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Fresh-Cut Vegetables: A Consumer Friendly Approach

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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 super-markets 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.***

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. The drudgery of peeling vegetables, shelling peas and trimming herbs and vegetables, and then combining these ingredients, often deters the people leading a busy lifestyle from preparing these foods. So, consumers generally purchase fresh-cut produce for convenience, freshness, nutrition, safety and the eating experience. The USDA and FDA definitions for "fresh" and "minimally- processed" vegetables imply that fresh-cut (pre-cut) products have been freshly-cut, washed, packaged and maintained with refrigeration. Fresh-cut products are in a raw state and even though processed (physically altered from the original form), they remain in a fresh state, ready to eat or cook, without freezing, thermal processing, or treatments with additives or preservatives.

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 pre-climacteric 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 enzymaticand 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).

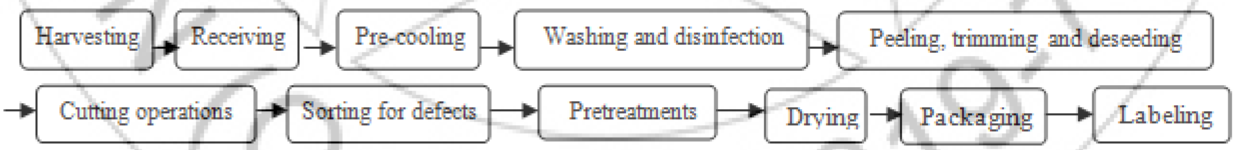
2.6 Aroma and Flavor

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 (Sapers *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 and broken cells, 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



Processing of Some Vegetables for Fresh-Cut

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

		buds		pieces		
5.	Asparagus	Based on length, diameter and tip	Free from bruises, fresh appearance, fresh-smelling and wholesomeness	Cutting lengthwise (12 cm)	Chlorinated water 100-200 ppm for 5 minutes	Cool storage (2-4°C)
6.	Baby corn	Hand-harvested 2-3 days after silking/plant is 45-50 days old	Free from damage caused by pests, bruises, fresh and free of silk	Hand husked and silk must be removed, cut lengthwise	Chlorinated water 100-200 ppm for 5 minutes	2-4°C
7.	Pak choi	Hand harvested at 25-30 days old plants to obtain young leaves	Graded according to size, quality with intact leaves and stem	Cut at the base of head	Chlorinated water (200 ppm) at 10°C for 5 minutes	2-4°C
8.	Green onion	Harvested by pulling	Damaged and wilted leaves are sorted	Trimmed by removing leaf tips and roots	Clean chlorinated water (50 ppm NaOCl)	Stored at 0°C
9.	Lettuce	Harvested by knife and vacuum cooled	Free from damages and wilting	Wrapper and core leaves removed; cut with leaf and midrib (5x3 cm)	50 ppm NaOCl at 5°C	5°C
10.	Carrot	Good quality without forking	Free from blemishes, insect damage	Cut in cubes (1.0 x 0.9 cm)	Cold chlorinated water (100 ppm) at 7°C for 15 minminutes	1°C

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 enhancesfirmness 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 CO_2 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.

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