Keywords: fresh-cut, quality, vegetables, nutrition, health

1. Introduction

There is a general trend to increase fresh vegetable consumption mainly due to their health properties (Huxley et al., 2004). Different organizations (WHO, FAO, USDA EFSA) recommend the increasing vegetable consumption to decrease the risk of cardiovascular diseases and cancer. Consumers’ increasing concern about food and health associated with reduced time to prepare meals has given the need to search for convenient products, with fresh like quality. So, purchase of fresh-cut produce from supermarkets is an easy and interesting alternative for convenience, freshness, nutrition, safety and the eating experience. This paper covers a review on the future prospect and different aspect of fresh-cut technology.

Abstract: There is a general trend to increase fresh vegetable consumption mainly due to their health properties. Different organizations like WHO, FAO and USDA EFSA recommend the increasing vegetable consumption to decrease the risk of cardiovascular diseases and cancer. Consumers’ increasing concern about food and health associated with reduced time to prepare meals has given the need to search for convenient products, with fresh like quality. So, purchase of fresh-cut produce from supermarkets is an easy and interesting alternative for convenience, freshness, nutrition, safety and the eating experience. This paper covers a review on the future prospect and different aspect of fresh-cut technology.

2. Physiological and Microbial changes associated with Fresh-Cut Processing

The physiology of fresh-cut vegetables is essentially the physiology of wounded tissue. Thus, the behavior of the tissue is generally typical of that observed in plant tissues that have been wounded or exposed to stress conditions (Brecht, 1995). This includes increased respiration and ethylene production, and, in some cases, induction of wound-healing processes. Other consequences of wounding are chemical or physical in nature, such as oxidative browning reactions and lipid oxidation, or enhanced water loss.

2.1 Respiration

The increase in respiration seen in wounded plant tissues is thought to be a consequence of elevated ethylene, which stimulates respiration. Breakdown of starch is enhanced, and both the tri carboxylic acid cycle and electron transport chain are activated (Laties, 1978). The respiratory climacteric may also be affected by wounding. The respiration rates of fresh-cut vegetables and fruits are generally from a few to over 100% higher than the intact produce (Rosen and Kader, 1989). However, more extensively damaged tissue, e.g. shredded carrots, can have even greater respiration rates (Varoquaux and Wiley, 1994).

2.2 Ethylene production

The potential effects of wound ethylene are dependent on the type and physiology of the tissue. Wounding climacteric fruits may cause increased ethylene production, which can speed up the onset of the climacteric, resulting in different physiological stage between intact and sliced tissue (Brecht, 1995). Wound ethylene production is usually greater in preclimacteric and climacteric than post-climacteric tissues (Abeles et al., 1992). Fresh-cut vegetables produce large amount of ethylene, which results in shorter shelf life of the products. Ethylene accelerates ripening, softening, and senescence, which lead to membrane changes, which is promoted by stresses (chilling injury and wounding) and this can enhance fruit ripening, may cause chlorophyll loss and yellowing of green stem and leafy vegetables (Saltveit, 1999) as in harvested broccoli florets (Tian et al., 1994) at 5°C. It stimulates phenolic compounds in lettuce and increases activities of phenyl-alanine-ammonialyase (PAL), peroxidase (POD) and polyphenoloxidase (PPO). Crisp texture of cucumbers and peppers is lost upon exposure to ethylene (Saltveit, 1999). Ethylene induced POD activity is correlated with increased lignin formation and cell wall thickening in lettuce.

2.3 Water Loss

Plant tissues are in equilibrium with an atmosphere at the same temperature with an RH of 99-99.5% (Burton, 1982). Any reduction of water vapor pressure in the atmosphere below that in the tissue results in water loss. In whole organs, the water in the intercellular spaces is not directly exposed to the outside atmosphere. However, cutting or peeling the 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 (Burton, 1982).

2.4 Colour Changes

The main physiological effects of fresh-cut processing is browning or surface darkening which leads to quality loss in fresh-cut produce. Discoloration due to browning and yellowing due to loss of chlorophyll occur in fresh-cut vegetables as a result of the disruption of compartmentation that occurs when cells are broken, allowing substrates and oxidases to come in contact (Heaton and Marangoni, 1996; Martinez and Whitaker, 1995). Wounding also induces synthesis of a number of enzymes involved in the browning reactions or substrate biosynthesis (Rolle and Chism, 1987).

2.5 Texture

Fresh-cut vegetables that maintain firm, crunchy texture are highly desirable because consumers associate these textures with freshness and wholesomeness (Bourne, 2002; Szczesniak, 1998). Indeed, the appearance of a soft or limp product may give rise to consumer rejection prior to consumption. The cut surface of fresh-cut vegetables loses moisture at an extremely rapid rate. Textural changes in vegetables are related to certain enzymatic and non-enzymatic processes. Enzymatic degradation of pectins is catalysed by pectin methylesterase (PME) and polygalacturonase (PG) (Van Buren, 1979). Pectin is first partially demethylated by PME, and later depolymerized by PG to polygalacturonic acid causing a loss of firmness. However, the controlled activation of PME results in improvement of the texture, as it increases the cross-linking between pectin chains and cations (Roy et al., 2001). This effect is favoured in the case of carrots as endogenous PG activity is almost nonexistent (Stratilova et al., 1998).

2.6 Aroma and Flavor

Flavor and aroma quality are important attributes for consumers and these attributes should be seriously examined when determining the shelf-life of fresh-cut products. The quality of intact vegetables and fruits is often determined almost exclusively based on appearance, sometimes to the exclusion of flavour and texture (Supers et al., 1997). For example, a mature green cantaloupe at less than half slip delivers a fresh-cut product with optimum visual shelf-life, but insufficient sugar or volatile composition associated with a desirable, ripe, whole melon (Beaulieu and Grimm, 2001). The aroma and flavour of fresh-cut vegetables is difficult to establish as initial product variability, potential post-cutting treatments and/or packaging affect flavor attributes differently.

2.7 Microbial Changes

Fresh-cut vegetables harbour lower numbers of microorganisms than unwashed whole vegetables, as a result of washing in chlorinated water. Increase in microbial populations on MP products is associated to damaged tissues, as microbial growth is greater on fresh-cut products than intact product (Ayala-Zavala et al., 2010). The chances of food borne illness due to pathogens or spoilage organisms growing in these products are very high (Manvell and Ackland, 1986). Temperature plays a significant role in determining the nature of the microflora associated with refrigerated fresh-cut vegetables. Vegetables are susceptible to attack by bacterial pathogens owing to their neutral pH. Spoilage of fresh-cut vegetables by bacteria is characterized by brown or black discoloration, production of off-odours, loss of texture and soft rot. Some of the spoilage causing organisms in fresh-cut produce is Pseudomonads (Palleroni, 1992), lactic acid bacteria, yeast and moulds (Tournas and Katsoudas, 2005). Some of the pathogenic organisms that are occasionally found is Listeria monocytogenes (Johnston et al., 2005), Salmonella, Clostridium botulinum, Shigella spp. and Escherichia coli.

3. Steps in Fresh-Cut Chain

![Steps in Fresh-Cut Chain Diagram](image)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop</th>
<th>Harvesting</th>
<th>Grading</th>
<th>Cutting</th>
<th>Washing</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sweet pepper</td>
<td>Light green colour-greenhouse grown and dark green colour-field grown</td>
<td>Free from blemishes, fresh and firm</td>
<td>Halve fruit lengthwise and cutting into strips</td>
<td>Cold chlorinated water (200 ppm) 10°C; 5 minutes</td>
<td>Refrigerated storage; 5°C</td>
</tr>
<tr>
<td>2.</td>
<td>Cauliflower</td>
<td>High quality curds</td>
<td>Free from damage and discoloration</td>
<td>Outer leaves removed; cutting into pieces (50-60 g each)</td>
<td>Water containing 50 ppm free chlorine; 4 ± 2°C for 5 minutes</td>
<td>Cold storage; 4°C</td>
</tr>
<tr>
<td>3.</td>
<td>Cabbage</td>
<td>White with tight head</td>
<td>Free from insects damage</td>
<td>Leaves cut into quarters and sliced into 3 cm wide strips</td>
<td>Chlorinated water (100 ppm NaOCl); 5°C for 4 minutes</td>
<td>5°C</td>
</tr>
<tr>
<td>4.</td>
<td>Broccoli</td>
<td>Good quality heads and unopened floral</td>
<td>Free from yellowing and damage</td>
<td>Outer leaves removed and cut into 50 g</td>
<td>Cold chlorinated water (50 ppm) at 5°C</td>
<td>≤ 5°C</td>
</tr>
</tbody>
</table>
4. Techniques to Enhance Shelf-Life of Fresh-Cut Produce

A number of physical and chemical treatments are designed to delay the decay processes in the tissues and to extend the shelf-life of fresh-cut vegetables.

4.1 Sanitizers

Fresh-cut fruit should be rinsed just after cutting with cold (0 to 1°C, 32 to 33.8 °F), chlorinated water at pH 7.0. This may help extend product shelf-life by reducing microbial load. **Antibrowning:** Browning can be slowed by dipping products in mildly acidic food grade solutions of acetic, ascorbic, citric, tartaric, fumaric or phosphoric acid. PPO most effectively catalyses cut-surface discoloration at a neutral pH (around pH 7.0) (Sapers et al., 1997). Dipping of fresh-cut Chinese cabbage, endive, lettuce and melon in solution of ascorbate, erythorbic acid and citric acid reduce enzymatic browning (Soliva, 2005).

4.2 Edible Coatings

Edible coatings have been formulated to prolong shelf life and maintain quality of fresh-cut vegetables by preventing changes in aroma, taste, texture, and appearance (Tharanathan, 2003). These coatings are generally made from one or more of four major types of materials [lipids, resins, polysaccharides (cellulose, pectin, starch, alginates, chitosan, gums, carrageenam etc. (Tay and Perera, 2004) and proteins. The application of edible coatings such as sodium caseinate or stearic acid may be used in reducing white blush in vegetables such as carrots. Edible coating of fresh-cut with calcium alginate enhances firmness and control leakage of segment and it improves crispiness of lettuce (Tay and Perera, 2004).

4.3 Firming Agents

The firmness of the flesh of fresh-cut products can be maintained through the application or treatment with calcium compounds. Dipping fresh-cut vegetables in solutions of 0.5 to 1.0 percent calcium chloride can be very effective in maintaining product firmness (Ponting et al., 1971). Application of calcium salts to shredded carrot, honeydew disc and melon help to retain tissue firmness (Gorny et al., 1999; Picchinoi et al., 1996).

4.4 Modified Atmosphere Storage

Modified atmosphere and low temperature storage can be used to reduce respiration rates and the deterioration of fresh-cut produce. MAP also inhibits biosynthesis and action of ripening hormone ethylene, slows down various compositional changes associated with ripening (softening, browning, decay etc.), and protects color of green vegetables. It also avoids incidence of chilling injury (Rivera et al., 2005). Modified atmospheres consisting of low oxygen and high CO₂ concentrations are used to reduce respiration rates and ethylene production in fresh-cut products (Al-Ati and Hotchkiss, 2002).

5. Conclusion

The changing dietary habits, hectic lifestyles, increased raw product availability, and an expanding selection of fresh-cut vegetables have made the fresh-cut produce market the fastest growing in the vegetable industry. Convenience and nutrition will remain significant demand factors that will affect the characteristics of the products the fresh-cut produce industry delivers. Maybe although most consumers like their meal ought to be ready in less than 30 minutes, consumers are concerned about more than just convenience and ease of preparation. Nutritional value is important, but freshness, shelf life, packaging, availability, and functional properties, not the least of which is taste, heavily influence purchase decisions.
References


