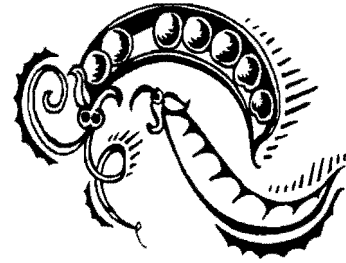


CHAPTER 12



FRESH-CUT PRODUCE

Produce which has been cleaned, cored, peeled, chopped, sliced, or diced and then packaged may be considered fresh-cut produce. Fresh-cut processing involves adding value to a raw agricultural commodity by preparing them for consumer use. Fresh-cut is currently the fastest growing produce market segment in North America and Europe. Consumers of such products may be retail consumers or food service establishments such as restaurants, hotels or hospitals. Fresh-cut products are attractive to consumers because they offer uniform piece size, convenience, reduced preparation time and 100% of the product is usable. This reduces labor costs, storage space requirements and training costs at food service establishments. All these factors have led to the rapid growth of this industry.

Contrary to other food processing techniques such as drying or canning, fresh-cut processing does not extend the shelf-life or preserve the produce. In fact, fresh-cut products are even more perishable and susceptible to the effects of temperature abuse than the whole products from which they are derived. Fresh-cut products must be kept continuously at temperatures between 0 and 5 °C during processing, distribution and marketing. If temperature abuse occurs, significant quality losses and spoilage occurs quickly. This chapter will cover the general steps involved in producing high quality and safe fresh-cut produce.

GENERAL DOS AND DON'TS FOR HIGH QUALITY FRESH-CUT PRODUCE

Certify that raw ingredient suppliers are using Good Agricultural Practices.

Use only the highest quality produce as raw ingredients.

Do not use diseased, decayed or over mature raw ingredients.

Always follow Good Manufacturing Practices.

Carefully monitor and maintain appropriate wash water pH and chlorine levels.

Monitor and maintain wash water temperatures near 0 °C.

Keep cutting and coring blades as sharp as possible.

Always keep finished products between 0-5 °C.

Continuously monitor ingredient and finished product temperatures.

Use appropriate flexible packaging materials, well suited to your product and markets.

Maintain first-in first-out ingredient and finished product rotation.

Assure food safety by implementing a HACCP program.

Prevent temperature abuse during distribution and marketing.

PRODUCT PREPARATION

Fresh-cut product preparation involves various steps which can be broken into specific unit operations. Each unit operation must be performed properly to assure that finished product quality, shelf-life and food safety are satisfactory. Temperature management, cleanliness and expeditious handling are primary considerations when processing fresh-cut produce. Each of the unit operations will be described briefly and its importance detailed.

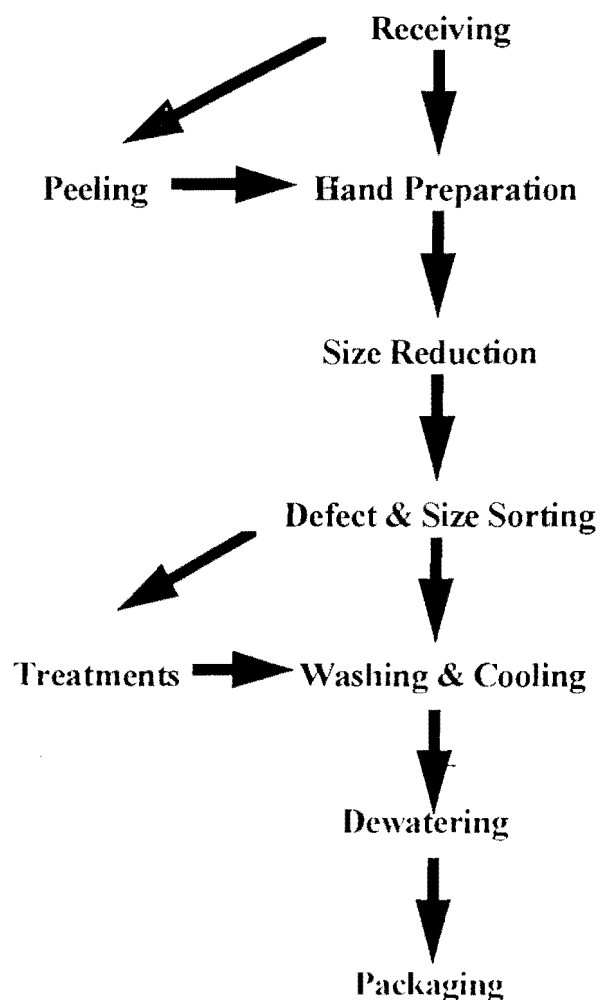
UNIT OPERATIONS IN FRESH-CUT PROCESSING

Raw Material Receiving and Storage

Ingredient Inspection :

The quality of fresh-cut product is highly dependent on the quality of bulk commodities used for processing. Poor quality ingredients will yield poor quality finished fresh-cut products. Produce being received for processing should be sampled and tested for receiving temperature, incidence of defects (i.e. bruising, blemishes, freeze damage in transit, etc.) and insect infestation. Dock facilities should be enclosed, well illuminated and refrigerated. Written specifications and sample plans should be used to inspect incoming bulk commodities and any variance from the specified quality should be immediately noted and brought to the attention of the processing management personnel.

Upon acceptance of raw materials, the lot should be tagged with the date of receipt on each box or bin, to assure first in first out

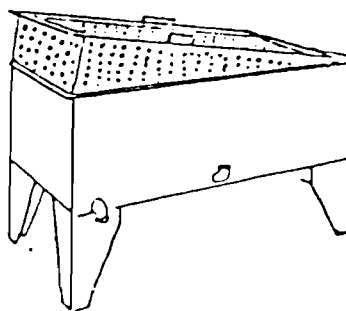


inventory rotation. The accepted product should be quickly moved into the appropriate temperature storage room. Permanent records of the amount and quality of each lot should be documented and be available to bulk commodity buyer and processing management team. Many problems can be avoided by rejecting inferior quality product on the receiving dock and not allowing it into cold storage or the processing room. If you are buying produce from another grower it is especially important to keep good records and do inspections before accepting incoming produce.

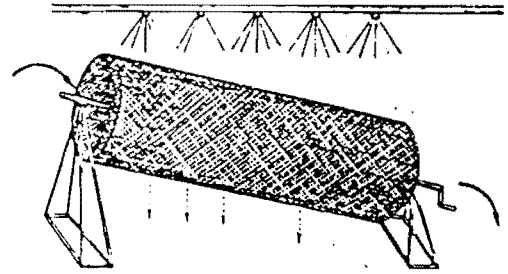
Product Flow: Bulk commodities should be segregated from finished products to prevent cross contamination. Incompatible commodities should also not be stored in the same cooler together (e.g. apples and lettuce). Intermediate stage commodities (e.g., whole peeled onions or carrots) are best stored with bulk commodities, as further processing and washing will be done. Stored in-process intermediates should also be date labeled to assure first in first out inventory rotation. Processing lines should be laid out in a linear fashion with as few 90° angles and vertical drops as possible. Treating whole bulk commodities and intermediate fresh-cut products as gently as possible during processing is important to minimize unnecessary bruising and stress which may reduce product quality and shelf life. Reusable plastic totes or bulk bins may be used to move or store product **BUT** they must be properly labeled (i.e. Food Only), as well as cleaned and sanitized on a regular basis.

Preliminary Washing and Sorting

Fruit and vegetable products are sometimes received with caked on dirt or dust. Washing, and even scrubbing, some commodities and then rinsing in cold chlorinated water may be necessary to remove dirt and reduce microbial populations before cutting. The rotary drum washer shown here can speed up the cleaning



of large amounts of small -sized produce. Immediately removing any fruits or vegetables that show signs of decay from the processing line will also help keep reduce microbial contamination.



Peeling

Some commodities such as carrots, onions and most fruit require peeling to remove tough fibrous skin before cutting. There are numerous peeling methods used in the canning and frozen food industry. However most are not appropriate for fresh-cut products.

Hand Peeling: Hand peeling of fruits and vegetable products will in most cases provide the highest quality product and the highest yield. Hand peeling is extremely labor intensive, but is currently the only option for some commodities.

Abrasive Peeling: Abrasive peelers are commonly used in the fresh-cut industry for such items as carrots and onions. These peelers utilize abrasive surface rollers to remove the outer skin from the product. The skin is washed away with a fine spray of water. Yields can be variable depending upon the operator as well commodity size, shape and quality. Abrasive peeling can be very damaging to commodities and may result in surface scaring which results in chalking or white blush in peeled carrots.

Size Reduction / Cutting

Product Hand Prep.: Cores, stems, seeds and other unwanted plant parts must be trimmed and discarded from the bulk commodities before further size reduction is done. Hand knives and stationary coring units are effectively used for this operation. Knives and corers should be kept clean, sanitary and sharp. Any products exhibiting decay should be discarded and not cut at these stations, as it will contaminate the cutting surface with microbes, and potentially allow for the

contamination of each successively trimmed fruit or vegetable. This is also the primary area for sorting out decay or defects. If defects and decay are not sorted out at this point, one defect will be cut into many small pieces and be dispersed in a large amount of product making it almost impossible to sort out.

Cutting Equipment: After preliminary trimming, size reduction is done via one of any number of cutting machines. There are many manufacturers of slicers and choppers such as Urshel, Brothers, Waterfall, Hobart, and Altman, to name just a few. Knife sharpness is a critical factor since dull knives can significantly reduce the shelf life of fresh-cut products. Replacing and/or sharpening knives on a regular basis is highly recommended. Tracking either the hours of operation on each set of blades or closely visually inspecting cut surfaces are methods which can be used to assess when blades need to be sharpened or replaced.

Size and Defect Sorting

Size Sorting : Size sorting is done to assure that finished product piece size is within acceptable limits to meet customer needs. The most effective way to accomplish this is by the use of shaker screen sizers, which allow undersize small pieces (fines) to pass through a vibrating screen. Pieces greater than the size of the aperture of the shaker screen will continue on to the next steps in processing.

Defect Sorting: Sorting after cutting is often done to remove physiological defects and/or off cut pieces. Due to the number of different defects which are encountered, trained people on the sorting line are the best solution to this problem. Increasing the number of persons sorting when high frequencies of product defects (e.g., tip burn in lettuce) are expected is the only solution.

Washing/Cooling

Properly washing and cooling fresh-cut products immediately after cutting is one of the most important steps in fresh-cut processing. Washing in cold chlorinated water after cutting helps remove microbes, dirt and cellular juices at the cut surfaces. Rinse water temperature, contact time, chlorine content and pH are all key parameters to assure that products are rinsed and cooled properly.

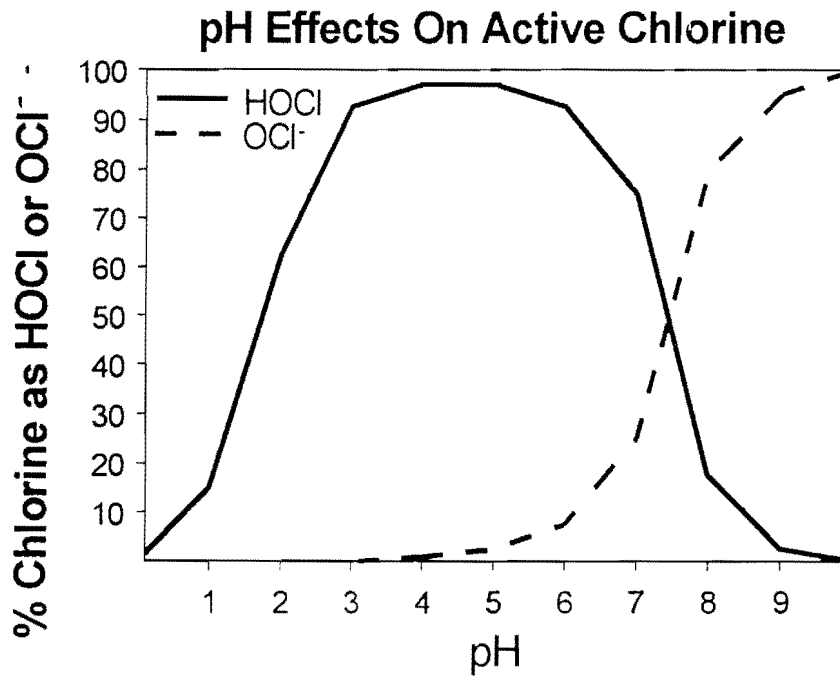
Temperature: Rinse water temperature should be as cold as possible for the product being rinsed, and 0 °C is optimal for most products. Rinse water temperature at the entrance and exit points from the rinse system should be monitored frequently if not continuously to assure that product is being cooled properly and to assure that the chilled water delivery system capacity has not been exceeded.

Contact Time: The longer the fresh-cut product is in contact with the rinse water the colder the fresh-cut product will become. Fresh-cut product must be as cold as possible when exiting the rinse water system (and kept cold) since it is almost impossible to cool fresh-cut products once they are bagged, boxed and palletized. Product temperature at the exit of the rinse water system should be monitored to assure that proper cooling has occurred. Rinse water may be sprayed on fresh-cut products from above via nozzles as it proceeds on a conveyor belt or the fresh-cut product may be submerged and flumed through the rinse system. Submerged fluming systems have the advantage of gently agitating the product pieces and more effectively removing dirt and other debris. Fluming also allows for the long distance transport of product to a separate packaging area.

Chlorination: Total chlorine up to 200 ppm is currently allowed in food processing rinse water to assure potability. 50 to 100 ppm is, however, usually sufficient. Maintaining these levels of chlorine at all times is critical to reduce microbial populations on a fresh-cut produce and reduce cross contamination in the rinse water system. Chlorine is injected into the rinse water system as either a gas or a liquid (Sodium or Calcium Hypochlorite). Careful monitoring and control of free

chlorine levels during processing is critical. Chlorine test kits or biological oxygen demand (B.O.D.) meters should be used to monitor and adjust chlorine levels. Excessively high concentrations of chlorine will damage fresh-cut produce and reduce shelf life as well as cause off flavors and odors.

pH: Chlorine functions best as a bactericide at a neutral or slightly acidic pH. If the pH of the rinse water increases above 7.5 chlorine is ineffective as a bactericidal agent because it is not in its active form. Closely monitoring the pH of the rinse water and adjusting it with an appropriate acid (phosphoric or citric) or base (sodium hydroxide) is an often overlooked factor in fresh-cut processing operations.



Effects of wash water pH on the % active (HOCl) and inactive (OCl⁻) forms of chlorine.

Dewatering Operations

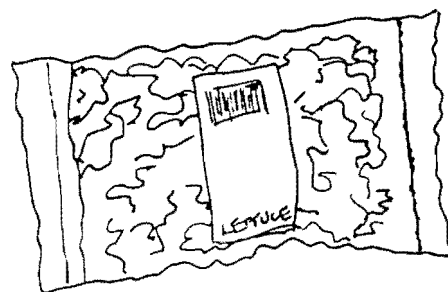
Centrifugation: The method of choice in the fresh-cut industry to dewater product is via centrifugation (spinning to force water to the outside of a collection vessel). The time and speed of centrifugation are key parameters to adjust for each product. Excessive centrifugation will result in cellular damage and cause products to leak fluids after packaging, greatly reducing quality.

Forced Air: Many fresh-cut products are too delicate to withstand centrifugal drying and forced air in a semi fluidized bed may be used to strip water away from products. It is most effective on product pieces which have smooth surfaces allowing water to be swept away from the product. Highly textured surfaces, with nooks and crannies are much more difficult to dry via this method. Any forced air used in such an operation must be filtered so as not to contaminate products.

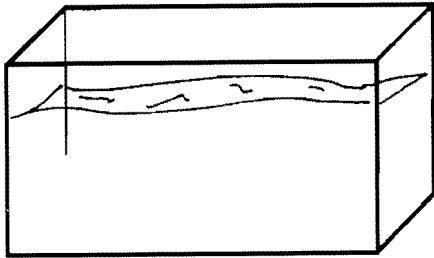
Packaging

Weighing: The first step in the packaging of fresh-cut products is getting the correct amount of product, into the package. This is often accomplished by manually weighing each bag of product and adding or removing product to the desired weight.

Bagging and Sealing: Polymeric film bags and trays for fresh-cut produce come in many sizes, shapes and formulations. Bags may either be purchased already sealed on the side and bottom or formed on site from rolls or pre-cut film. Side and bottom sealing films on site requires substantial capital expenditure for equipment and is used for high volume items. Pre-formed bags are slightly more expensive than rolls of film but require only small capital investment for sealing machines. When fresh-cut products are packaged, the atmosphere within the package may be evacuated or flushed with a mixture of gases to more rapidly establish a desirable modified atmosphere. The correct combination of packaging material, produce weight and gas composition within a package are critical components which must be determined for each product to maintain product quality and extend



product shelf life. (See the section on MAP in Chapter 5 for details). Packaging cannot correct for unsanitary product handling, temperature abuse or poor quality raw materials. Incorrect choice of packaging materials may also cause accelerated deterioration of products. Some processors add a freshness indicator label to the package in order to give produce buyers and consumers additional confidence in produce quality.



BAG LEAK DETECTOR: Tank of clear glass (a 20 gallon fish tank works well) full of clean water allows workers to check visually for air leaks in sealed bags of fresh-cut produce.

Proper sealing of bags is critical in maintaining product quality since as bags with imperfect seals will have near ambient oxygen concentrations and accelerated browning. Seal bar cleanliness, temperature and dwell time must all be carefully controlled and monitored to assure good seals are being consistently produced. Seal integrity as well as side and bottom seals on pre-formed bags should be checked often.

Metal Detection: As part of a good manufacturing practice all fresh-cut products should be screened for the presence of extraneous ferrous and non ferrous metal fragments. Nails and staples from bins and boxes as well as fragments from knives and screws from equipment are all possible sources of metal fragment contamination. Metal detectors must be properly calibrated to function effectively and whenever product package size changes the metal detector must be recalibrated. As the net weight or volume of product going through a metal detector increases sensitivity decreases. On line metal detectors should also be equipped with some sort of ejection device which removes any product which sets off the metal detector. Numerous brands of metal detectors are available and allow for the continuous screening of bagged products.

Boxing: Fresh-cut product boxing is the last step in the processing operation. Boxes should be pre-cooled to make sure that cold product is not packed into warm boxes. Boxes of product should always carry a date of manufacture or use by date and production code to allow first in first out product rotation and possibility of product recall in case such an event is needed. Numerous sizes and types of box forming, sealing, and labeling equipment are available.

TREATMENTS FOR SHELF LIFE EXTENSION

Signs of deterioration of fresh-cut products include bruised or broken pieces, wilting, shrivelling, flaccidity, mushiness, development of off-colors, presence of free liquid in the package, presence of undesirable odors, or bloated bags due to excess gas in sealed bags.

Fresh-cut products generally fail due to the following reasons:

- 1) microbial spoilage;
- 2) excessive tissue softening; and/or
- 3) tissue browning at cut surfaces.

One of the reasons fresh-cut products are so popular with health conscious consumers is the lack of additives and preservatives used during processing. However, some acceptable treatments do exist for shelf life extension.

Microbial Spoilage

The best tool to fight against microbial spoilage is implementation and monitoring of a vigorous cleaning and sanitation program (described earlier in this chapter). Cold temperatures and the chlorination rinse of fresh-cut products effectively reduce microbial growth and are key factors for attaining good product shelf-life. It must be remembered that there is no one step during fresh-cut processing that kills pathogens and no amount of washing will completely remove pathogens from produce if it is contaminated.

Control of Tissue Softening

Tissue softening is a very serious problem especially in fresh-cut fruit products. The flesh firmness of fresh-cut fruit products can be maintained by treatments calcium salts. Dipping fresh-cut products in solutions of 0.5 -1.0% (1% = 10g per liter of water) calcium chloride is very effective in maintaining product firmness. However, calcium chloride may leave a bitter off-flavor on some products. Calcium salts such as calcium lactate and calcium acetate may also be used. Key factors which must be addressed when using such treatments are salt concentration, temperature and contact time.

Control of Browning

An important issue in fresh-cut processing is the control of browning of cut surfaces. Oxidative browning is caused by the enzyme polyphenoloxidase (PPO) which in the presence of oxygen converts phenolic compounds in fruits and vegetables to brown pigments. Outlined below are a number of strategies which may be used to reduce PPO browning.

Reduced Oxygen: Because PPO requires oxygen to induce browning, reducing the amount of oxygen in a package of fresh-cut product by modified atmosphere vacuum packaging or gas flushing will significantly reduce the rate of browning. Reducing the oxygen concentration in a package of fresh-cut products will only slow the rate of browning and not completely stop it. Careful design of a fresh-cut package is essential to assure that the proper amount of oxygen is present. Excessive amounts of oxygen in a package may accelerate browning, while too little oxygen may cause anaerobic metabolism and the production of off flavors and odors.

Acidification: PPO works best at promoting browning at a neutral pH of 7. Therefore, browning can be slowed by dipping products in mildly acidic food grade solutions of acetic, ascorbic, citric, tartaric, fumaric or phosphoric acid. The lowered product pH slows browning but acids may leave off flavors as well as tissue softening and must be used with care.

Reducing Agents: Ascorbic acid or erythroate (an isomer of ascorbic acid) are two common compounds used in the food industry to prevent PPO browning. Ascorbic acid or erythroate stop

PPO browning by converting quinones (formed by PPO from phenolics) back to phenolic compounds. Unfortunately, once all the ascorbic acid or erythroate are used up, PPO browning will proceed uninhibited. Ascorbic acid or erythroate are commonly used as a 1% solution to prevent browning of cut surfaces. These compounds are organic acids so they also reduce the pH of commodities and slow PPO browning.

COSTS AND BENEFITS OF FRESH-CUT OPERATIONS

Costs:

equipment

labor

materials

cooling (mechanical refrigeration or ice)

Benefits:

higher market value

Examples:

Peeled cucumber or radishes dipped in lime juice make refreshing snacks. The produce costs about Rs 5/kg (Rs 0.10 to 0.20 per piece) and the fresh-cut produce sells for Rs 2 per piece.

Fresh fruits sell for about Rs20/kg (Rs 2/100g). Peeled, cut fruits served on a plate sell for Rs 5 to Rs10 for a 100g serving.

SUPPLIERS OF EQUIPMENT AND MATERIALS FOR FRESH CUT PROCESSING

bin dumpers	Brothers' Metal Products, Inc Weldfab Manufacturing Inc
citrus peeler/corers	Murotech Corporation
conveyors	Brothers' Metal Products, Inc Weldfab Manufacturing Inc
custom fruit/veg fresh-cut equipment vegetable equipment	Garrouette, Inc Vanmark Corporation
dicers	Urschel Laboratories
freshness labels (time-temperature indicators)	Lifeline Technology, Inc.
packing/sorting tables	Brothers' Metal Products, Inc

shredders	Commercial Slicers Con., Inc Urschel Laboratories
slicers	Brothers' Metal Products, Inc Urschel Laboratories Commercial Slicers Con., Inc
spinners / spin driers	Brothers' Metal Products, Inc Sunrise Food Machinery Weldfab Manufacturing Inc
strip cutters	Urschel Laboratories
sterilization control systems (chlorine)	Stranco, Inc
wash tank conveyors	Brothers' Metal Products, Inc

Supplier Addresses/Phone/FAX:

Brothers' Metal Products, Inc., 1270 North Grove Street, Anaheim, CA 92806
Phone: (714) 630 1051 FAX: (714) 632 5032

Commercial Slicers Company, Inc., 56A North Seneca Street, Waterloo, NY 13165
Phone (315) 539 5415 FAX: (315) 539 4640 e-mail: comm slicer@aol.com

Garrouette, Inc., P O Box 1747, Watsonville, CA 95077
Phone: (408) 722 2487 FAX: (408) 722 3409

Murotech Corporation, 23820 Hawthorne Blvd., Torrance, CA 90505
Phone: (310) 791 1776 FAX: (310) 791 7252

Stranco, Inc., P O Box 389, 595 Industrial Drive, Bradley, IL 60915
Phone: (815) 932 8154 FAX: (815) 932 0674 e-mail: sales@stranco.com

Sunrise Food Machinery, P.O. Box 2106, Freedom, California 95019
Phone (408) 696 0222 FAX (408) 722 0207

Urschel Laboratories, P O Box 2200, Valparaiso, IN 46384-2200
Phone: (219) 464 4811 FAX: (219) 531 0219 e-mail: marketing@urschel.com

Vanmark Corporation, Industrial Parkway, Creston, IA 50801
Phone: (515) 782 6575 FAX: (515) 782 9209

Weldfab Manufacturing, Inc., 11045 Commercial Parkway, Castroville, CA 95012
Phone: (408) 633 3620 FAX: (408) 633 0644

REFERENCES

International Fresh-cut Produce Association. 1997-98. *Membership Directory and Buyer's Guide*

Kader, A.A. and Mitcham, E. 1995. Standardization of Quality. *Perishables Handling Newsletter* Special Issue on Fresh-Cut Products 80:7-9.

Luh, B.S. and Woodroof, J.G. 1975. *Commercial Vegetable Processing*. AVI Publishing Co., Westport, CT.

Wiley, R.C. 1994. *Minimally Processed Refrigerated Fruits and Vegetables*. New York: Chapman and Hall

Woodroof, J.G. and Luh, B.S. 1986. *Commercial Fruit Processing*. AVI Publishing Co., Westport, CT.