Journal of food processing and technology

OPEN ACCESS Freely available online

Research Article

Novel Approach to Enhance the Shelf Life of Fresh Cut Fruits and Vegetables: A Review

Desta Dugassa Fufa*

Department of Food Science and Postharvest Technology, Haramaya Institute of Technology, Dire Dawa, Ethiopia

ABSTRACT

The market for chilled fresh-cut produce has witnessed dramatic growth in recent years, stimulated largely by consumer demand for fresh, healthy, convenient and additive-free foods which are safe and nutritious. Growing consumer interest in international markets in new or exotic tastes has promulgated growth in the international trade of fresh-cut products. Consumers generally purchase fresh-cut produce for convenience, freshness, nutrition, safety and eating experience. Fresh-cut processing involves cutting through the tissue of fresh produce, thus causing major tissue disruption and release of enzymes that interact with substrates associated with the fruit tissue. Wounding of the fruit tissue by cutting also increases ethylene production and stimulates respiration and phenolic metabolism. Slicing, dicing and shredding procedures as well as temperature abuse during storage can, however, result in increases in populations of mesospheric aerobic microorganisms associated with fresh-cut products. Therefore, it is essential to adopt various strategies that can minimize quality loss and assure safety for fresh cut produce.

Shelf life of fresh cut produce can be extended by adopting several chemical and physical posts cutting treatments viz. acidification, use of reducing agents, application of edible coatings, natural antimicrobials, use of firming agents and by reducing the O_2 levels by means of modified atmospheric packaging. Quality loss can be reduced and safety of fresh cut produce can be achieved by minimizing mechanical damage during cutting, transfer of contamination during washing operation and also temperature management during processing operations and post processing period. In a nutshell, the fresh cut produce stability can be enhanced to a greater extent by adopting combined treatment techniques.

Keywords: Biochemical changes; Fresh cut processing; Physiological changes; Postharvest handling; Shelf life

INTRODUCTION

Fresh-cut fruits and vegetables can be defined as any fresh fruit or vegetable that has been physically modified from its original form (by peeling, trimming, washing, and cutting) to obtain 100% edible product that is subsequently bagged or prepackaged and kept in refrigerated storage. Fresh-cut produce includes any kind of fresh commodities and their mixtures in different cuts and packaging. Items such as bagged salads, baby carrots, stir-fry vegetable mixes, and fresh-cut apples, pineapple, or melon are some examples of this type of product. Growing consumer interest in international markets in new or exotic tastes has promulgated growth in the international trade of fresh-cut products. The production of fresh-cut produce requires relatively little product transformation; it requires investment in technology, equipment, management systems and strict observance of food safety principles and practices to ensure product quality.

Nowadays, fresh-cut produce is one of the fastest growing food categories in U.S. supermarkets, where packaged salads are the most important item sold. Fresh cut fruit and vegetable sales have grown to approximately $15 billion per year in the North American food service and retail market and account for nearly 15% of all produce sales. According to the United Fresh Produce Association (2007), the largest portion of U.S. fresh cut

Corresponding author: Desta Dugassa Fufa, Department of Food Science and Postharvest Technology, Haramaya Institute of Technology, Haramaya University, Dire Dawa, Ethiopia; Phone no:+251923797359; E-mail: ddestaman@gmail.com

Received date: April 06, 2021; **Accepted date:** April 20, 2021; **Published date:** April 27, 2021

Citation: Fufa DD (2021) Novel Approach to Enhance the Shelf Life of Fresh Cut Fruits and Vegetables: a Review. J Food Process Technol. 12: 891.

produce sales at retail is fresh cut salad, with sales of $2.7 billion per year. However, the fast food sector is increasing the demand for packaged fresh cut fruits by offering healthier choices on their menus. Scott (2008) reported that the U.S. sales of fresh-cut fruit items increased for every product, ranging from 7% to 54% growth. The fresh cut vegetables and fruits from European market trend are quite different, when compared to other countries. The fresh cut industry is rising in many European countries with the United Kingdom, France, and Italy as share leaders. In Italy, for example, the sales exceeded 42,000 tons of production, corresponding to €375 M ($450 M U.S.) in 2004. Over the last decade, ready-to-eat mixed salad packs have been one of the greatest successes of the UK food industry. Currently, the countries with higher growth in the fresh-cut fruits and vegetables market are Germany, Netherlands, Spain and United Kingdom. Compared to western world, the fresh cut produce processing industries in African continent is still in its infancy stage, even though plenty of produces are available, due to lack of technical knowledge and non-availability of resources, these two things are hampering the growth of the fresh cut processing industries in African countries. Therefore, this review will highlight the biochemical changes that occur for fresh cut fruits and vegetables and various strategies that need to be adopted for minimizing quality loss and to ensure safety during fresh-cut processing [1].

PHYSIOLOGICAL EFFECTS OF FRESH-CUT PROCESSING

Fresh-cut processing involves cutting through the tissue of fresh produce, thus causing major tissue disruption and the release of enzymes that interact with substrates associated with the fruit Tissue. Wounding of the fruit tissue by cutting also increases ethylene production and stimulates respiration and phenolic metabolism. Phenylalanine Ammonia Lyase (PAL), an enzyme that catalyses the formation of phenolic compounds, is stimulated by ethylene production. Phenolic compounds in turn serve as substrates for polyphenoloxidase enzymes which, in the presence of oxygen, eventually lead to the formation of complex brown polymers. Increased respiration rates result in water loss and a reduction in the levels of carbohydrates, vitamins and organic acids, with a net negative impact on flavor and aroma. Water loss is also enhanced by membrane and cell wall degradation, and results in loss of turgor [2]. At the same time, microbial growth at the cut surface also increases as sugars become available, thus accelerating the opportunity for microbial spoilage.

BIOCHEMICAL CHANGES BROUGHT ABOUT BY FRESH-CUT PROCESSING

Color change

Browning or surface darkening is one of the main physiological effects of fresh-cut processing and leads to quality loss in fresh-cut produce. It is the result of oxidation of phenolic substrates present in the produce by Polyphenol Oxidase (PPO) enzymes. The extent of browning is dependent on the concentrations of active PPO and phenolic compounds in the produce tissue, pH, temperature and oxygen available to the tissues as well as on the presence of antioxidant compounds [3].

High levels of PPO enzymes are generally found in tissues that are rich in phenolic compounds. Levels of PPO and PPO substrates change during the life cycle of fruits and vegetables. Carotenoids, a yellow pigment in fruit and vegetable tissues, are highly susceptible to oxidative breakdown that is catalysed by lipoxygenase enzymes. Yellowing of green vegetables such as broccoli and spinach reduces their quality and shelf-life. Dehydration of surface debris on cut and peeled carrots results in a translucent appearance, referred to as ‘white blush’, which reduces their market appeal.

Flavor quality changes

Key components of flavor in fresh fruits are sweetness, acidity, astringency and bitterness. Many flavor and aroma components are lost in fresh-cut fruits through enzymatic reactions brought about by cutting, and through the increased respiration rates of the fruit tissue Microbial spoilage also contributes to flavor degradation in fresh-cut products. Fresh-cut products can acquire off-flavors with the growth of lactic acid bacteria or pseudomonads, resulting in fermentation and the production of acids, alcohols and carbon dioxide gas (CO_2). Lipase enzymes and the breakdown of amino acids in fruits by microorganisms can contribute to the alteration of fruit flavors [4].

Texture quality changes

The unprotected cut surface of fresh-cut fruits loses moisture at an extremely rapid rate. Such high rates of water loss result in rapid wilting and shrivelling of fresh-cut produce and thus a loss of the crisp, firm texture of the product. Tissue softening of fresh-cut produce during storage is the result of structural changes in the primary cell walls; this is caused by enzymatic activity that leads to dissolution of the rigid pectic cells and a decrease in their resistance to pressure. Decreased rigidity due to water loss is the main cause of tissue softening in fresh-cut fruits. While there is a paucity of data on the effects of fertilizer on fresh-cut fruit quality, too much nitrogen is known to reduce firmness, while high levels of potassium and calcium can improve fruit quality at harvest.

Quality loss due to microbial contamination

Fresh-cut vegetables harbour lower numbers of microorganisms than unwashed whole vegetables, as a result of washing in chlorinated water. Slicing, dicing and shredding procedures as well as temperature abuse during storage can however result in increases in populations of mesophilic aerobic microorganisms. The effects of processing and storage conditions on the survival and growth of pathogenic microorganisms on fresh-cut produce is a public health concern. Microbes associated with fresh-cut fruit and vegetable products can vary greatly in accordance with the produce type and storage conditions. Temperature plays a significant role in determining the nature of the microflora associated with refrigerated fresh-cut fruits and vegetables. Spoilage of fresh-cut vegetables by bacteria is characterized by brown or black discoloration, production of off-odours, loss of texture and soft rot. Fruit products undergo fermentative spoilage by lactic acid bacteria or yeasts and wilting owing to vascular infections [5].

POST-HARVEST HANDLING TO ASSURE QUALITY AND SAFETY OF FRESH PRODUCE

Harvested produce should be placed in a shaded area so as to avoid sun damage if awaiting transportation to the processing plant. Produce must be properly handled to avoid bruising and contamination.

Pre-cooling

Pre-cooling is the rapid removal of field heat from fresh produce. It is among the most efficient quality enhancements available to commercial producers and ranks as one of the most essential value-added activities in the horticultural chain. Proper pre-cooling can prevent quality loss due to softening by suppressing enzymatic degradation and respiratory activity; prevent wilting by slowing or inhibiting water loss; slow the rate of produce decay by slowing or inhibiting microbial growth (fungi and bacteria); reduce the rate of ethylene production and minimize the impact of ethylene on ethylene-sensitive produce.

Washing and disinfection

Any dirt on the surface of produce must be thoroughly removed by washing in water. The produce must be subsequently washed in potable water containing a sanitizer in order to reduce the risk of the transfer of microbial contamination during processing. A sanitizing agent or sanitizer is an antimicrobial agent applied to destroy or reduce the number of microorganisms of public health concern, without affecting produce quality and consumer safety. Sanitizers minimize the transmission of pathogens from water to produce, reduce the microbial load on the surface of the produce and prevent microbial build-up in the processing water [6].

Sanitizer treatment

Sanitizers applied to fresh fruits and vegetables must be safe in use and must be used in accordance with given instructions. The sanitizer concentration in the processing water should be routinely monitored and adjusted to prescribed levels. Should it not be possible to monitor the sanitizer concentration, recommendations for the reuse of sanitized water should be followed. In order to minimize the build-up of organic materials, the water must be filtered, or otherwise changed. Technical assistance on the use of sanitizers should be sought when necessary.

Post-harvest handling and sanitation treatments have considerable impact on the microbiological quality of fresh-cut produce. Washing whole fruits and vegetables in clean water only achieves an insignificant reduction in microbial populations. The use of sanitizers such as chlorine, peroxyacetic acid, hydrogen peroxide, acidified sodium chloride or ozone can provide an additional 1-2 log reduction in the initial population of microorganisms on the surface of fresh produce. Chlorine is currently the most commonly used sanitizer in washing operations. Chlorine has been successfully used at concentrations ranging from 50 to 200 parts per million (ppm) to wash fruits in fresh-cut fruit studies and fresh-cut mango studies. Improper use of chlorine can, however, lead to the retention of a faint chlorine odor on the fresh-cut fruit. Despite its common use as a disinfectant for decontamination of fresh produce, chemical hazards associated with chlorine or chlorine residues are of concern. The use of chlorine in the processing of minimally processed products has been banned in some European countries [7].

Alternatives to chlorine

Chlorine dioxide (ClO_2): Chlorine dioxide is effective against many microorganisms at lower concentrations than free chlorine. It is highly effective at neutral pH. Its reactivity is however reduced by the presence of organic matter. It has been approved for use in flume waters in fruit and vegetable operations by the Food and Drug Administration. The oxidizing power of chlorine dioxide is 2.5 times that of chlorine. Chlorine dioxide may produce hazardous by-products such as chlorite (ClO_2) and chlorate (ClO_3). Its noxious odour is toxic to humans. Microbial susceptibility to chlorine dioxide depends on the microbial strain and environmental conditions during application. Chlorine dioxide can be used on processing equipment at a maximum level of 200 ppm, whereas for whole or uncut produce it can be used at a level of 3 ppm.

Acidified sodium chlorite (ASC, $NaClO_2$) : This chlorine-based sanitizer has a strong oxidizing capacity, which has been approved by the United States for application on fruits and vegetables, including fresh-cut produce, by spraying or dipping in 500-1200 ppm solution.

Ozone (O_3): Ozone rapidly undergoes spontaneous decomposition under conditions of high pH (pH >8) leading to the production of oxygen which is a non-toxic product. Ozone must be generated on site from air. Gaseous ozone is toxic to humans (>4 ppm). The maximum permissible level for short-term exposure is 0.3 ppm in air. It is corrosive to common materials, thus stainless steel should be used. Ozone must be filtered in order to remove organic and particulate materials. Ozone has been given a generally recognized as safe (GRAS) status for use in food contact applications. Concentrations of 1 ppm or lower in water and short contact times are sufficient to inactivate bacteria, moulds, yeasts, parasites and viruses. An ozone concentration of 0.5-4 ppm is recommended for wash water, whereas for flume water an ozone concentration of 0.1 ppm is recommended [8].

Electrolyzed water: It is available in the form of Acidic Electrolyzed Water (AEW) or Neutral Electrolyzed Water (NEW). The AEW is known as electrolyzed oxidizing water and is strongly acidic (pH of 2.1 to 4.5). It contains HOCl as an antimicrobial component. The AEW is used widely in Japan. It has biocidal effects against O157:H7, *S. enteritidis, L. monocytogenes*. The bactericidal power of AEW is higher than that of a 5-ppm ozone solution in the decontamination of fresh-cut lettuce. NEW on the other hand has a neutral pH (close to 7.0). It contains between 15 and 50 ppm of available chlorine obtained from 2.5 percent NaCl. It is generally two to three times more effective than NaOCl [9].

QUALITY OF FRESH-CUT FRUITS AND VEGETABLES

The quality of fresh-cut fruits and vegetables depends on several factors, which may be described by different sensory attributes such as color, aroma, texture and also by nutritional value.

Appearance and color

The appearance of the product is an important factor affecting the consumer choice. It may comprise size, shape, color, gloss and absence of visual defects including morphological, physiological, physical or pathological ones. An important aspect, during the shelf-life of fresh cut products, is the preservation of the tissue color avoiding the surface browning. For example, it is well documented that lettuce and carrots may be subject to changes in color due to biochemical processes, in particular, chlorophyll degradation and browning, in case of lettuce, or carotene degradation, whiteness and browning for carrots. This is probably the major defect of fresh cut fruits and vegetables, able to reduce their quality and shelf-life. The occurring of browning is different between fruits and vegetables, for example, in case of lettuce, browning appears very slowly because of the de novo biosynthesis of polyphenols. In case of apple, the high amount of polyphenols caused a rapid enzymatic browning. Generally, the vegetable browning is related to tissue wounding (cutting, breaking, etc.), which induces the biosynthesis of phenolic compounds and consequently of the browning. The main enzymes involved in the synthesis of brown pigments are peroxidase and polyphenol oxidase. These enzymes, in the presence of oxygen, converts phenolic compounds into dark-colored pigments.

Moreover, some vegetables and fruits are susceptible to dehydration and subsequent discoloration due to the damaged cells or to the removal of protective skin. In carrots for example, in stress conditions, lignin is synthesized with the role of defense from microorganisms and other stress factors. The lignin formation and the reversible surface dehydration of the outer layers lead to a discoloration of the tissues, increasing the whiteness [10].

Texture

Textural quality factors include firmness, crispness, juiciness and toughness depending on the product. Products that maintain firmness, crunchiness and other texture parameters are desirables for the consumers because; they are generally associated to freshness of the produce. In minimally processed vegetables, changes in texture parameters are generally associated to enzymatic and non-enzymatic processes. Enzymes involved in the loss of firmness are Pectin Methylesterase (PME) and Poligalacturonase (PG) that cause the degradation of pectins. The stimulation of PME activity with mild heating treatments has been correlated with texture maintenance, therefore only the combined action of PME and PG lead to a loss of firmness. Considering lettuce, it is very difficult maintaining the texture during storage. The cutting process makes start undesirable biochemical reactions that lead to a loss of crispness. In particular, the tissue softening and the associated leakage of juice are the major textural defects of fresh-cut fruits and vegetables.

Flavor

The flavor of the products comprises the taste and aroma of the products. Aroma compounds are detected by olfactory nerve endings in the nose. Taste is the detection of nonvolatile compounds by different receptors in the tongue. Flavor includes tastes like sweet, sour, astringent, bitter and off-flavors. The flavor quality of fresh-cut fruits and vegetables is affected by their content of sugar, organic acids, phenolic compounds and volatile active molecules. Hundreds of volatile compounds are responsible of the flavor of the products, and some of them are presents in very low concentrations (part per billion). A wide range of volatile molecules were detected and belonging to several chemical groups such as alcohols, aldehydes, ketones, esters, furanes, glucosinolate, lactones, nitrogen and sulfurcontaining compounds, terpenes and other compounds. Esters are usually the major components affecting the aroma in fruits. Several studies demonstrated that the sensory quality may decline before to the textural and physiological quality. Based on sensory evaluation and in order to satisfy the consumers, it is necessary to get more information as possible about the optimum volatile compound concentration ranges.

Nutritional quality

Fresh-cut fruits and vegetables can be a source of vitamins, minerals and dietary fiber. Besides, they contain other minor constituents (flavonoids, carotenoids, polyphenols, and other phytonutrients), that may have a beneficial effect on human health and reduce the risk of cancer and heart diseases. Losses in nutritional quality are common during the storage, and they are enhanced by physical damage, high temperatures during storage, low relative humidity. Moreover, a decrease in the antioxidant activity during process has been reported for different kind of fruits and vegetables.

STRATEGIES FOR MINIMIZING QUALITY LOSS AND ASSURING SAFETY DURING FRESH-CUT PROCESSING

Minimizing mechanical damage and microbial contamination during cutting

The quality and status of equipment used for peeling and cutting is critical in fresh-cut processing operations. Use of the sharpest cutting tools will extend product shelf-life. Dull utensils have been proven to cause excessive cell damage and bruising leading to poor quality. Severe peeling and cutting must be avoided. Studied the impact of blade sharpness on the quality of fresh-cut melons stored at 5°C. The results indicated that melon chunks cut with a dull blade were susceptible to a translucence disorder, increased leakage and high ethanol concentrations in the package. Pear slices cut with a freshly sharpened knife retained their visual quality longer than fruit cut with a dull hand slicer showed that slicing with a blunt blade enhanced the penetration of fresh-cut carrots by *E. coli* and its subsequent survival during storage. Frequent sharpening of machine and hand knives and proper cleaning and sanitizing of processing equipment and surfaces that come in contact with fresh-cuts is clearly a key control point in fresh-cut fruit processing.

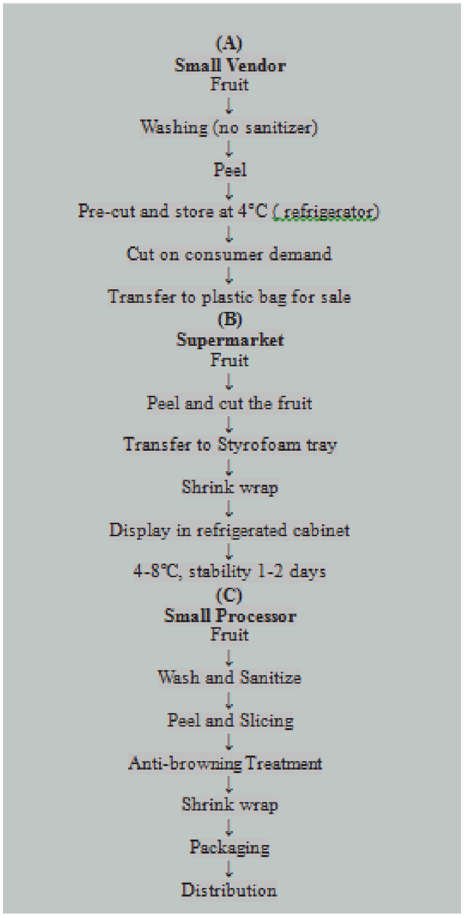

Figure 1: Strategies for Minimizing Quality Loss and assuring Safety during Fresh-Cut Processing.

Minimizing transfer of contamination during washing operations

Many large fresh-cut processing operations treat and recycle water in order to conserve this precious commodity. Care must be taken in recycling water so as not to introduce new risks of increased microorganisms to produce during washing. It is recommended that the best quality water be used for the final rinse of intact fruits and vegetables prior to fresh-cut processing. Many operations inject chlorine as a disinfectant along with acid in order to maintain a pH range of 4.5-5.5 and assure the effectiveness of chlorine during washing operations. Measurement and recording of the chlorine level and the pH of wash water is a critical element of any quality assurance programme. When used to reduce the temperature of wash water, ice should be routinely tested in order to ensure that it is not a source of contamination. The disinfectant level in wash water can be monitored through the measurement of Oxidation Reduction Potential (ORP). ORP is a measure of the oxidation level in the water in millivolts, and gives an indication of the efficacy of a sanitizer during processing. The stronger the oxidation, the faster the microbes are killed. Variables that affect antimicrobial activity during processing directly affect the ORP value and may also be used to determine the effectiveness of oxidizers such as hypochlorous acid, hypobromous acid, chlorine dioxide, ozone and peroxides. Water quality can be maintained by closely following mixing directions for sanitizers ; using test strips or instruments to routinely measure sanitizer levels and pH ; removing debris and filtering wash water before recycling.

TEMPERATURE MANAGEMENT DURING PROCESSING OPERATIONS

Temperature control is essential at each step of a fresh-cut fruit process, in the distribution chain and in retail. Low temperature storage helps to slow the respiration rate, maintain quality and prolong shelf-life by keeping product temperature at the point where metabolic activity and microbial deterioration are minimized. Low temperature storage slows the growth of mould and bacteria. Thus the ideal storage temperature for each commodity should be researched carefully. Temperature is the most important factor in the preservation of fresh-cut fruit quality. The rates of chemical and biochemical reactions that affect quality are largely determined by temperature. Heat and low temperature are both used in the pre-treatment of whole fruits and vegetables prior to fresh-cut processing in order to increase shelf-life. Mild heat treatment of whole apples before processing resulted in the retention of firmness during storage in some fresh-cut apple cultivars. Low temperature pretreatments such as the hydrocooling of asparagus and baby corn reduced respiration rates, reduced toughening of the texture and prolonged the quality of fresh-cut products. Heated wash water treatments were shown to reduce pathogens on mango fruits (such as 'Nam Dok Mai'). Mangoes treated with 100 ppm chlorine at 50°C had virtually no retention of aerobic bacteria on fruit skin and fresh-cut samples. Many fruits of tropical or subtropical origin are sensitive to low temperatures. These fruits are injured after a period of exposure to chilling temperatures , but above their freezing points.

At these temperatures, fruit tissues are weakened owing to their inability to carry out normal metabolic processes. Various physical and biochemical alterations and cell malfunctions occur in response to chilling stress. When chilling stress is continued, these alterations and malfunctions lead to the development of a variety of chilling injury symptoms such as surface lesions, internal discoloration, water-soaking of the tissue and failure to ripen normally.

A number of fresh-cut fruit products, exhibit less sensitivity to chilling injury (CI) than intact fruits. The reasons why peeled tissue tolerates lower temperatures are unclear, but the degree of ripeness may play a role. Ripe fruit has been known to tolerate low temperatures better that unripe fruit drew the following conclusions regarding the handling of fresh-cut products that are sensitive to chilling injury: It is important that intact chill-sensitive produce is not stored below the recommended storage temperature, before being prepared as a fresh-cut product. Once a chill-sensitive commodity is prepared as a fresh-cut product, storage at low temperature is needed to retard microbial growth and ensure quality. Microbial changes take place more rapidly than the appearance of any symptom of chilling injury. For chill-sensitive commodities, temperature and controlled atmosphere suitable for the intact produce are often not suitable for fresh-cut pieces.

POST-CUTTING TREATMENTS DESIGNED TO EXTEND THE SHELF-LIFE OF FRESH-CUT PRODUCTS

A number of physical and chemical treatments designed to delay physical decay processes in the tissues and to extend the shelf-life of fresh-cut fruits and vegetables have been developed and tested. Chemical methods rely on the inhibition of specific reactions that generate undesirable changes. Physical methods include reductions in temperature and/or oxygen concentration, the use of Modified Atmosphere (MA) and the application of heat or high pressures.

CHEMICAL POST-CUTTING TREATMENTS

Wounding and ethylene can initiate phenolic metabolism that ultimately leads to browning in fresh-cut tissue. Control of discoloration (pinking, reddening or blackening) or browning at cut surfaces is, therefore, a critical issue for fresh-cut producers. Outlined below are a number of strategies that may be used to reduce cut-surface discoloration and maintain the textural integrity of fresh-cut produce.

Acidification: The PPO most effectively catalyses cut-surface discoloration at a neutral pH (around pH 7.0). Browning can therefore be slowed by dipping products in mildly acidic food grade solutions of acetic, ascorbic, citric, tartaric, fumaric or phosphoric acid. Quite often, combinations of acids (for example combinations of ascorbic and citric acid) are more effective than the use of acids individually. However, these acids may impart off-flavours or promote tissue softening and must therefore be used with care.

Reducing Agents: Reducing agents such as ascorbic acid or the erythrobate isomer of ascorbic acid are commonly used in the food industry to prevent PPO-mediated cut-surface discoloration. Ascorbic acid and erythrobate reduce PPO-induced discoloration at cut-surfaces by converting quinones (formed by PPO from phenolics) back into phenolic compounds. Once all of the ascorbic acid or erythrobate is exhausted, PPO browning will proceed uninhibited. Ascorbic acid or erythrobate are commonly used in solution at a concentration of 1 μM. Given their acidic nature, they may also reduce the surface pH of commodities, further slowing the rate of browning.

Application of Edible Coatings: The application of edible coatings such as sodium caseinate or stearic acid may be helpful in reducing white blush in vegetables such as carrots. Treatments that modify the water-retaining capacity of the cut surfaces also prevent white blush development.

Natural Antimicrobials: Some plant extracts such as ginger, marigold and cinnamon exhibit antimicrobial activity. Cinnamon extract at 500 ppm was shown to control banana crown rot. Chitosan, a polysaccharide extracted from chitin, a natural substance in the shells of shrimp and crab has been shown to be effective in controlling rambutan fruit rot, mango anthracnose, banana crown rot and Botrytis cineria in strawberries. The application of vanillin as a dip at a concentration of 80 MN storage at 5 degree Celsius are effective in reducing the microbial populations in fresh-cut mangoes.

Firming Agents: The firmness of the flesh of fresh-cut fruit products can be maintained through the application or treatment with calcium compounds. Dipping fresh-cut products in solutions of 0.5 to 1.0 percent calcium chloride was shown to be very effective in maintaining product firmness. Calcium ions form cross links within pectin chains, resulting in stronger cell walls. Calcium chloride treatments can, however, result in bitter off-flavours in some products.

CONCLUSION

Shelf life of fresh cut produce can be extended by adopting several chemical and physical posts cutting treatments viz. acidification, use of reducing agents, application of edible coatings, natural antimicrobials, and use of firming agents and by reducing the Oxygen levels by means of modified atmospheric packaging. Quality loss can be reduced and safety of fresh cut produce can be achieved by minimizing mechanical damage during cutting, transfer of contamination during washing operation and also temperature management during processing operations and post processing period. Consumers have become more appealed in food health and more interested in fresh and convenience products. Moreover, nutrition experts agree in asserting that the consumption of sufficient amounts of fruits and vegetables is important in a healthy lifestyle while the presence of fiber, vitamins, minerals and phytonutrients can play an important role to prevent cardiovascular diseases, certain types of cancer, obesity, and diabetes. This situation is an opportunity for the introduction to the markets of new food products such as fresh-cut fruits and vegetables that may represent a strategy to increase the consumption of fruits and vegetables to the recommended levels for a healthy diet. In fact, minimally processed fruits and vegetables come across the consumer desire for convenience, quality, appearance, and healthy nutrition. So there will be a great scope for such processing industries in urban set up especially in African countries.

REFERENCES

1. Baldwin EA, Scott JW, Christine K. Flavor trivia and tomato aroma: Biochemistry and possible mechanisms for control of important aroma components. Hortscience. 2000;35:1013-1021.

2. Belloso MO, Fortuny RS. Advances in Fresh-Cut Fruits and Vegetables Processing. CRC Press, Boca Raton, Florida. 2010;4-7.
3. Brackett R. Shelf-stability and safety of fresh produce as influenced by sanitation and disinfection. Journal of Food Protection. 1992;55:808-814.
4. Braun L, Cohen M. Herbs and Natural Supplements an Evidence based Guide. Elsevier publications. 2015;1-1362.
5. Cantwell M. Damage and the need for very sharp knives. Perishable Handling Quarterly 1998;96:4.
6. Diana MAB, Rico D, Henehan GTM, Frias J, Barat J, BR Catherine. Extending and measuring the quality of fresh-cut fruit and vegetables: a review. Trends in Food Technology. 2007;18:210-218.
7. Fagundes C, Augusto B, Carciofi M, Monteiro AR. Estimate of respiration rate and physicochemical changes of fresh-cut apples stored under different temperatures. Food Science and Technology. 2013;33:14-20.
8. Francis GA, Nychas A, Sofos GJ, Colelli JN, Amodio G, Spano G. Factors affecting quality and safety of fresh-cut produce. Critical Reviews in Food Science and Nutrition. 2012;52:595-610.
9. Gorny J, Kader A. Controlled atmosphere suppression of ACC synthase and ACC oxidase in golden delicious apples during long term cold storage. Journal of American Society of Hortculture Science. 1996;121:751-55.
10. Hadi MAM, Zhang FJ, Wu FF, Zhou CH, Tao J. Advances in fruit aroma volatile research. Molecules.2000;18:8200-29.