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# Minimal Processing and Shelf life extension in Vegetables

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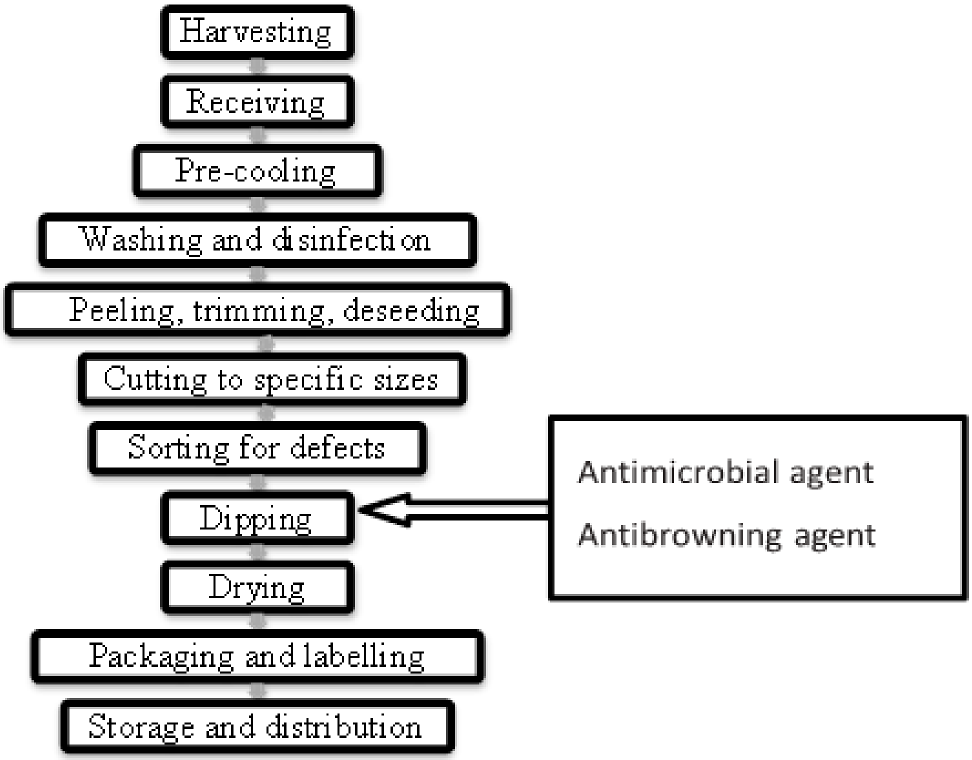
**SUMMARY**

Minimal processing of vegetables generally involves sorting, cleaning, washing, peeling, trimming and deseeding fresh produce and cutting it to specific size. They must not only look fresh, but must have the sensory properties like aroma, taste, texture and visual appeal associated with freshly prepared produce. Thus only fresh produce of good quality must be used as the starting material in minimal processing. Minimal processed vegetables must also be safe, wholesome and nutritious.

## INTRODUCTION

In the fresh produce industry, minimally processed products, also called ready-to-use, fresh-cut or pre-cut produce have been defined as vegetables that have been trimmed, peeled and/or cut into a fully usable product, which is subsequently packaged to offer consumers high nutrition, convenience and flavour while maintaining freshness. Over the years, minimal processed fruits and vegetables (MPFV) have become a mainstream commodity and have been the fastest growing segment of the produce sector in many countries around the world, particularly in the developed countries, stimulated largely by consumer demand for fresh, healthy, convenient and additive-free foods which are safe and nutritious. The food industry has responded to this demand with creative product development, new production practices, innovative use of technology and skillful marketing initiatives. The market of MPFV full-fledged enormously in Europe, particularly in France but also in the UK at the start of the 1990s. According to market research conducted by ACNielsen Global Services in 66 countries, representing over 75% of consumers in the world, the global demand for food ready for consumption, among which are minimally processed vegetables increased by 4% between 2005 and 2006. Also, the sales of fresh, ready to eat salads increased by 10% during the same year.




**Typical flow chart for preparation of minimal processed vegetables**

Some examples of fresh-cut fruits and vegetables are as follows:

**Fresh-cut fruits:** Melon chunks and slices, cored and sliced pineapple, apple wedges treated with antibrowning preservatives, peeled citrus fruits and segments, de-capped strawberry, de-stemmed and washed grapes, sliced kiwifruits and fruit salads etc.

**Fresh-cut vegetables:** Shredded lettuce, shredded and diced cabbage, washed and trimmed spinach, peeled "baby" carrots, cauliflower and broccoli florets, sliced or diced tomatoes, peeled and sliced potatoes, snapped green beans, trimmed green onions, cleaned and diced onions, and mixed salads, etc. Fresh-cut herbs are also marketed widely. Whilst 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. Infact, a major challenge facing the industry, however, is the rapid quality deterioration and reduced shelflife of fresh-cut products in comparison to whole fruits and vegetables due to physiological disorder and decay.

**Effect of Minimal Processing on Vegetables**

In an ideal case, minimal processing can be also considered as invisible processing. The microbiological, sensory and nutritional shelf life of minimally processed vegetables or fruit should be at least 4-7 days, but preferably even longer, up to 21 days depending on the market; the loss of ascorbic acid and carotenes is the main limiting factor of nutritional quality. They deteriorate because of physiological ageing, biochemical changes and microbial spoilage, which may result in degradation of the colour, texture and flavour of the produce.

**Physiological changes**

It includes several kinds of changes such as increase in respiration, browning, ethylene production, water loss, microbial degradation etc. 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.

**Physical and biochemical changes**

**Ethylene production:** The ethylene production in MPFV increases as time progress. It may enhance ripening and softening of fruits which lead to senescence, wounding and chilling injury. This stress induced ethylene production causes chlorophylls loss and yellowing of green stem and vegetables. Ethylene production accelerates in mechanical injured plant tissues.

**Respiration rate:** The shelf life of MPFV is inversely proportional to the increase in respiration rate (physiological) and ethylene production (biochemical). Higher respiration rate leads to ageing of products by using energy during oxidation-reduction processes. Furthermore, the respiration activity of minimally processed produce will increase 1.2-7.0 fold, or even more, depending on the produce, cutting grade and temperature. Increase in respiratory activity have been reported by several authors in melon, pineapple, papaya, guava, onion and potato. The effect of peeling and slicing on rate of respiration is different in climacteric and non- climacteric fruits. Rate of respiration are mainly responsible for α-oxidation of fatty acid in some vegetables such as potato. If packaging conditions are anaerobic, this leads to anaerobic respiration and thus the formation of ethanol, ketones and aldehydes.

**Colour:** Browning or surface darkening is one of the main physiological effects of fresh-cut processing and leads to quality loss in fresh-cut produce. Polyphenol oxidase is a vital enzyme considered regarding damage of minimal processed fruits which causes browning. Enzymatic browning involves the presence of four different components: oxygen, an oxidizing enzyme, copper and a suitable substrate. If any of the components from the system is removed, then browning is prevented. Another important enzyme is lipooxidase, which catalyzes peroxidation reactions, causing the formation of numerous bad-smelling aldehydes and ketones. 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. 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. Senescence is the root cause of yellowing of the tissues in green vegetables and fruits, due to the degradation of chlorophyll, which is not appealing to consumers and has a negative effect on sale of the product. It has been demonstrated that colour change from bright green to brown in fresh as well as in minimally fresh processed green vegetables is related to loss of bound magnesium atom of chlorophyll, which is substituted by hydrogen to form pheophytin, an olive coloured pigment.

**Flavour and odour:** Key components of flavour in fresh fruits are sweetness, acidity, astringency and bitterness. Many flavour 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 flavour degradation in fresh-cut products. Fresh-cut products can acquire off- flavours with the growth of lactic acid bacteria or pseudomonads, resulting in fermentation and the production of acids, alcohols and carbon dioxide gas (CO2). Lipase enzymes and the breakdown of amino acids in fruits by microorganisms can contribute to the alteration of fruit flavours.

**Texture:** 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.

**Microbial degradation**

The exudates from the cut tissue are an excellent medium for the growth of fungi and bacteria, and the subsequent handling of the processed products creates the potential for the development of microorganisms. Minimal processing in fruit and vegetables causes the cell disruption which lead to liberate intermixing of enzyme and substrates which is responsible for the growth of exogenous and native microorganism on products. If this food is taken without any subsequent heat treatment, various food-borne diseases (FBDs) can arise, due to pathogens in minimally processed products which increase the risk of food poisoning. The cell injuries, stress and senescence create pores which allow the diffusion of small molecule compounds and water into intercellular spaces. According to the World Trade Organization, the majority of FBDs occurring in Latin American countries are caused by eating food contaminated with pathogenic microorganisms; in Brazil, over 60% of these diseases are caused by Salmonella sp., Staphylococcus aureus, Clostridium perfringens, Bacillus cereus, and Clostridium botulinum. So Food and Drug Admistration (FDA) set some clear guidance for MPFV to minimize microbial hazards. This guideline includes Good manufacture practices (GMP), Good. Agricultural Practices (GAP) and HACCP. Also, because minimally processed fruit and vegetables are not heat treated, regardless of the use of additives or packaging, they must be handled and stored at refrigeration temperatures, at <5°C to achieve a sufficient shelflife and ensure microbiological safety. The following are the technologies towards extension of shelf life of minimally processed vegetables developed by ICAR-IIHR, Hessaraghatta Lake Post, Bengaluru.

**Shelf life extension of fresh-cut coriander leaves**

Pre-treatment of the freshly harvested, trimmed coriander leaves with 50 ppm kinetin and packaging using suitable semi-permeable films (25 micron thickness polypropylene) has resulted in the shelf life of 21 days at low temperature of 8 °C for varieties like Arka Isha.

**Shelf life extension of fresh-cut French beans**

Pre-treatments of the freshly cut French beans (preferably varieties like Arka Sarath) with 100 ppm available chlorine in the form of sodium hypochlorite and packaging using suitable semi permeable films of different gas and vapour permeability were used to obtain a equilibrium modified atmosphere of 12-14% oxygen and 5-6% carbondioxidewith a shelf life of 9-10 days.

**Shelf life extension of minimally processed (shredded) cabbage**

Freshly shredded cabbage were treated with calcium salts, surface dried and packed in 35 micron thick polypropylene films. This technology provides methods/specific protocols for preparation of minimally processed cabbage with shelf life ranging from 19-21 days at 8 °C storage. This technology uses low cost dip solutions, which are non- hazardous to health and available locally.

**Shelf life extension of fresh cut radish**

Pre-treatments of the sliced radish with glucose and packing in a cling film or micro-perforated polypropylene films to retain near normal atmosphere has given a shelf life of 6-8 days at 8 ◦C in radish.

**Shelf life extension of fresh-cut cucumber**

Browning of the cucumber rings is prevented through pre-treatments of the freshly-cut cucumber with ascorbic acid and packaging using suitable semi-permeable cling film to obtain a shelf life of 6 days at 8 $^{o}$C.

**Shelf life extension of fresh-cut carrot**

Freshly cut carrot slices/cubes/ sticks are to be treated with edible coating (pectin) , air dried and to be packed in semi permeable flexible films (925 micron thickness) to obtain suitable modified atmosphere. 21 days shelf life was achieved for fresh-cut carrots prepared through this optimized protocol (at 8°C storage).

**Shelf life extension of fresh-cut green capsicum**

Demand for Ready-to-eat (RTE/fresh cut) vegetables is on the rise due to change in life style as a result of high income levels and woman employment. Fresh cut capsicum spoils due to browning, flavor loss and drying of cut surface. Pre-treatments of the freshly cut green capsicum with calcium propionate and packaging using PD 961 films maintain the shelf life for 9-10 days at 8$^{o}$C. Chemicals with the Generally Recommended as Safe (GRAS) status were used.

**Minimally processed onion**

It is a ready-to-cook convenient product for use in salad and culinary preparation.Presently only ready-to-cook peeled multiplier onion is available in market which has a limited shelf life (2-3 day only). The uniqueness of this process is that pre-treatment developed retains the freshness, flavour and quality for longer time (12 days at 8°C). Moreover, much time saving in pre-preparation of onion. Very much suitable for usage of onion in bulk for culinary recipes in hotels, marriages and other functions, hostels, street fast food vendors, and also for working couples in urban areas.


**Shelf life extension of peeled garlic**

Pre-treatments of garlic cloves in hot water and packaging in BOPP films or equivalent were given to maintain high humidity and modified atmosphere. The product has a minimum shelf life of 3 days at ambient temperature (approx. 28ºC), and up to 15-18 days at low temperature storage (8ºC). It reduces problems of sprouting, browning and softening and the protocol does not involve any chemicals treatment.


**Arka high humidity storage box for shelf life extension of Green leafy vegetables**

- Arka High Humidity storage box was designed and developed by ICAR-IIHR which maintains higher relative humidity needed by green leafy vegetables to retain freshness.
- Green leafy vegetables had a shelf life of 36 hours in Arka High humidity Storage Box kept in room temperature (26-28°C, 52% RH) as compared to shelf life of less than 24 hours in commercial practice.
- With no electricity consumption and without any refrigeration, freshness of green leafy vegetables is retained in Arka High Humidity Storage box for 36 h .
- Highly suitable for vegetable retail shops, super markets and vegetable vendors. This Arka High Humidity storage box gives hygienic way of storage of fresh green leafy vegetables.

## CONCLUSION

Research on minimally processed fruits and vegetables is still needed to develop products that have a high sensory quality, microbiological safety and nutritional value, in particular products intended for retailing. Studies have shown feasibility of shelf life of 7-8 days at refrigeration temperatures (5°C), but for some markets this is not enough: a shelf life of 2-3 weeks is sometimes necessary. Novel equipment can be created to carry out unit operations, such as peeling and shredding more gently and also hurdle technology should be applied more often to the minimal processing of produce. More investigation about growth of pathogenic bacteria and nutritional changes in minimally processed fruit and vegetables with long shelflife, need to be carried out. There is lot of scope of advancement in active-packaging systems and edible films for minimally processed fruits and vegetables.

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