre-cut bell peppers, cut romaine lettuce, diced celery and other ready to eat vegetables showed that microbial and pathogen counts can be significantly reduced by low-dose irradiation without affecting sensory characteristics.

The irradiation of fruits and vegetables is approved by US-FDA to a maximum of 1kGy for disinfection. It is difficult, if not impossible to either wash pathogen off produce completely or inactivate by chemical treatments. Irradiation is a promising technology that can be used to improve the safety of ready to eat fruit and vegetables. Combination of irradiation with other treatments such as chlorination seems especially promising.

Color Preservation

1. Enzymatic browning

Enzymatic browning is the most limiting factors on the shelf life of fresh-cut products. During the preparation stages, produce is submitted to operations where cells are broken causing enzymes to be liberated from tissues and put in contact with their substrates. Consequences of enzymatic browning are not restricted to discoloration, undesirable tastes can also be produced and loss of nutrient quality may result. PPO (polyphenol oxidases) has been considered one of the most damaging enzymes to quality maintenance of fresh produce.

Different factors such as pre-harvest, post harvest and processing factors, browning and enzymes other than polyphenoloxidase affect the browning. In pre-harvest factors, the agricultural practices, soil, fertilizers, climate and harvesting may contribute in the development of browning. Susceptibility to browning may differ from cultivar to cultivar. Figure 1 shows differences in shelf life of different cultivars of fresh-cut pear slices.

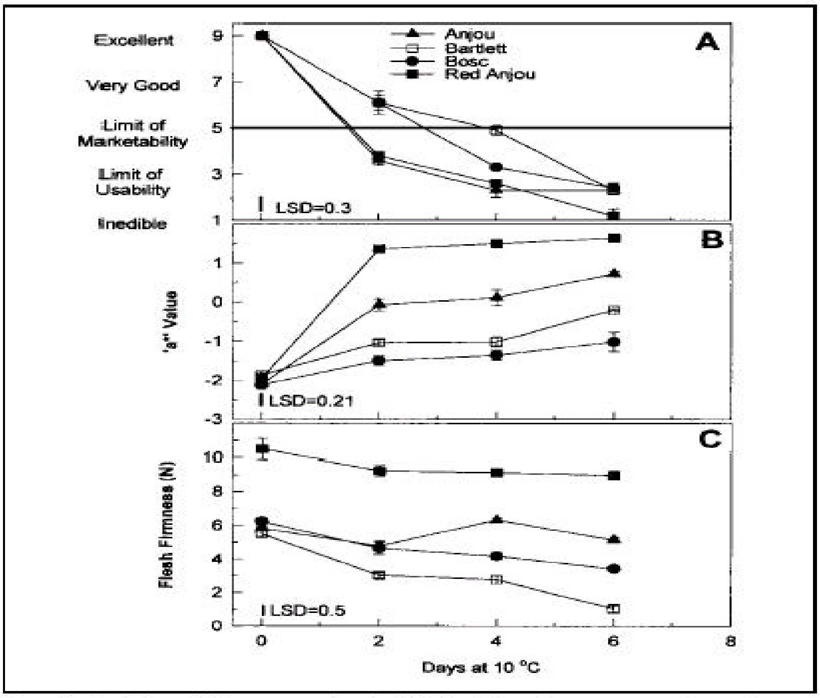

Fig.1. Cultivar differences in shelf life of fresh-cut pear slices based on (A) the number of days to a visual quality score of 5 (limit of marketablility), (B) cut surface browning intensity (a* value), and (C) fresh firmness. Bartlett, Boscm, and Anjou were ripened to 65±8.9N firmness, cut, and then kept in air at 10℃ and 90% to 95% relative humidity. Data shown are the means (± standard deviation) of 3 replicates. Vertical bar=pooled LSD at the 5% level.

The browning can be controlled through physical and chemical method. In chemical method, sulfites had a widespread application in controlling both enzymatic and non-enzymatic browning. Heat inactivation is an effective method of browning prevention, and PPO is considered an enzyme of low thermo stability, although differences in heat stability are reported for different cultivar and PPO isoforms.

Preservation of fresh-cut products can be achieved using a combination of treatments. A common treatment combination includes ascorbic acid and calcium chloride for the prevention of apple slices. Table 3 shows that the highest concentrations of ascorbic acid (1%) and $CaCl_2$ (0.1%) utilized resulted in the lowest loss of reflectance or browning readings. It also showed that the use of $CaCl_2$ alone caused almost as much inhibition on Newton Pippin apples, this was not so for Golden Delicious.

2. Physical treatments and browning control

Low temperature is one of the most commonly used approaches to controlling enzymatic activity in fresh-cut products during handling. At low temperatures, not only is enzymatic activity reduced, but also general metabolic rates are lower, which assists in extending product shelf life.

Table 3. Concentrations of Ascorbic Acid (1%) and $CaCl_2$ (0.1%) Result Browning

Loss of Reflectance compared to freshly sliced pineapples		
TREATMENT	var. Newton Pippin	var. Golden Delicious
Control - water dip	62.5	60.5
0.05% CaCl2	24.8	58.9
0.1% CaCl2	23.3	51.2
0.5% AA	57.9	59.2
0.5% AA + 0.05% CaCl2	26.9	48.0
0.5% AA + 0.1% CaCl2	24.2	25.6
1% AA	25.5	45.6
1% AA + 0.05 CaCl2	20.5	39.2
1% AA + 0.1 CaCl2	4.2	17.0

3. Reducing oxygen availability

This treatment includes modified atmosphere packaging (MAP) and edible coatings. It is important to avoid damaging low levels of oxygen or high levels of carbon dioxide, which lead to anaerobic respiration, resulting in the development of off-flavors and odors and increasing susceptibility to decay. Using a moderate vacuum packaging with polyethylene (80µm) for the storage of shredded Iceberg lettuce at 5°C was inhibited over a 10-day period. MAP was also efficient in controlling microbial buildup during storage.

On the other hand, edible coatings are used as a semi-permeable barrier that helps reduce respiration, retard water loss and color changes, improve texture and mechanical integrity, improve handling characteristics, help retain volatile flavor compounds and reduce microbial growth. In the application of some coatings it is possible to induce the formation of cross-links between pectin molecules of the fresh-cut product surface and the coating. Interestingly, different food additives can be incorporated into coating formulation, such as coatings with antioxidants (e.g. ascorbic acid).

4. Other color changes

Although browning discoloration is the major color change occurring on various fresh cut vegetables and fruits, other color changes also occurs on some vegetables that also affects their quality. Some of these colorations are white blush in carrots and yellowing or degreening in lettuce and broccoli and are discussed below.

5. White blush in carrots

This is also known as white bloom and is a discoloration defect that results in the formation of a white layer of material on the surface of peeled carrots, giving a poor appearance to the product. Once the carrots are exposed to the air, they dehydrate and the dried cell debris acquires a whitish color forming a white layer on the carrot surface thus affecting the quality.

Coating carrots with edible films have also been shown to control this quality defect. Losses of carotenes have been described in fresh cuts carrots, and with application of an edible coating

50% retention of beta-carotene were obtained after 28 days of storage compared with 33% in the control.

6. Yellowing or degreening

Yellowing or loss of the green pigmentation is a normal process that occurs in many fresh cut green vegetables and fruits during ripening or senescence. This is mainly accelerated by increased respiration or increased ethylene production that occurs during ripening or upon wounding of the fresh cut produce.

During the preparation process of fresh cut products, there is a release of acids and enzymes and these may be involved in the loss of the green pigmentation. Use of modified atmosphere packaging and storage at 10º C has been used to retain the green color of broccoli. In their study, the concentrations of carbon dioxide and oxygen inside the broccoli package reached equilibrium within 48 hours and were 8% and 10% respectively. This caused reduction in respiration rate and the modified atmosphere packaging contributed to retention of the green color of the broccoli.

Prevention of Texture Loss in Fresh-cuts

After harvesting it is important to store fruits and vegetables at the appropriate temperature and relative humidity to preserve their quality. Plant tissues are in equilibrium with an atmosphere at the same temperature with an RH of 99-99.5%. Cutting or peeling the fruit or vegetable exposes the interior tissues and drastically increases the rate of evaporation of water. The difference in rate of water loss between intact and wounded plant surfaces varies from about 5 to 10 fold for organs with lightly suberized surfaces (e.g. carrot and parsnip), 10 to 100 fold for organs with cuticularized surfaces (e.g. spinach leaf, bean pod, and cucumber fruit), to as much as 500 fold for heavily suberized potato tubers.

Tissue softening is a very serious problem with fresh-cut fruit products that can limit shelf life. Flesh firmness of fresh-cut fruit products can be maintained by application or treatment with calcium compounds. Dipping fresh-cut products in solutions of 0.5 to 1.0% calcium chloride is very effective in maintaining product firmness. However, calcium chloride may leave bitter off flavors on some products. Firmness of slices from 12 untreated apple cultivars stored at 2 °C (35.6 °F) decreased steadily for 7 days and more rapidly thereafter.

Conclusion

Fresh-cut vegetable and fruit products differ from traditional, intact vegetables and fruits in terms of their physiology and their handling requirements. Fresh-cut vegetables deteriorate faster than intact produce usually because of the wounding associated with processing. Integration of good sanitation, proper handling, proper packing and proper temperature management techniques along the marketing channel from the harvest point until the consumption point is essential to attain high quality level of fresh cut produce.

Avoiding desiccation at the cut surface of some fresh-cut products is critical for maintaining acceptable visual appearance. Flesh firmness of fresh-cut fruit products can be maintained by application or treatment with calcium compounds. Calcium is thought to stabilize membrane systems and maintain cell wall structure in vegetables and fruits.

Yellowing or loss of the green pigmentation is mainly accelerated by increased respiration or increased ethylene production that occurs during ripening or upon wounding of the fresh cut produce. Browning in fresh-cut produce can be controlled through physical and chemical methods. In chemical method, sulfites had a widespread application in controlling both enzymatic and non-enzymatic browning. The physical methods include, modified atmosphere storage and storage under controlled temperature.

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