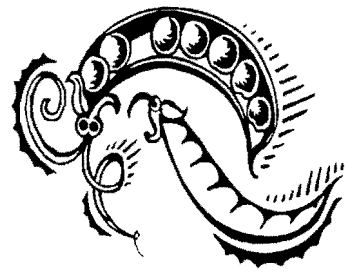
CHAPTER 11



INTRODUCTION TO PART II: SMALL-SCALE PROCESSING

There are many reasons to become familiar with the many technologies used for processing horticultural crops. Economic opportunities abound for enterprising small agri-business people worldwide. Processing produce to a fresh-cut or preserved state can **add value** to produce that commonly sells for a low price in its fresh state. Starting a small-scale processing operation **provides new jobs** for your community, requires only a small capital investment in equipment and supplies, and can result in a fast return on investment. When conditions are not suitable for storage or immediate marketing of fresh produce, processing **reduces perishability**.

While storage of fresh produce requires special facilities and cooling equipment, constant temperature and RH management and strong, ventilated storage containers, processed horticultural product can be stored in any cool, dark location, has a much longer shelf life, and often increases your marketing options. You can avoid selling your fresh produce at the lower prices offered during glut periods or during the usual season for fresh market, and decrease some of the costs associated with fresh handling, storage and transport. Processed products can then be offered for sale during periods when the fresh produce is not available or is in short supply, or during holiday periods when people purchase food gifts and use specialty processed foods for their celebrations.

Typical quality problems and sources of losses when processing horticultural products include some of the same problems encountered when handling fresh produce, as well as problems related to the use of inappropriate processing methods and packaging practices.

Typical quality problems and sources of losses when processing horticultural products:

Harvesting at improper maturity
Inadequate sorting to remove diseased and contaminated produce
Inadequate washing and cleaning of produce before processing
Improper trimming (removing too much or too little of the inedible portions)
Use of improper processing methods
Misuse of processing methods (incorrect times or temperatures for processing)
Inadequate or inappropriate packaging materials

The second part of this book will assist you to identify and utilize scale-appropriate, cost-effective postharvest technologies for horticultural produce to:

- Reduce postharvest losses due to weight loss, decay and physical damage
- Maintain produce quality and economic value during processing and storage
- Assure food safety during processing
- Increase income by adopting postharvest technologies that are profitable for your small-scale operation.

Many horticultural crops can be successfully processed to high quality food products using simple technologies. Being technically able to process produce, however, is often quite different than being able to do so and make a profit. The key element is always the market, and what consumers want to buy and eat, and whether they will pay you enough for the processed product to cover your costs and leave you a profit. In some regions of the world, canned and dried products are shunned. Consumers may believe processed foods are less nutritious or somehow unnatural. In other countries, some processed products are given high value, and producers may grow purely for processors. Organic apples in the US sell for $30 to $75 more per ton as compared to conventionally grown fruit.

Freezing produce is relatively easy, but requires higher capital investment by processors (in the equipment for freezing and maintaining low temperatures during handling, storage, shipping and

marketing) and has a higher cost for consumers (home freezers). Another factor are your costs for labor and the power for processing. Labor costs may differ by the level of skills required for processing various products, while power costs will depend upon the method chosen and the time required for processing.

Once you have identified a processed product that is valued by your potential customers, you must have a reliable supply of high quality fresh produce. When you are also the grower, this will simplify planning and procurement. You can process only the fresh produce you can't sell immediately after harvest, or deliberately sort for the various markets (highest grade for fresh market, seconds for processing). Processing is not the way to get rid of your culls, however, although sometimes you can salvage some produce with purely cosmetic problems or minimal defects. Drying or canning over-mature, stringy green beans or over-ripe tomatoes is sure to give your customers something to complain about. Care must be taken to sort out decayed or infested produce, since one strawberry or one tomato with a fungal infection or will contaminate the flavor of your entire batch of juice. **Always begin with produce of high quality**, since processing will not improve visual, textural or flavor quality. Produce for processing must be harvested at the proper maturity and handled very gently during transport to the processing facility and during sorting operations (ripe fruits, red tomatoes, fresh young vegetables are very delicate). Pretreatments are often used to preserve color, flavor and fesh texture, and all these costs must be considered.

WORKSHEETS

Worksheets are provided the end of Part II of the book to assist you to calculate the costs and benefits associated with handling and processing horticultural products and determine potential profits. Processed products depend upon high quality fresh ingredients, so the postharvest handling steps for fresh produce discussed in Part I are still very important considerations and are part of the costs you will encounter. Worksheet 5 focuses on collecting basic information needed for producing and marketing products of any kind (overhead, expected yields, estimated postharvest losses, anticipated market prices). Worksheet 6 requires that you calculate and list the actual direct costs incurred when you grow, handle, store and/or process a horticultural crop.

Worksheet 5: Basic Information

Worksheet 6: Costs

Worksheet 7: Benefits

Worksheet 8: ROIC

Much of this you should know from your day-to-day recordkeeping for running your business. Worksheet 7 outlines expected benefits in terms of sales and profit, and Worksheet 8 helps you to determine the return on investment (leading you through the calculation of how long it will take to recover invested capital). If you are not sure of the market prices you may receive, you can do the calculations for a worst case (lowest price) and best case (highest price) scenario and determine whether your investments will be worthwhile within that range of possible outcomes.

PROCESSING METHODS

When choosing a processing method you must consider the type of produce, the costs associated with the method and the market demand for the processed product. Fresh-cut technologies are the most complex and can be expensive, and must be undertaken with great care to protect food safety. The processing methods that are more commonly used by small-scale produce handlers include dehydration (drying), fermenting, juicing, freezing, pickling in acid or salt, preserving in oil or sugar, canning and bottling.

FRESH-CUT (minimally or semi-processed): Cleaning, trimming, coring, slicing or otherwise processing fresh produce to a "ready to eat" state adds value but also increases perishability and requires special packaging and excellent temperature management. Shelf life is typically reduced to 7 to 14 days and refrigeration is critical throughout the marketing period. See Chapter 12 for details.

DEHYDRATION: Removal of water from most fruits and vegetables increases shelf life, and drying reduces weight and volume, which reduces the cost of storage and transport. Most dried products are packaged in air-tight containers (plastic bags or glass or plastic bottles), while some can be covered with edible oil and bottled. See Chapter 13 for details.

FERMENTATION: Popular throughout the world as a food preservation method, and over 3,500 individual fermented foods have been described by Campbell-Platt (1987). The details of fermentation are too complex to be covered in this book.

JUICING: Many fresh fruits and some vegetables can be processed into excellent juices either alone or in combination. Juices must be heat processed to stabilize flavor and color, then canned, bottled or frozen to reduce perishability. See Chapter 14 for details.

FREEZING: One of the best methods for preserving natural color, flavor and nutritive value. Two excellent references are the *Ball Blue Book* (1995), and *Keeping the Harvest* (Chioffi and Mead, 1991). Details on freezing are not offered in this book, since it is difficult to manage a freezing operation profitably on a small scale. Inadequate packages or fluctuating temperatures can lead to immediate quality deterioration (soft, mushy produce) and a single power failure can be a disaster.

PICKLING: Peserving in vinegar or brine is defined as pickling. Olives and cucumbers can be salt or brine cured to add value and increase shelf life. Recipes vary widely and are often related to the region of the world where processing was first undertaken. Vinegar is used for vegetable pickles (cucumbers, gherkins, hot peppers, tomatoes, onions, cole crops) fruit pickles (peaches, pears, watermelon rind), relishes and chutneys. See Chapter 14 for details.

PRESERVING IN OIL or SUGAR: Specialty products such as peeled garlic, fruit jams and chutneys are preserved in oil or sugar. Processing can add value and greatly increases shelf life and marketing options. See Chapter 14 for details.

CANNING/BOTTLING: Produce can be canned or bottled alone or in combinations, in its raw state or after cooking. High acid products such as most fruits, tomatoes, pickles and preserves can be heat processed in a boiling water bath (100 °C or 212 °F), while low acid products such as vegetables must be processed at 115 °C or 240 °F in a steam pressure canner. Specialty product preparations (juices, preserves, jams, pickles) are often bottled to increase shelf life, enhance display qualities (labels, bottle style) and increase marketing options. See Chapter 14 for details.

INFORMATION SOURCES FOR FOOD PROCESSING

Many useful reference books are available to guide you in selecting appropriate techniques and methods for processing your fresh produce. The Ball Corporation. publishes *The Ball Blue Book: Guide to home canning, freezing and dehydration*, which is an excellent source of basic information for anyone who is new to food processing. A catalog of postharvest processing equipment is available from Intermediate Technology Publications (9 King Street, London WC2E 8HW, UK). Included are driers, storage containers, cleaners, hand mills, power mills, shellers, decorticators (seed removers), oil processing equipment, fruit presses, and root crop cutters/graters. Sources of specific processing equipment and supplies are listed at the end of Chapters 12 through 14.

GENERAL REFERENCES

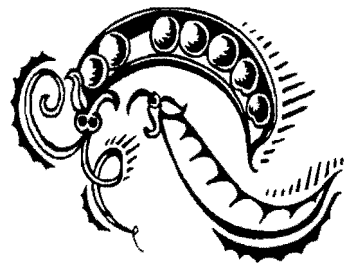
Azami, S. and Battcock, . 1994. Crop processing, small enterprise and the eradication of poverty. *Postharvest News and Information* 5(3):27N-38N

Ball Corporation. 1995. *The Ball Blue Book: Guide to home canning, freezing and dehydration.* Muncie, Indiana: Alltrista Corp.

Chioffi, N. and Mead, G. 1991. *Keeping the Harvest: Preserving your fruits, vegetables and herbs.* Pownal, VT: Storey Communications, Inc.

Fellows, P. and Hampton, A. 1992. *Small-Scale Food Processing: a guide to appropriate equipment.* London: Intermediate Technology Publications/CTA

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 lead 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

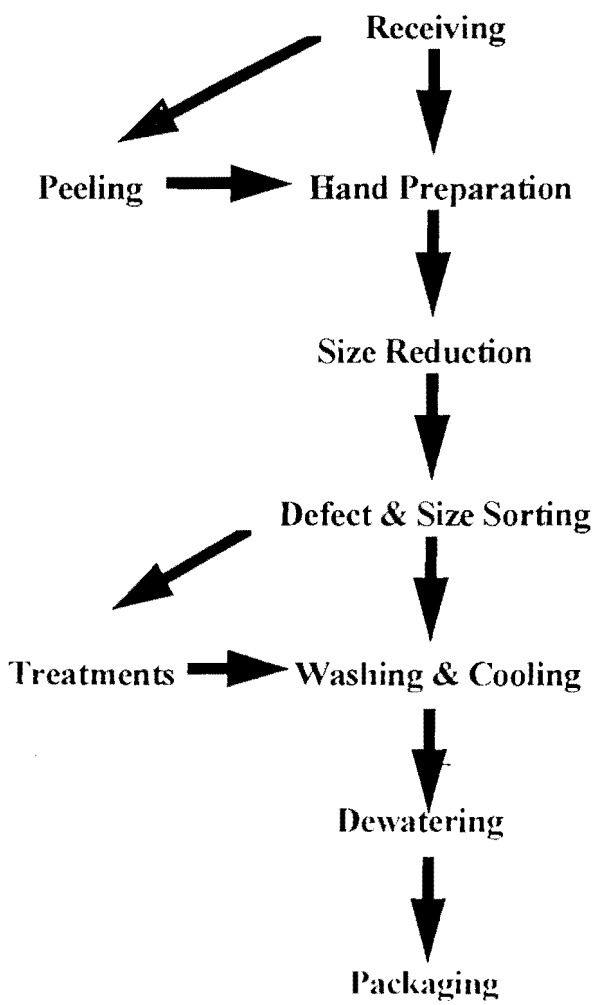
Fresh-cut product preparation involves various steps which can be broken into specific unit operations . Each unit operation must be performed properly to assure that finished product quality, shelf-life and food safety are satisfactory. Temperature management, cleanliness and expeditious handling are 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.



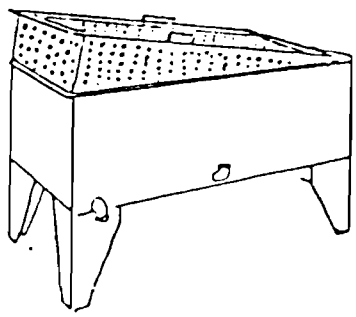
Upon acceptance of raw materials, the lot should be tagged with the date of receipt on each box or bin, to assure first in first out

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.

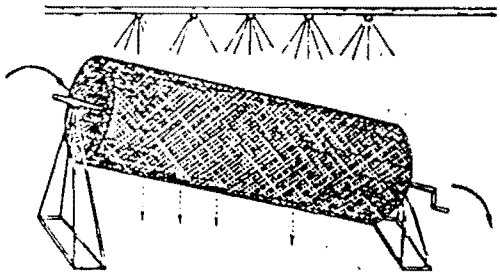
Product Flow: Bulk commodities should be segregated from finished products to prevent cross contamination Incompatible commodities should also not be stored in the same cooler together (e.g. apples and lettuce). Intermediate stage commodities (e.g., whole peeled onions or carrots) are best stored with 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.

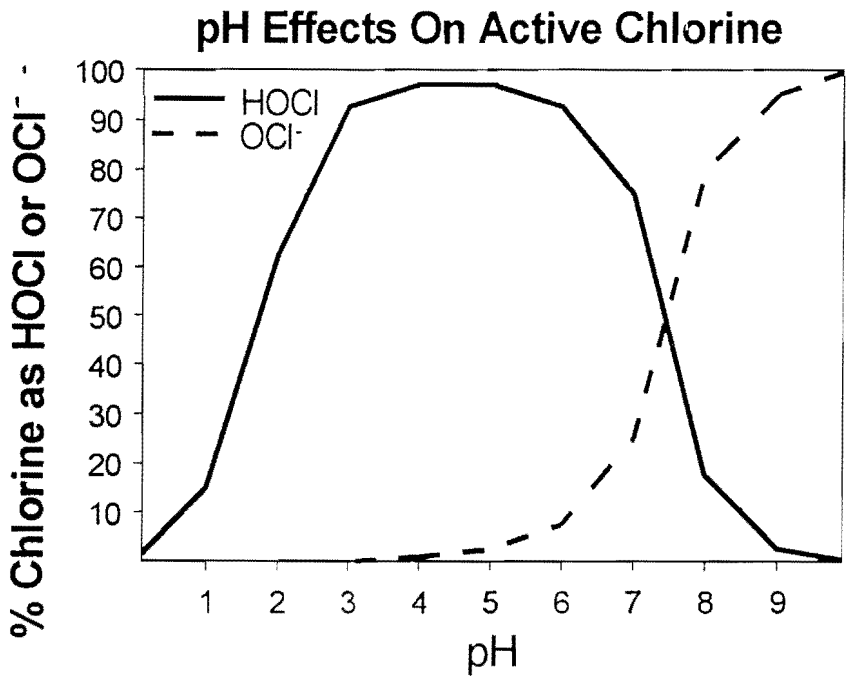
Temperature: Rinse water temperature should be as cold as possible for the product being rinsed, and 0 °C is optimal for most products. Rinse water temperature at the entrance and exit points from the rinse system should be monitored frequently if not continuously to assure that product is being cooled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

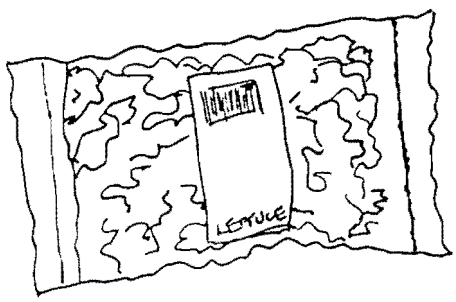
Centrifugation: The method of choice in the fresh-cut industry to dewater product is via centrifugation (spinning to force water to the outside of a collection vessel). The time and speed of centrifugation are key parameters to adjust for each product. Excessive centrifugation will result in cellular 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.

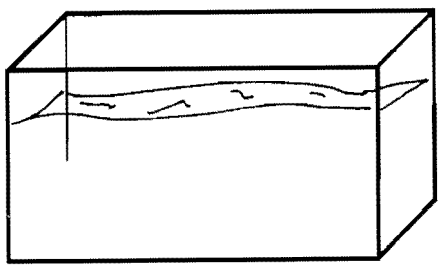
Packaging

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 precut 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, flacidicity, 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 erythrobate (an isomer of ascorbic acid) are two common compounds used in the food industry to prevent PPO browning. Ascorbic acid or erythrobate stop

PPO browning by converting quinones (formed by PPO from phenolics) back to phenolic compounds. Unfortunately, once all the ascorbic acid or erythrobate are used up, PPO browning will proceed uninhibited. Ascorbic acid or erythrobate 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 020 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	Garroutte, Inc Vanmark Corporation
dicers	Urschel Laboratories
freshness labels (time-temperature indicators)	Lifeline Technologiy, 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: commslicer@aol.com

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

Murotech Corporation, 23820 Hawthorne Blvd., Torrance, CA 90505
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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
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Weldfab Manufacturing, Inc., 11045 Commercial Parkway, Castroville, CA 95012
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REFERENCES

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

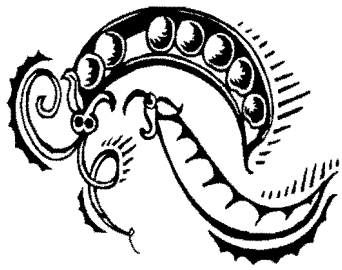
Kader, A.A. and Mitcham, E. 1995. Standardization of Quality. *Perishables Handling Newsletter* Special Issue on Fresh-Cut Products 80:7-9.

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.

CHAPTER 13



PRODUCE DRYING

Dehydration or drying of fruits and vegetables can be accomplished with little capital and produces plenty of high quality, less perishable food products. Drying is the simplest and most natural of all food processing technologies, and preserves fresh produce by removing most of its free water. The lower water content slows the rate of respiration, enzymatic action and overall deterioration rate, makes products less susceptible to decay and much easier and less expensive to store and transport. While all horticultural produce can be dried, not all commodities become high quality, good tasting dried products.

You can dry produce naturally in the sun (direct solar drying), via solar assisted methods (indirect solar drying), or with added ventilation and heat to speed the process (electric, gas or diesel powered driers). Drying in the sun is the least expensive method, and quite viable if your climate is hot and dry during harvest time, but also the slowest method and often results in products of a lower overall quality. Pre-treatments such as blanching and ascorbic acid dips used before drying can assist you to reduce losses of flavor, color and nutritional quality that can occur when drying produce. Value can be added to dried products by enhancing flavor during drying (for example by adding spices to vegetables, or sweetening fruits with sugar or honey dips).

This chapter will provide information on 1) produce types and cultivars known to result in high quality dried products, 2) a variety of pre-treatments used to reduce quality deterioration, 3) details on methods of direct solar, indirect solar and power-assisted drying, 4) dehydration equipment you can build or buy and 5) packaging options for dried produce. The chapter concludes with a simplified example to help you to work out the costs and benefits related to producing and drying fresh produce and packaging, storing and marketing dried products.

GENERAL DOs AND DON'Ts FOR PROCESSING HIGH QUALITY DRIED HORTICULTURAL PRODUCTS

Dry only those fruits and vegetables that will result in a high quality, marketable product.

Start with high quality freshly harvested produce. Allow fruits to ripen on the tree or vine.

In general, the faster a food is dried, the better the quality of the dried product will be (better flavor, color, texture and higher nutritional value).

Wash produce thoroughly before pre-treatments and/or preparation for drying.

Pre-treatments can reduce browning and loss of vitamins (blanching, sulfuring, various dips such as lemon juice, acsorbic acid solution, sodium bisulfite, pectin or honey).

Dry as quickly as possible, but keep drying temperatures from getting so high that the produce flavors change and produce becomes "cooked" (maximum 53 to 57 °C or 130° to 140 °F).

Expose as much surface as possible to speed drying rate (slice, shred, grate or chop).

Dos and Don'ts continued:

Peel produce to expose more surface area, remove stems, seeds, pits.

Produce pieces should be uniform in size and thickness.

Spread produce out in a thin, single layer on slatted or screen trays.

Remove surface moisture (wipe with a clean cloth or paper towel).

Air movement over and below the trays will increase drying rate.

Always test produce for adequate dryness before storing (until leathery for fruits, 15 to 20% moisture; crisp-hard for vegetables, about 5% moisture. Actual times for complete drying will vary widely).

If drying outdoors in the sun, take trays indoors if it threatens to rain, and at night to prevent the collection of dew on the produce.

Take care to avoid dust, dirt and insect contamination during drying.

Consider adding value with special seasonings or sweetening produce during drying if you have a ready market for such products.

Seal wooden trays with mineral oil (pine and cedar will transfer odors to produce).

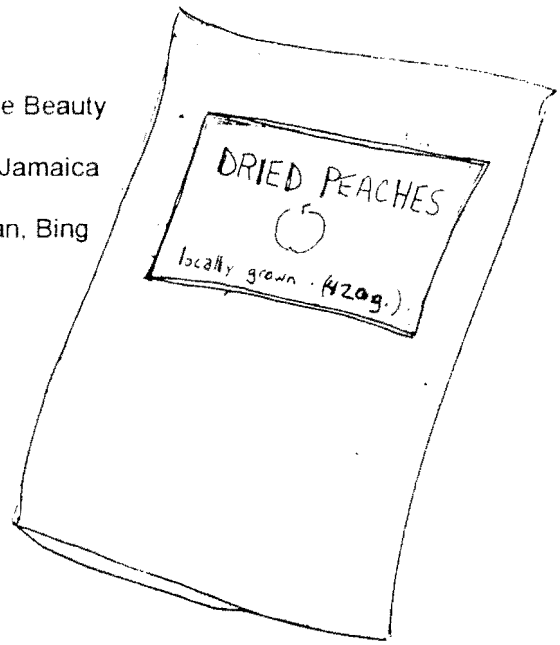
Do not use galvanized screen for trays, as it will contaminate foods.

Store dried products in small, airtight containers and protect products from light.

Check stored products for moisture, and dry further if any condensation is found in containers to avoid problems with fungal growth, mycotoxins or aflatoxins (found predominanatly in tree nuts)

HORTICULTURAL COMMODITIES AND CULTIVARS SUITABLE FOR DRYING

Nuts: All nut crops must be dried before storage.



Fruits (fully ripe):

Apples-- Gravenstein, Granny Smith, Jonathan, Rome Beauty
Apricots-- Blenheim/Royal, Tilton
Bananas-- Cavendish, Gros Michel, Martinique, Red Jamaica
Blueberries
Cherries (sweet)-- Lambert, Royal Ann, Napoleon, Van, Bing
Currants-- black, seedless varieties
Dates
Figs-- Kadota, White Adriatic, Black Mission
Grapes--Thompson Seedless
Kiwifruit
Mangoes
Melons-- cantaloupe, Honey Dew, watermelon
Nectarines
Papayas
Peaches
Pears--Bartlett, Summer
Persimmons
Pineapples
Plums-- prune types, D'Agen, French Imperials, Brooks, Italian Prune
Strawberries

Vegetables:

Beans (green)-- Tendergreen, Blue Lake
Beets--small sized Detroit Dark Red, Morse Detroit, Ohio Canner
Carrots-- Imperator, Red Cored Chantenay
Corn (sweet)-- yellow varieties
Garlic-- use only firm cloves with no bruises
Horseradish-- use only fully mature roots
Mushrooms-- *Boletus edulis*, Chantrelles, Morels, *Agaricus, Bisporus*
Okra-- less than 4 inches (10 cm)
Onions-- Southport White Globe and Yellow Globe, Red Creole, White Creole, Ebenezer
Parsley and herbs
Parsnips
Peas (green)-- Dark Seeded, Thomas Laxton
Peppers (sweet and chilies)
Potatoes
Pumpkins
Squash (winter)
Sweetpotatoes
Tomatoes-- fully ripe Roma or paste types, Red Pear, Del Oro, Viva Italia
Turnips --young, small

PRE-TREATMENTS

Preparation for Processing

In addition to washing produce with clean, good quality water, certain produce requires special preparation before drying for best results.

Removing any inedible parts: Woody stems (cherries, grapes, currants, berries, mushrooms), inedible peels or pods (onions, garlic, kiwifruit, melons, bananas, mangoes, green peas) and pits or seeds (cherries, papayas, melons) should be removed.

Peels can be removed from stone fruits, tomatoes, and apples to speed drying rate.

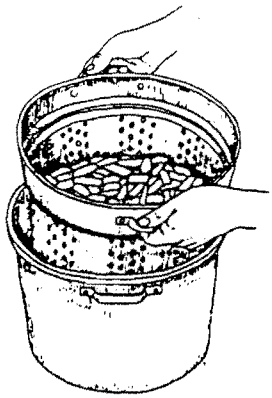
Fruits such as grapes, plums and blueberries have a waxy coating on their peels which must be "checked" by quickly dipping in boiling water or the skins must be pierced before beginning the drying process.

Apricots, peaches and plums will dry faster if their backs are "popped" after being halved and pitted (pushing the peel side inward to expose more of the surface).

Large sized fruits should be cut or sliced into pieces of uniform size and thickness (1/4 inch to 1/2 inch, or 0.6 to 1.2 cm thick). Smaller sized fruits can be halved or quartered.

Vegetables should be cut or sliced into smaller pieces (1/8 inch cubes, shredded or diced) to reduce drying time-- taste and texture are lost if drying takes too long (more than 14 hours).

Pre-treatments--Blanching



Some vegetable produce benefits from **blanching in boiling water or steam** before drying. Blanching is quick, incomplete cooking, which ends certain enzymatic reactions in the fresh product, expels tissue gases. Blanching decreases the microbial population present on the surface of fresh produce and helps retain bright color, good texture and fresh flavor after processing. Follow the chart below for blanching times, and always rinse blanched produce under very cold water or dip the hot produce into and ice water bath to stop the cooking process. Steam blanching takes a little longer, but results in less loss of vitamins B_1, B_2, niacin and C than boiling water blanching.

Blanching times for vegetables

Boiling water: Use one gallon of boiling water per pound (8 liters per kg) of produce.
Steam blanching: Use 2 inches (5cm) of water per lb or 1/2 kg of produce.
Place produce in a colander, on a wire rack or in a steam basket.

Commodity	Blanching time (minutes)*	
	Boiling water	Steam
Beets	15, until tender	30
Carrots	5	5
Corn (whole ear, cut kernels off, repeat)	3	5
Green Beans	3	4
Leafy greens	2	
Mushrooms	3 to 5	4 to 5
Okra		3 to 4
Parsnips	3	4
Peas	2	3
Potatoes (new)	4 to 6, until translucent	
Pumpkin	2 to 3, until soft	
Sweetpotatoes	5 to 10, until soft	5 to 10
Tomatoes	30 seconds,then cold water dip to remove skins	
Turnips	5	5 to 8

*Add 1 minute to blanching times for each 2000ft if you live at an elevation of over 4000 ft.

Sources: Chioffi, N. and Mead, S. 1991. *Keeping the Harvest.*
and McClure, S. 1992. *The Harvest Gardener.* Pownal, VT: Storey Communications Inc.

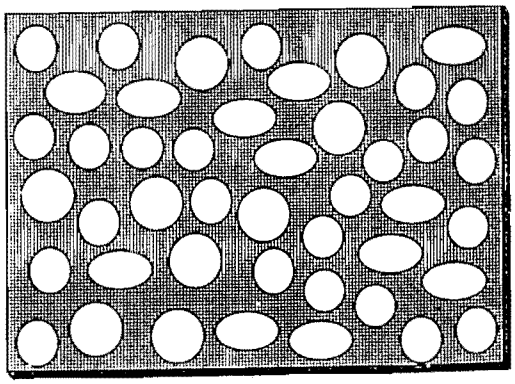
Pre-treatments--Sulfuring

Fruits such as apples and apricots are sometimes treated with sulfur before being dried. Sulfuring helps prevent darkening, loss of flavor and loss of vitamin C and reduces the microbial population present on produce tissues. Fruits dry faster after being sulfured, and insects are not as much of a problem during drying. Treatments can be made by exposing prepared produce to fumes from burning sulfur powder for up to several hours or via solutions (dipping fruit in a potassium metabisulfite or sodium bisulfite solution for one minute).

Despite its technical benefits, treatment with sulfur can be a problem for several reasons. Some consumers dislike the taste of sulfured produce, while a small percentage may have an allergic reaction (always label your products as sulfured to provide consumers with this information so they can protect themselves from harm). Fruits treated with sulfur fumes cannot be dried indoors, since the odors are too strong.

Sulfuring by dipping in bisulfite solutions: Recommended for apples, green peas, available as commercial preparations such as Fruit-Fresh®.

Use a solution of 1% potassium metabisulfite (1 Tbsp in 1 gallon, or 10 ml in 1 liter of water) for one minute or 2% sodium bisulfite solution (2 Tbsp in 1 gallon, or 20 ml in 1 liter of water) for up to 5 minutes. Drain and pat dry before laying produce out on drying trays.



DRYING TRAY:
Sliced produce spread in a thin, single layer on a screened tray.

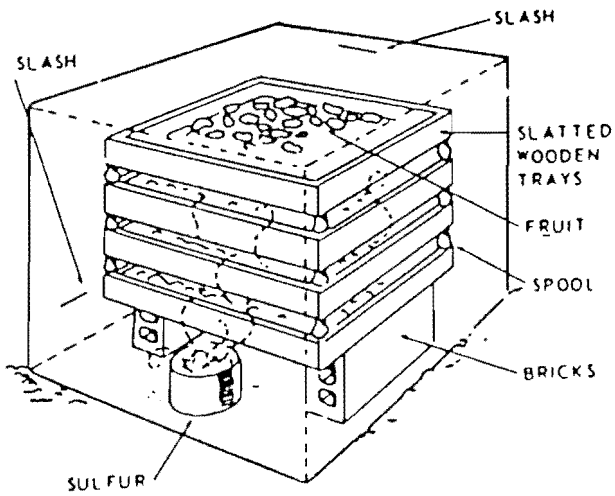
Sulfuring times via burning sulfur powder for selected fruits:

(burn one tablespoon of sulfur powder per pound or 35 ml per kg of fruit)

Commodity	Sulfuring Time		
	Halves	Quarters	Slices
Apples		1 hour	45 min
Apricots	3 hours	2 hours	
Cherries	30 minutes	20 minutes	
Nectarines	3 hours	2 hours	
Peaches	2 to 3 hours	2 hours	1 hour
Pears	4 to 5 hours	2 hours	1 hour

Sources: Miller, M. et al. 1981. *Drying Foods at Home*. University of California, Division of Agricultural Science, Leaflet 2785, and Hobson, P. 1994. *Making and Using Dried Foods*. Pownal, VT: Storey Communications, Inc.

A low cost sulfuring box can be constructed from a large cardboard or lightweight wooden box that is vented in several places to allow adequate ventilation. Trays for drying can be stacked using bricks and wooden spools as spacers. The trays must be made completely of wood, since sulfur fumes will corrode metal. The entire assembly must be located out of doors, preferably on bare soil. Use one tablespoon of sulfur powder per pound (35 mls per kg) of fruit. Place the sulfur in a container well away from the side of the box since it will become quite hot. Once the powder is burning well, seal the bottom edges of the box with soil.



Source: Miller (1981)

Pre-treatments-- Recipes for fruit dips

Some fruits can benefit from a brief dip in acid, pectin, sugar or salt solution. Never leave fruit in the pre-treatment solution for more than a few minutes (3-4 minutes maximum).

Ascorbic acid dips: Recommended for apple slices, apricots, bananas, peaches, nectarines, pears. use 5 grams vitamin C tablets crushed in 1 L or 1 quart of lukewarm water or 30 ml (2 Tbsp) acsorbic acid powder in 1 L or 1 quart lukewarm water. Slice or chop fruits directly into the solution, remove with slotted spoon, drain well and pat dry.

Pectin dip: Recommended for berries, cherries and peaches and nectarines
1 box powdered pectin in 1 cup (250 ml) water, stir, boil 1 minute. Stir in 1/2 cup (125 ml) granulated sugar, dissolve. Add cold water to make two cups (500 ml) syrup. Chill. Cut fruit into syrup, coat thoroughly, remove with slotted spoon, drain well and place on trays.

Honey dip: Recommended for bananas, pears, peaches, nectarines, apricots, pineapple, strawberries. Mix 1 cup (250 ml) granulated sugar in 3 cups (750 ml) hot water. Stir in one cup (250 ml) honey. Dip cut fruit, remove with slotted spoon, drain well and place on trays.

Fruit juice dips: Recommended for apples, apricots, peaches, nectarines, bananas
Pineapple: Dip cut fruit in undiluted pineapple juice. Drain well, place on trays.
Lemon: Mix 1/4 cup (63 ml) lemon juice with one quart (1 L) warm water.
Dip cut fruit, remove with slotted spoon, drain well and place on trays.

Salt water dip: Mix 6 Tbsp (90 ml) flaked pickling salt in 1 gallon (4 L) lukewarm water. Slice or chop fruit directly into solution, remove with slotted spoon, drain well and pat dry.

DRYING TEMPERATURES AND TIMES FOR PRE-TREATED FRUITS AND VEGETABLES

Test produce for dryness about one half way through the recommended drying time. Dried fruits will be pliable (apples, apricots, plums, strawberries) or leathery (cherries, grapes, peaches, pears) while dried vegetables will be crisp (garlic, parsnips, hot peppers, potatoes, tomatoes), hard and brittle (beets, corn, green beans, carrots, peas), papery (onions) or tough (sweet peppers, rhubarb).

Fruits (fully ripe, sliced):	Solar drying (days)	Power-assisted dehydration Temperature °F	°C	Time in hours (check at 1/2 way)
Apples	2-3	130	54	6-8
Apricots	2-3	130	54	12-36
Bananas	2	130	54	6-8
Blueberries	2-4	130	54	12-24
Cherries	1-2	130	54	10-12
Currants		130	54	18-24
Dates		130	54	12-24
Figs	5-6	130	54	36-48
Grapes	3-5	130	54	24-48
Kiwifruit		140	60	12-18
Mangoes		130	54	24-36
Melons		130	54	10-14
Nectarines		130	54	10-12
Papayas		130	54	24-36
Peaches	4-6	130	54	24-36
Pears	2-3	130	54	12-18
Persimmons	3-5	130	54	18-24

	Solar drying (days)	Power-assisted dehydration Temperature °F	°C	Time in hours (check at 1/2 way)
Fruits (fully ripe, sliced):				
Pineapples	3-4	130	54	24-36
Plums/prunes	4-5	140	60	18-24
Strawberries	1-2	130	54	12-18
Vegetables (diced or chopped):				
Beans (green)	4-5	130	54	48
Beets	1-3	130	54	4-8
Carrots	2-3	130	54	12-18
Corn (sweet)	1-2	130	54	8-12
Garlic		130	54	6-8
Mushrooms	1-2	130	54	8-12
Okra	1-2	130	54	8-12
Onions	2-3	130	54	12-24
Parsley and herbs		90	32	6-8
Parsnips	1-2	130	54	12-18
Peas (green)	2-3	130	54	12-18
Peppers (sweet and chilies)	1-2	130	54	8-18
Potatoes	2-3	130	54	12-18
Pumpkins	2-3	130	54	12-18
Squash (winter)	1-2	130	54	8-18
Sweetpotatoes	1-2	130	54	12-18
Tomatoes (fully ripe)	1-2	130	54	6-8
Turnips	2-3	130	54	12-18

Sources: Hobson (1994) and DeLong (1979)

DRYING METHODS

Solar Drying

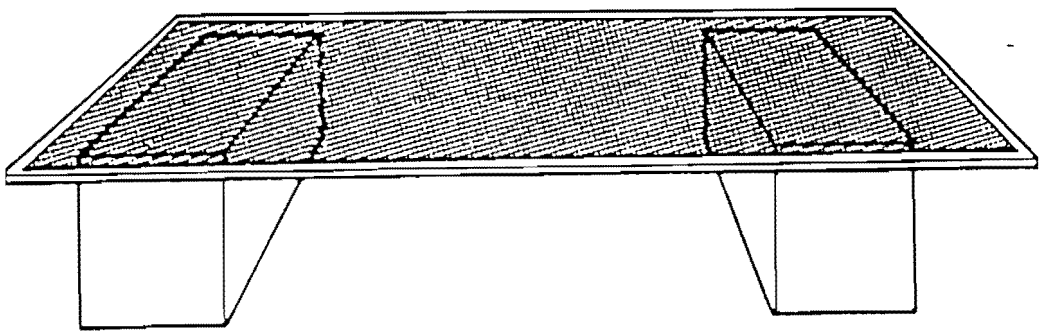
Horticultural produce can be dried using direct or indirect solar radiation. The simplest method for solar drying is to lay produce directly upon a flat black surface and allow the sun and wind to dry the crop. Nuts can be dried effectively in this way.

Solar drying is recommended for:

apples
stone fruits
pineapple
currants
grapes
figs
dates
pears

Solar drying works best in a hot, dry climate. When drying produce in the sun, place the prepared produce in the sun for the first 2 or 3 days, then move it to a ventliated shady spot to complete drying. If you live in a location with a high relative humidity, solar drying may take too long to produce a high quality product.

Simple direct driers can be made from trays of screening material propped upon wooden or concrete blocks to allow air to circulate under the produce. A layer of cheesecloth can be draped loosely over the produce, protecting it from insects and birds while drying. Produce dried outdoors in India is often unsafe due to exposure to bird droppings.

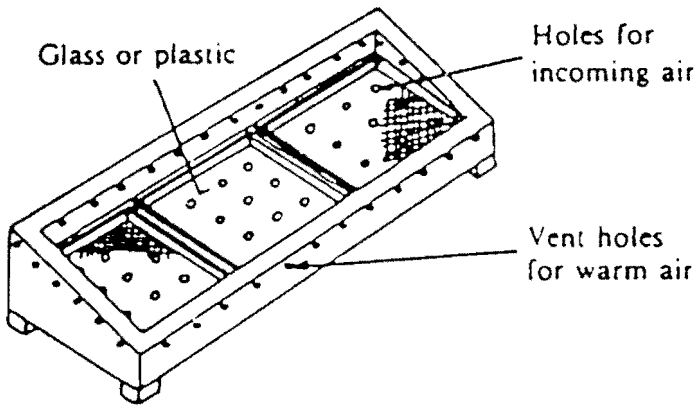


Trays should be made of food-grade materials such as stainless steel, plastic or nylon. **Copper, aluminum and galvanized metals (cadmium and zinc plated metals) should not be used--** copper reduces the vitamin C content in many foods, aluminum will discolor some fruits, and zinc and cadmium are dissolved by fruit acids and cause dried products to become toxic.

Solar driers

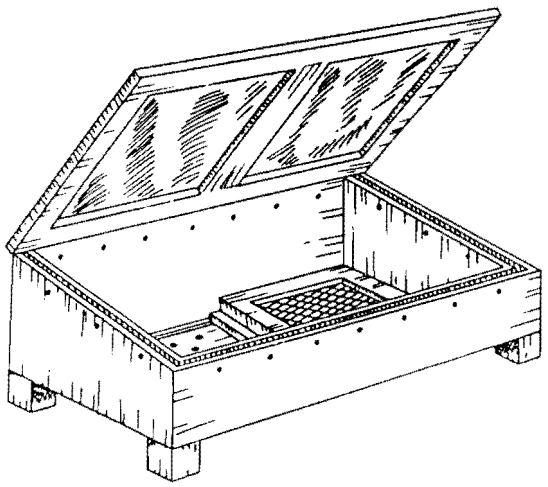
More complex models of solar driers have glass or clear plastic windows that cover the produce, providing some protection from insects while capturing more of the heat of the sun.

Direct solar drier (Source: Yaciuk, 1982):



Brace or Lawand type cabinet drier :

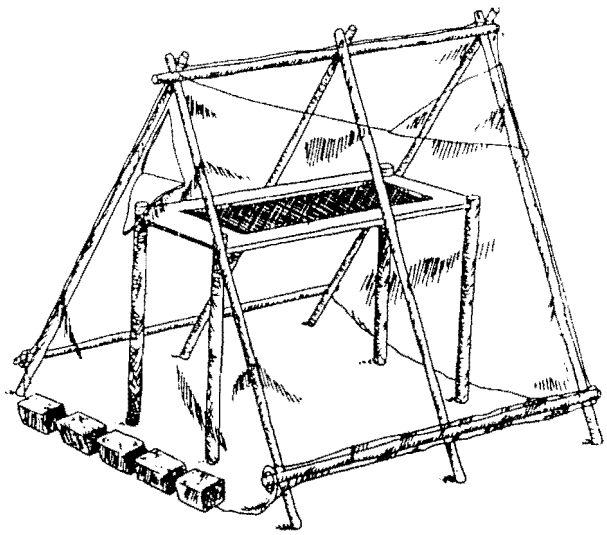
(Source:Intermediate Technology Publications,1995)



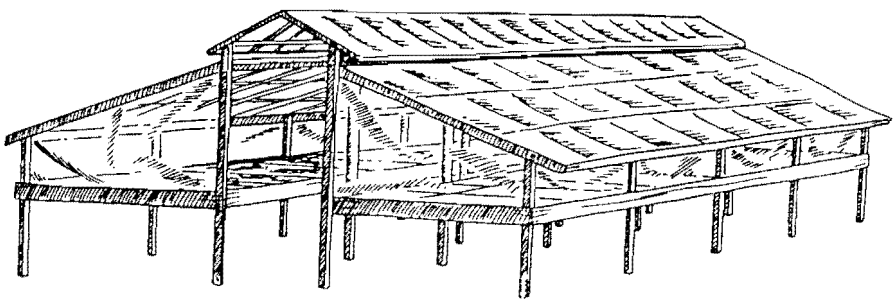
In order to improve the efficiency of sun drying, some sort of structure must be used to capture solar radiation. Further improvement comes when you add a fan to move air through the trays of produce. Various types of solar driers have been developed and are illustrated below.

Tent drier (clear plastic cover with a black floor):
(Source: Intermediate Technology Publications; 1995)

PAgrExCo has set up several 40 to 50 meter long tent driers with polythene covers as demonstration projects in Punjab.

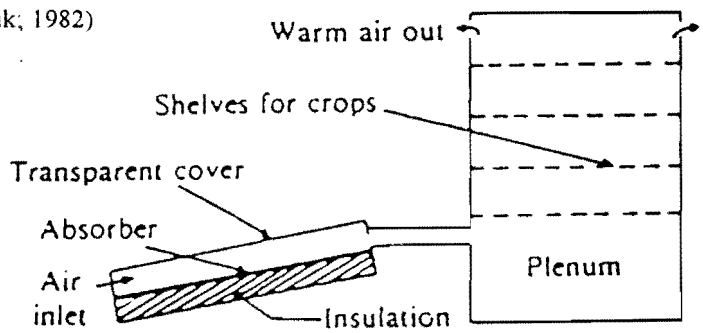


Walk-through drier:
(Source: Intermediate Technology Publications; 1995)

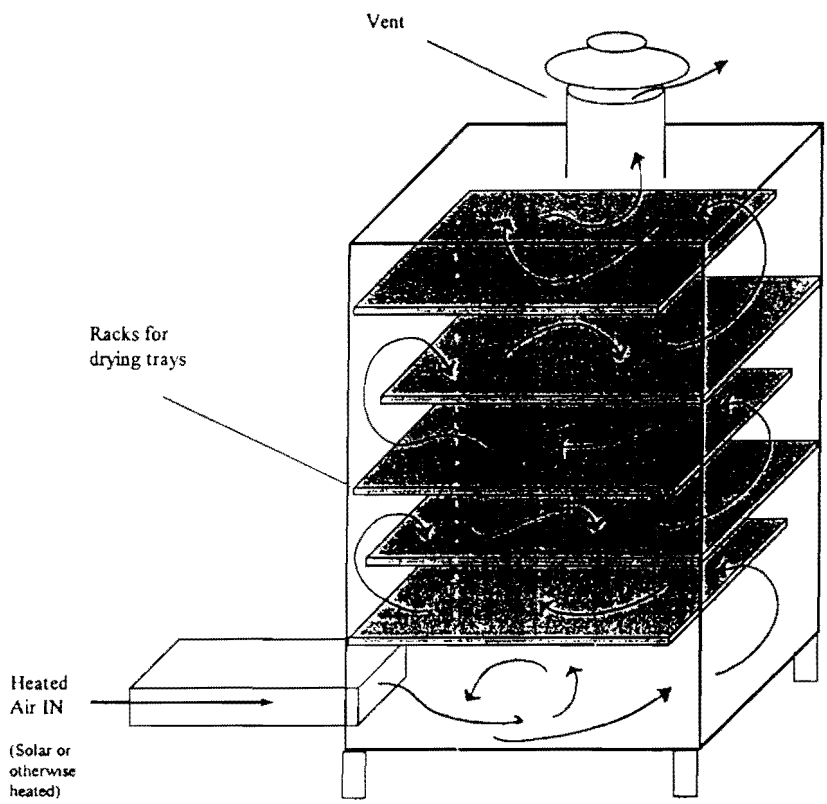


Indirect driers are constructed so the sun shines upon a solar collector (a shallow box, the insides painted black, topped with a pane of glass) heating air which then moves upward through a stack of four to six trays loaded with produce.

Cut-away views:
(Source: Yaciuk; 1982)

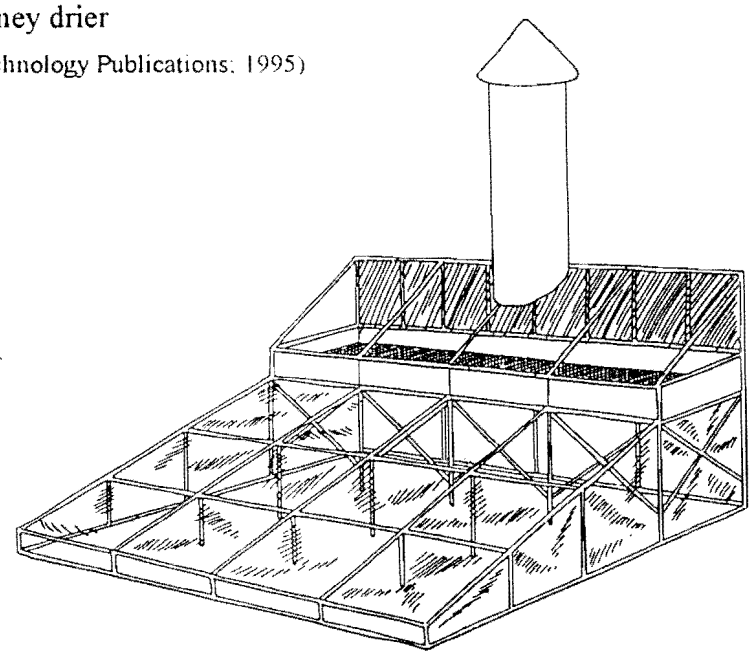


Air flow inside indirect drying cabinet:



One ton indirect chimney drier

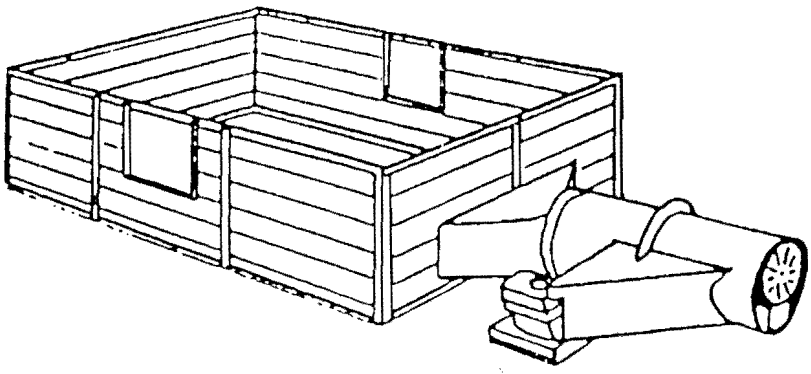
(Source: Intermediate Technology Publications; 1995)



Forced-Air Dehydrators (electric, oil or gas powered)

For quicker, more effective drying, or for drying during wet weather, a dehydrator can be used indoors in a dry, well ventilated room. Never dry sulfur treated produce indoors.

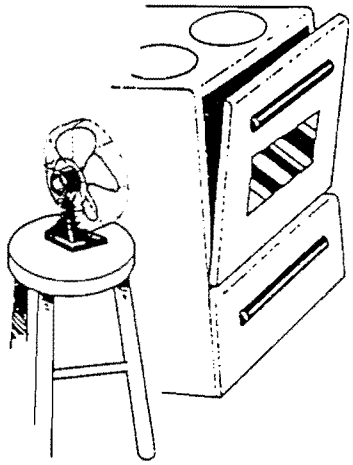
Nut crops can be dried in bulk using a dehydrator that combines a steady stream of air with an external source of heat. The plenum chamber below the produce is covered with a floor of perforated sheet metal or wooden slats. A fan located between the furnace and the plenum chamber moves the hot air through the drying produce. The batch dryer illustrated here is constructed of wood, has an axial type fan and burns kerosene or diesel oil. A wide variety of dryers are available from manufacturers around the world.



Source: Clarke (1987)

Oven Drying

If the weather doesn't permit solar drying in your region, or your normal solar drying operations are threatened by rain, fruits and vegetables can be dried in a large gas or electric oven if the oven can be run at a low temperature. Place the prepared produce on baking or metal screen trays, set the oven temperature at 57 °C (140 °F) and leave the door ajar 5 to 10 cm (2 to 4 inches). Drying time can be reduced if ventilation is increased by using a small fan placed outside the oven. Rotate the trays every 3 or 4 hours within the oven and turn foods occasionally to promote uniform drying. While tending the trays requires more labor, the quality of the finshed product will be greatly improved if you pay close attention to the drying process.



Source: Georgia Coop. Ext. Service (1984)

PACKAGING AND STORAGE OF DRIED PRODUCTS

Suitable packages for dried products include air tight jars, plastic or glass bottles or plastic bags. Fill containers as full as possible to remove air before sealing, and consider heat-sealing or vacuum sealing plastic bags to extend shelf life. Avoid metal containers and keep packaged products in a cool, dark place during storage.

Check packages a few days after dried produce has beens sealed inside-- if there is any condensation inside the container, then the product needs further drying. Shelf life is typically one year when products are properly dried and sealed in air tight packages.

COSTS AND BENEFITS OF DRYING PRODUCE

Costs
Produce
Pre-treatments
Trays and/or equipment
Power

The cost of dried produce depends upon the initial cost of the fresh produce, the cost of any pre-treatments, the cost of power (cost of one kilowatt hour or cost of fuel used for drying) and the time required for complete drying.

$$\frac{\text{(cost per kwh x hours to dry)}}{\text{weight of dried produce}} + \frac{\text{(costs of produce + pre-treatments)}}{\text{weight of dried produce}} = \text{Cost per lb of dried produce}$$

The costs of storage, transport and marketing dried produce will be lower in comparison to handling fresh produce.

Benefits:
Extended shelf life
Reduced losses
Longer marketing period

Example 1: If fresh peaches are selling in California for the cost of production ($0.20/lb) at the peak of the season because of a glut on the market, fresh marketing will not provide a profit to the small-scale grower who does not have access to inexpensive cold storage facilities. The cost of drying 1000 lbs of produce is $100.

1000 lbs of fresh peaches yields 150 lbs of dried product with a market value of $4.00/lb.

$200 of fresh produce can be processed to $600 of dried product.
$600 -$100 = $500 potential profit.

Example 2: If fresh tomatoes are selling in Punjab for the cost of production (Rs5/kg) at the peak of the season because of a glut on the market, fresh marketing will not provide a profit to the small-scale grower who does not have access to inexpensive cold storage facilities. The cost of drying 1000 kg of produce is Rs 9200, including the non-recurring costs for trays and polythene covering.

1000 kg of fresh tomatoes yields 150 kg of dried product with a market value in gourmet specialty food shops in New Delhi of Rs 200/kg.

Rs 5000 of fresh produce can be processed to Rs 30,000 of dried product.
(Rs 30,000-Rs 5000) -Rs 9200 = Rs 15,800 potential profit.

SOURCES OF DRYING EQUIPMENT, SUPPLIES AND PACKAGING CONTAINERS

almond hulling/drying	Mid-State Manufacturing
apple parer/corer	Orchard Equipment and Supply Co.
electric food drier	Garden Way Country Kitchen
glass and plastic bottles and jars.	General Bottle Supply Co., Inc
plastic bags	U.S. Plastic Corporation
mylar ® film	Dow Chemical

Refer to Appendix D for addresses and phone numbers of suppliers.

REFERENCES

Best, R., Alonso, L. and Velez, C. 1983. The development of a through circulation polar heated air dryer for cassava chips. 6th Symposium, International Society for Tropical Root Crops. (Lima, Peru, Feb. 21-26, 1983).

Brett, A. et al. 1996. *Producing Solar Dried Fruits and Vegetables for Micro- and Small-scale Rural Enterprise Development: A Series of Practical Guides*. Chatham, UK: NRI

Chioffi, N. and Mead, G. 1991. *Keeping the Harvest.* Pownal, Vermont: Storey Communications, Inc.

Clarke, B. 1987. *Post-Harvest Crop Processing: Some Tools for Agriculture.* London: Intermediate Technology Publications.

DeLong, D. 1979. *How to Dry Foods*. Los Angeles: HP Books

FAO. 1985. *Prevention of Post-Harvest Food Losses: A Training Manual.* Rome: UNFAO.

Fuller, R.J. 1993. Solar Drying of Horticultural Produce: Present Practice and Future Prospects. *Postharvest News and Information* 4(5): 131N-136N.

Georgia Cooperative Extension Service. 1984 *So Easy to Preserve.* University of Georgia, Athens, Georgia.

Hart, R. M. 1995. *Dirt Cheap Gardening.* Pownal, VT: Storey Communications, Inc.

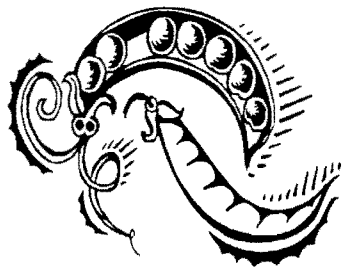
Hobson, P. 1994. *Making and Using Dried Foods*. Pownal, VT: Storey Communications, Inc.

Kader, A.A. and Thompson, J.F. 1992. Postharvest Handling Systems: Tree nuts. In: Kader, A.A. (Ed). *Postharvest Technology of Horticultural Crops (2nd ed).* University of California, Division of Agriculture and Natural Resources, Publ. 3311.

Miller, M. et al. 1981. *Drying Foods at Home*. University of California, Division of Agricultural Science, Leaflet 2785.

Yaciuk, G. 1982. Food Drying: Proceedings of a Workshop held at Edmonton, Alberta, 6-9 July 1981. Ottawa, Ontario: IDRC

CHAPTER 14



CANNING AND BOTTLING SPECIALTY PRODUCTS

The market for specialty products is large, and includes processed foods sold through retailers in gift shops, gourmet and specialty food stores, health food stores, upscale delicatessen markets and direct to consumers at farmers' markets, on-farm shops and tourist-oriented farm stores. According to *From Kitchen to Market* (Hall, 1996), condiments (sauces, dressings, seasonings, herbs and spices) make up 40% of the average sales in gourmet shops, while prepared foods, confections, meats and miscellaneous foods (including mushrooms, fruits and vegetables, soups, rice and pasta) each account for about 10% of sales. Beverages, coffees/teas, and cheeses each make up about 5% of sales.

Horticultural produce is processed to become part of the following categories:
Condiments (salsas, pickles, chutneys, herb-vinegars, jams, jellies and preserves)
Beverages (juices, sparkling fruit-flavored waters)
Confections (fruit-based candies, cookies, cakes)
Miscellaneous (bottled herbed-mushrooms, fruit or vegetable-based snack-foods).

Start-up costs for a nationally distributed specialty food product can be enormous, and investment in production, packaging, labelling, advertising and promotion may not be repaid for years, if at all. We suggest, instead, that you start with a small product line or even one product,

and sell it directly to the people who now purchase your fresh produce. All food processing must be done in a location that will pass a health department inspection. Most likely this means you will need to rent an industrial kitchen (perhaps in a local restaurant during off hours) or work with a co-packer (a food processor of a similar product who has extra capacity).

The average annual growth of processed fruits and vegetables in India over the past 5 years is about 22%.

Year	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97
lakh tonnes	3.60	4.69	5.59	6.76	8.50	9.60

(Source: Ministry of Food Processing Industries/Government of India

This chapter will provide information on 1) produce types and cultivars known to result in high quality canned and bottled products, 2) a variety of pre-treatments used to reduce quality deterioration of processed products, 3) details on methods of boiling water bath and pressure canning, 4) packaging options for canned or bottled produce. If you choose not to process produce yourself, it is usually simple to find one of the many food processors who offer co-packing services. The chapter concludes with an example designed to help you to work out the costs and benefits related to producing and processing fresh produce and handling, storing and marketing canned or bottled products.

GENERAL DOs AND DON'Ts FOR CANNING/BOTTLING HIGH QUALITY SPECIALTY PRODUCTS

Market test your processed products on a small scale by providing samples to your fresh produce customers.

Start with only the best quality, freshest ingredients.

Use only high quality containers and food grade caps/liners for a proper seal.

Sort and wash produce thouroughly before chopping/slicing/pre-treating.

Follow recommended procedures for pre-treatments such as blanching, peeling, seeding or coring to ensure high quality.

Leave enough headspace when filling containers.

Measure acidity to determine the proper processing method to use.

Make sure canned/bottled products are processed at the proper temperature and/or pressure for the recommended length of time.

Adjust processing times for altitude. Add 5 minutes to boiling water bath times for altitudes from 3001 to 6000 ft; 10 minutes for altitudes from 6001 to 8000 ft. For altitudes over 100 ft, increase the pressure for processing via pressure canners to 15 lbs pressure (weighted gauge) or 12 lbs (dial gauge).

Follow the safety practices outlined in Chapters 10 and15 to prevent food safety problems during processing.

Work with a reputable co-packer to process produce if you are unwilling to make the investments necessary to ensure high quality and food safety.

Store products in a cool, dark place.

Check containers to make sure a vacuum seal is present. Signs that products have spoiled include broken seals, seepage, mold, yeast growth, gassiness, fermentation, spurting liquid when jar is opened, sliminess, cloudiness, and disagreeable odors.

PREPARATION FOR PROCESSING

Some vegetable produce benefits from blanching in boiling water or steam before canning. Blanching is quick, incomplete cooking, which ends certain enzymatic reactions in the fresh product, expels tissue gases. Blanching decreases the microbial population present on the surface of fresh produce and helps retain bright color, good texture and fresh flavor after processing. Follow the chart below for blanching times, and always rinse blanched produce under very cold water or dip the hot produce into and ice water bath to stop the cooking process. Steam blanching takes a little longer, but results in less loss of vitamins B_1, B_2, niacin and C than boiling water blanching.

Blanching times for selected commodities

Boiling water: Use one gallon of boiling water per pound or 8 liters per kg of produce
Steam blanching: Use 2 inches (5cm) of water per lb of produce
Add one minute for each 2000 ft altitude if you live at elevations over 4000 ft.

Commodity	Blanching time (minutes)	
	Boiling water	Steam
Asparagus	3	5
Brocolli	3	5
Brussels sprouts	4	
Cabbage (wedges)	5	6
Carrots	5	5
Cauliflower	3 (add 4 tsp or 45 ml of salt)	
Collards	3	4 to 5
Corn (sweet)	7	
Green Beans	3	4
Eggplant	4 (add 4 oz or 125 ml lemon juice)	
Leafy greens	2	
Mushrooms	3 to 5	4 to 5
Okra		3 to 4
Parsnips	3	4
Peas	2	3
Potatoes (new)	4 to 10, until translucent	
Pumpkin	2 to 3, until soft	
Sweetpotatoes	15 to 20, until soft	
Zucchini/summer squash	3	4

Sources: Chioffi, N. and Mead, S. 1991. *Keeping the Harvest.*
and McClure, S. 1992. *The Harvest Gardener.* Pownal, VT: Storey Communications Inc.

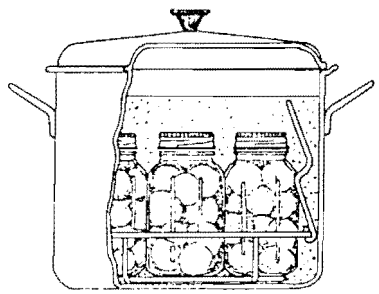
Canning and Bottling Methods

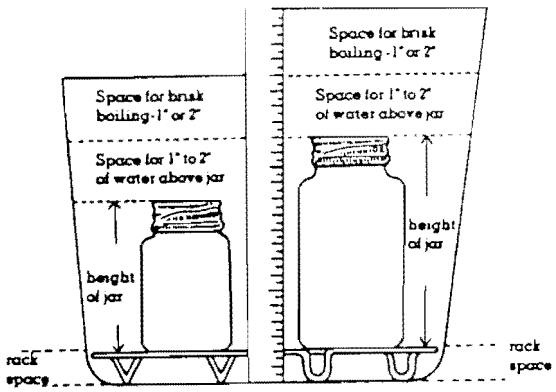
Two types of canners are commonly used to process horticultural crops. These are the boiling water canner, and the pressure canner. The choice of method depends on the acid content of the produce you are processsing. Canners come in all sizes, and can be matched to the facilities you have for cooking and heating.

Boiling water bath

A water bath canner is a large pot with a loose cover and a rack to hold jars off the bottom. The pot should be deep enough to cover the canning jars by one to two inches and still have another inch of space to allow brisk boiling. The diameter of the pot should be no more than four inches wider than the diameter of the stove's burner to ensure even heating.

Acidic foods such as fruits, tomatoes, pickles and relishes (pH < 4.5), and high sugar foods such as jams, jellies, syrups and marmalades can be safely processed using a boiling water bath.

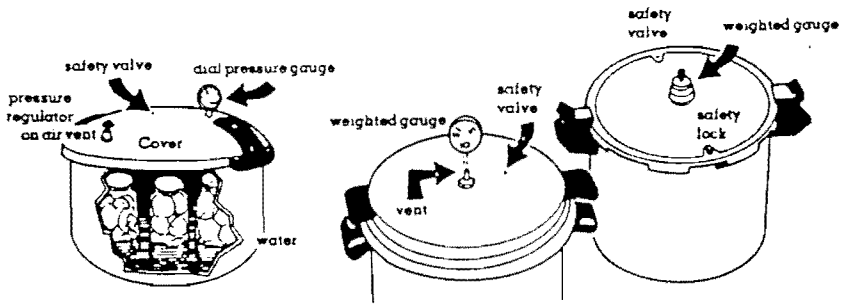




Source: Georgia Cooperative Extension Service, 1984

Pressure canning

A pressure canner is required for processing low acid foods such as vegetables (pH > 4.5). A pressure canner is a specially made heavy pot with a locking lid, an inner rack and a steam vent in the lid. The vent can be adjusted using a weight, value or screw, depending on the type of canner. A pressure gauge registers the air pressure inside the canner. A dial gauge gives a reading of the actual pressure, while weighted gauges will rock gently when the canner is at the proper pressure. Ten pounds of pressure at 115 °C (240 °F) is recommended for canning vegetables at 0 to 1000 ft altitude..



Pressure Canners

Source: Georgia Cooperative Extension Service, 1984

CANNING CONTAINERS

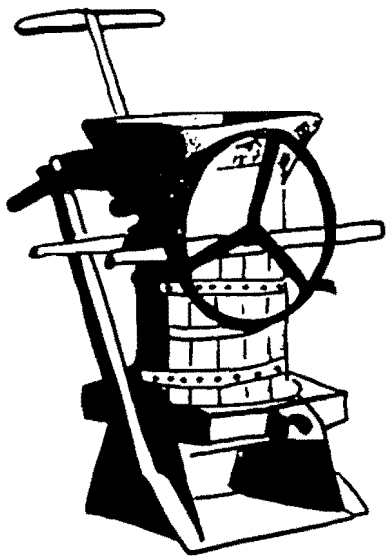
There are several types of glass canning jars used for processing horticultural crops. The ball type jar and the zinc capped jar both require rubber rings as seals. These can sometimes be difficult to obtain, but if locally available, make excellent containers. Most people are familiar with the two-pieced lids used for home canning. Currently containers (bottles or jars) with a plastisol lined lid are the most commonly used container for small-scale processing. Air bubbles must be removed by gently running a non-metallic spatula around the inside of the jar between the food and the side of the jar.

No matter which jar is used, when filling containers, it is important to leave a small amount of headspace to allow for expansion of the food while processing. If a jar is filled too full, it may explode. If too much headspace is left, the food may spoil, since all the extra air may not be driven out during processing. As a rule, leave 2.5 cm (1 inch) headspace for low acid foods and vegetables; 1.3 cm (1/2 inch) headspace for acid foods (pH < 4.5), fruits and tomatoes; and 0.7 cm (1/4 inch) headspace for juices, jellies and jams, pickles and relishes (Ball, 1995).

Processed Products: Juices

Fruits

To process tomatoes or fruits to juices, fruits are simmered in water or their own juice in a stainless steel, glass or enamelware pot. When tender, the product is cut into pieces and pressed through a food mill, colander or several layers of cheesecloth. Sugar or lemon juice can be added, to taste.



The juices must then be either frozen or canned for storage. Juices can be frozen in jars or freezer containers (leave 1.3 cm or 1/2 inch headspace). Most fruit juices can be canned in a boiling water bath for 20 minutes, but apple and grape juices can be processed in hot water (82 °C or 180° F) for 30 minutes. Recent problems with apple juice (Odwalla) have lead to requirements for labelling on pasteurization.

Apple juice:

24 lbs apples

2 liters or quarts water

Wash apples, drain, remove stem and blossom ends, chop and place in a large pot. Add water and cook until tender, stirring frequently. Strain through several layers of cheescloth into a second pot. Heat juice just to a boil, then fill hot jars, leaving 0.7 cm or 1/4 inch headspace. Add caps and process in a boiling water canner for 10 minutes. Yield about 12half-liters or pints.

Mango Squash: Use ripe fruits, washed with clean water and dried. Squeeze each fruit, rolling it between your palms to break down the pulp, then remove the stem end and squeeze out the thick pulp and juice. To make a 25% pulp squash, combine 1.75 kg sugar, 40 g citric acid and 1.25 kg water and bring to a boil. Cool and filter through a muslin cloth. Add 1 kg mango pulp, filter again through a muslin cloth. Add 2.9 g potassium metabisulfite as a preservative (dissolved in a small quanity of juice) and mix thoroughly. Fill clean, dry glass bottles, leaving about 1 inch headspace. Source: Department of Food Science and Technology, PAU.

Vegetables

Vegetables should be chopped or shredded, then simmered for 45 to 50 minutes until mushy. The juice can then be pressed or strained from the vegetable pulp, and frozen or canned. Canning vegetable juices requires processing at 10 pounds of pressure in a pressure canner. Pints should be processed for 55 minutes, and quarts for 85 minutes.

Processed Products: Pickles and Vinegars

The high acid content of pickled vegetables allows you to use a boiling water bath rather than a pressure canner, and reduces the time required for processing. The salt used for pickling is free of additives found in table salt, which will cause clouding. Flavored vinegars are so highly acid that no further processing is necessary if vinegar is decanted into sterilized bottles. To sterilize containers: fill with hot water place in an open pot; cover with water and boil for 10 minutes.

For the highest quality product, use only the freshest produce and herbs.

Spicy Dill Green Beans

(Tilgner, 1998)

Ingredients:
green beans, whole, washed, drained, trimmed and cut to fit vertically in jars
(1 lb makes about two pint jars)

5 parts vinegar
5 parts water
0.5 parts canning salt

per pint jar
- 1/4 tsp crushed hot red pepper
- 1/2 tsp whole mustard seeds
- 1/2 tsp dill seed
- 1 clove peeled garlic
- 5 sprigs fresh dill

Pack beans into hot, clean jars. Add pepper, mustard seed, dill seeds, garlic and fresh dill. Combine vinegar, water and salt; heat mixture to boiling. Pour liquid over beans, filling to 1/2 inch below top of jar. Seal jars, adjust lids (not too tight). Process in a boiling water bath for five minutes. Remove from boiling water, complete seals (tighten lids) and let cool completely before handling.

Mango Pickle (Achar):

Use sour varieties of well developed but under-ripe mangoes, washed and cut lenthwise into slices. .

Ingredients

mango slices	1 kg
salt	250 g
fenugreek (methi)	50 g
fennel (saunf)	50 g
nigella (kalaunji	20 g
red chilli powder	25 g
tumeric powder (haldi)	20 g
black pepper	25 g
cumin (zira)	25 g
thyme (ajwain)	25 g
mustard oil	

Dip mango slices into 2% salt solution (brine) to prevent blackening of cut surfaces.
Drain the brine, spread slices on trays and place in the sun for 1 to 2 hours to remove surface moisture.
Mix fenugreek, fennel, nigella, black pepper, cumin and thyme and fry in mustard oil unitl slightly browned. Cool to room temperature and add salt, tumeric and red chilli powder. Add mango slices and mix thouroughly.
Transfer mixture to a large glass or stone jar, press well to squeeze the air out and cover content with a layer of mustard oil.
Examine the pickle after 2 or 3 days and add oil if needed to ensure the pickle is covered with oil.
The pickle is ready for eating in 2 to 3 weeks.

Source: Department of Food Science and Technology, PAU.

Flavored Vinegars:

Use only glass or enamel pots and glass containers since vinegar is corrosive. Crush flavorings (fresh herbs of your choice, spice seeds, peeled shallots or onions, hulled berries) and place them in a glass jar. Use 250 ml (1 cup) of herbs or 125 ml (1/2 cup) of berries for each 0.5 L (16 oz) of cider vinegar. Slowly heat the vinegar in a glass pot until warm (not boiling). Pour the vinegar into the glass jars over the herbs/flavorings and seal tightly. Place the jars in a sunny location and let vinegar mature for about two weeks. Shake daily and taste periodically. When vinegar has reached desired taste, filter through cheesecloth into a clean sterile bottle. Add fresh herbs or spices for decoration and seal. Use only cork, plastic or glass lids. Store in a cool, dark place.

Herbs in cider vinegar:
tarragon, dill, marjoram, sage, thyme, chile peppers.

Use white vinegar
for red basil or chive blossoms.

Processed Products: Preservation in Oil or Salt

One of the simplest methods of preservation is to cover peeled or dried produce with edible oil and seal it in a clean container. In India the most popular products are preserved in mustard oil. Use high quality olive oil for the best flavor and highest market price in the U.S. and Europe. Salt cured products are becoming less popular as people change their food habits and eat less salty foods. An exception is olives, for which there are many recipes and well-guarded secret processing methods. The example provided here comes from Morocco.

Products in oil:
Dried tomatoes
Dried chili peppers

Moroccan black olives:

10 kg black olives, very mature, defect free
2 kg unrefined canning salt
1/2 liter olive oil

Mix olives and salt and put the mixture into deep baskets. Cover with something heavy that will press the liquid out of the olives (during 2 to 3 weeks) and leave in a shady place. After 3 weeks, wash olives thouroughly with clean water, dry in sunlight for 1 to 2 days. Mix with 1/2 liter olive oil and ladle into jars, close firmly.

Processed Products: Specialty Sauces, Salsas, Chutneys

A few inexpensive ingredients that you produce on your farm can be combined into specialty products that yield high prices at the market. Recipes are from Ball (1995) and Chioffi and Mead (1991).

Spicy tomato ketchup:

Ingredients
35 to 45 medium tomatoes, very ripe, peeled, quartered, cored
2 sweet red peppers, seeded and cut into pieces
2 sweet green peppers, seeded and cut into pieces
2 hot red peppers, diced
4 large onions, diced
3 cups cider vinegar
2 cups sugar or honey (use less if desire less sweetness)
3 Tbsp salt

Tie into a cheescloth bag:
1 tsp whole allspice, 1 tsp whole cloves, 1 tsp broken cinnamon stick.

Combine vegetables in a large pot, cook until tender (15 to 30 minutes). Remove from heat and run through a food mill. Add all remaining ingredients except vinegar and simmer uncovered until thick while stirring frequently. Add vinegar and cook an additional 15 minutes. Remove bag of spices, ladle into hot clean jars. Add lids and process for 15 minutes in a boiling water canner. Yield: 8 to 10 cups.

Hot Salsa:

6 lbs tomatoes, ripe, peeled, seeded, cored, chopped.
2 lbs green peppers, seeded and chopped
1.5 lbs onions, chopped
1 lb hot peppers, chopped (remove seeds if you desire a milder version)
1 1/4 cups cider vinegar
3 cloves garlic, minced
2 Tbsp cilantro, minced
3 Tbsp salt

Combine all ingredients in a large pot, bring mixture to a boil. Reduce heat and simmer 10 minutes. Ladle hot salsa into hot jars, leaving 1/4 inch headspace. Add lids, process 15 minutes in a boiling water canner. Yield: 12 cups.

Peach chutney:

Ingredients
20 medium peaches, peeled, pitted and chopped
1 cup raisins (250 ml)
1 medium chopped onions
2 cups brown sugar (500 ml)
1/4 cup mustard seed (125 ml)
2 Tbsp ginger (40 ml)
2 tsp salt (15 ml)
1 clove garlic, minced
1 hot red pepper, finely chopped
5 cups vinegar (1.25 L)

Combine all ingredients in a large pot. Cook slowly until thick (about 40 minutes), while stirring frequently. Ladle hot chutney into hot jars, leaving 0.7 cm (1/4 inch) headspace. Add lids and process 10 minutes in a boiling water canner. Yield: 14 jars (250 ml each).

REGULATIONS AFFECTING FOOD PROCESSING

Food safety and sanitation requirements

Contact the Food and Drug Administration and ask for a current copy of their publications on how to start a food business and *Current Good Manufacturing Processes*. The FDA has an office in Washington, DC and in each US state.

Food and Drug Administration
Center for Applied Nutrition FDA (HFS-585)
200 C Street, SW
Washington, DC 20204

The Government Printing Office can provide you with a copy (for a fee) of the current Code of Federal Regulations. Chapters 1 through 3 of the Code cover the regulations affecting food processing operations, including use of additives, color, good manufacturing practices and food standards.

Superintendent of Documents
GPO
Washington, DC 20402

Labeling

Products shipped interstate which do not conform to the FDA labeling regulations will be removed from store shelves Some key elements include a list of ingredients and a net weight statement (in metric measurements) on the lower third of the label.

THE NUTRITIONAL LABELING AND EDUCATION ACT (1990):

Exceptions to the law that all products carry nutritional information include coffee, tea and spices, containers too small to carry a nutritional label, and producers whose total annual revenues are less than $500,000.

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Packaging

If you are aiming for the gourmet market, your processed product better look beautiful! Visit *http://www.packstrat.com* for information on all sorts of packaging materials. Here are some sources of labels, design services, marketing materials and containers:

Labels Plus
2407 106th St. SW
Everett, Washington 98204
(206) 745-4592
FAX: (206) 523-1973

Packagemasters, Inc.
P O Box
118352 Sindle Ave.
Little Falls, New Jersey 07424
(201) 890-7511
FAX: (201) 890-0470

Presentation Packaging
870 Louisiana Ave. South
Minneappolis, Minnesota 55426
(800) 326-2698 or (612) 540-9544
FAX: (612) 540-9522 or -9628

Southern Atlantic Label
1300 Cavalier Blvd.
Chesapeake, Virginia 23323
(804) 487-2525
FAX: (804) 487- 9712

Sources of containers (metal, plastic, PET, and glass):

Agri-Pack
870 Louisiana Ave.South
Mineappolis, Minnesota 55426
(800) 328-1784

Fruit and vegetable containers.
Fruit and jam gift containers.

Berlin Packaging
111 North Canal St., Suite 300
Chicago, Illinois 60606
(800) 4-BERLIN
FAX: (800) 423-7545

Largest U.S. distributor of glass, plastic and metal containers.

Essentials 'N Such 3999 N. Chestnut Ave. Suite 368 Fresno, California 93726	Bottles, jars, vials.
General Bottle Supply Co., Inc P.O Box 58734 1930 East 51st Street Los Angeles, California 90058 (213) 581-2001	Glass and plastic bottles, vials and jars. Metal caps with plastisol liners. Wide range of PET containers.
Southland Container, Inc. 8620 Dorsey Run Road Jessup, Maryland 20794 (410) 792-2088 FAX: (410) 792-7453	Manufacture and distribution of packaging materials
Sunburst Bottle Co. 7001 Sunburst Citrus Heights, California 95621	Vinegar bottles, vials, canning jars.
Western Specialty Container 17955 East Ajax Circle Industry, California 91748 (818) 912-8600 FAX: (818) 913-5337	Decorative containers, tamper-evidence bands

CO-PACKERS

Working with a local co-packer can reduce many of the costs associated with food processing and packaging. Some co-packers can even provide product distribution services through their marketing networks. According to Hall, (1996), benefits and cost savings of co-packing include:

- elimination of capital costs of facilities and processing equipment
- access to experts in food processing
- compliance with the complex process of meeting federal, state and local regulations
- product uniformity and quality control
- purchasing power (containers, labels, etc)
- networking
- low cost technical services
- marketing assistance
- distribution

Some co-packers specialize in processing either dry or liquid products, while others provide only packaging or only labeling services. Contact co-packers in you area to identify which companies can provide the services you need. A few examples of California based companies are provided here, and many more can be found in telephone directories and in the Appendix on co-packers provided in Hall, 1996.

California Style Gourmet Products
6161 El Cajon Blvd., #200
San Diego, CA 92115
(800) 243 5226
Fax (619) 265 0893

Lodi Nut Co., Inc.
1230 S. Fairmont Ave.
Lodi, CA 95240
(209) 334 2081
FAX (209) 369 6815

Radich Bor-do-lay, Inc.
8130 Berry Ave., Suite 100
Sacramento, CA 95828
(916) 387 2107
FAX (800) 795 8349

Spectrum Naturals, Inc
(specializes in organic products)
133 Copeland Street
Petaluma, CA 95476
(707) 778 8900
FAX (707) 765 1026

COSTS AND BENEFITS OF CANNING AND BOTTLING SPECIALTY PRODUCTS

Costs:
fresh produce
materials
containers, labels
equipment
power for processing
labor

Benefits:
longer shelf life
added value
reduced postharvest losses

Example 1: Preparation, packaging and marketing of a low sugar kiwi-strawberry jam. Approximately $100 worth of fresh produce grown in California is processed to yield $1350 of processed product.

Costs:

equipment (pots, ladles, cooling rack)	$50
kiwifruit (100 lbs, trimmed, peeled)	$50
strawberries (100 lbs of very ripe berries)	$50
bottles and lids(300 each)	$150
labels-- custom printed (300)	$75
sugar (50 lbs)	$5
pectin (5 lbs)	$10
feul for cooking	$5
total costs	$395

Benefits:
Market value

300 (10 oz) jars of specialty jam @ $4.50 /jar	$1350

Example 2: Preparation, packaging and marketing of mango pickle. Approximately Rs 500 worth of fresh produce is processed to yield Rs 6000 of processed product.

Costs:	
equipment (drying trays, stone jar)	Rs500
labor (1 day @ Rs 80/day)	Rs 80
mangoes (100 kgs, trimmed, peeled)	Rs 500
salt	Rs 100
spices and mustard oil	Rs1000
bottles and lids(400 @ Rs3)	Rs1200
labels-- custom printed (400 @ Rs0.10)	Rs 40
total costs	Rs 3420

Benefits:	
Market value	
400 (0.5 kg) jars of specialty pickles @ Rs 30/kg	Rs 6000

SOURCES OF PROCESSING AND CANNING/BOTTLING EQUIPMENT AND SUPPLIES

bottle capper	Countryside General Store
bottling equipment	Orchard Equipment and Supply Co.
can sealer	Countryside General Store
cider jugs, plastic	Rockford Package Supply Co.
hand-press	Michigan Orchard Supply Orchard Equipment and Supply Co. Garden Way Country Kitchen
juice presses /non-citrus	Goodnature Products, Inc Michigan Orchard Supply Orchard Equipment and Supply Co.

REFERENCES

Alejandro, R. no date. *Specialty Food Packaging Design.* Glen Cove, NY: PBC International.

Ball Corporation. 1995. *The Ball Blue Book: Guide to home canning, freezing and dehydration.* Muncie, Indiana: Alltrista Corp.

Chioffi, N. and Mead, G. 1991. *Keeping the Harvest: Preserving your fruits, vegetables and herbs.* Pownal VT: Storey Communications Inc.

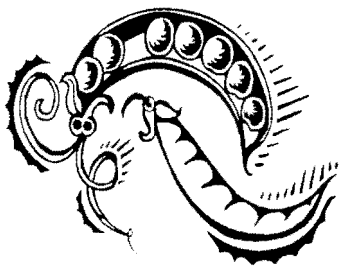
Georgia Cooperative Extension Service. 1984. *So Easy to Preserve.* University of Georgia, Athens, Georgia.

Hall, S.F. 1996. *From Kitchen to Market: Selling your Gourmet Food Specialty* (2nd edition). Chicago: Upstart Publishing Co.

Singh, R. 1998. *Fruits: India—the Land and the People.* New Delhi: National Book Trust, India.

Stoner, C.H. (Ed). 1977. *Stocking Up.* Emmaus, Penn: Rodale Press.

CHAPTER 15



FOOD SAFETY DURING PROCESSING

Consumers expect that food processors will manufacture wholesome and nutritious foods. To do this, food processors must have systems in place to assure that products which are being manufactured do not have physical, chemical or microbial contaminants introduced during processing and packaging. Common some sources of potential contamination include animal waste fertilizers, contaminated irrigation water, human handling practices, contaminated containers, inadequate postharvest washing, improper packaging, poor temperature management and contamination in the food preparation area.

If food safety systems are not in place during processing, hundreds if not thousands of consumers are at risk. A single incident of personal injury traced back to a specific food processor may put that company out business and result in criminal prosecution of the owners and management. Systems which assure the safety and wholesomeness during food processing fall into three categories 1) Good Manufacturing Practices (GMP's), 2) Sanitation Procedures and 3) Hazard Analysis Critical Control Points (HACCP). These systems will be discussed in detail and may be applied to fresh-cut processing, or traditional processing operations. Assuring that food products are manufactured in a safe and wholesome manner does add cost to the final product. However, your long term success as a food processor depends on your ability to consistently produce safe products. Food safety should not be confused with food quality. Food safety programs simply

assure that food products are safe to consume and prevent injury to consumers. This chapter will cover food safety issues during processing. Food safety begins during production, so the production and postharvest handling of raw ingredients should be carefully monitored (see Chapter 10).

GENERAL DO'S AND DONT'S TO ASSURE FOOD SAFETY DURING PROCESSING

Follow state regulations regarding the type of licenced facility you may use for food processing (for example, no home or farm kitchens).

Educate and train employee's in proper food handling practices and personal hygiene.

Strictly adhere to Good Manufacturing Practices (GMP's).

Design food processing and storage areas to allow for easy cleaning and sanitation.

Monitor raw material suppliers for adherence to Good Agricultural Practices.

Keep processing facility grounds clean and free from clutter.

Processing facilities should be completely enclosed from the outside environment by walls.

Windows or other glass should not be present in the food processing area.

Processing facility floors, walls and ceilings must be cleanable and in good repair.

Adequate lighting should be present and be protected in case of breakage.

Pipes, ducts and fixtures should not be suspended over processing areas.

Use only potable (safe to drink) water.

Monitor water quality regularly.

Plumbing should be of adequate size and design for sanitary food processing (floor drains, separate sanitary sewers, etc.).

Dos and Don'ts continued:

Adequate numbers of toilets and hand wash stations should be provided for employees.

Toilets facilities should be segregated from the processing area.

Written sanitation schedules and procedures should be established and monitored on a regular basis.

Cleaning and toxic chemicals should be stored in a secured locked area.

Effective rodent and insect control programs should be in place and monitored.

GOOD MANUFACTURING PRACTICES (GMP's)

GMP's are guidelines to assure that food for human consumption is safe and has been prepared, packed and held under sanitary conditions. These guidelines deal with personnel involved in food processing, physical plant and grounds as well as facility construction and design.

Personnel GMP's: Personnel working in food processing can be a significant source of food contamination. This includes production employees, maintenance employees, supervisors and management. It is the responsibility of processing faciltiy management to educate and train all food handlers about sanitary handling of food. Employees experiencing diarrhea, vomiting, open skin sores, boils, fever, or disease must report these symptoms to their supervisor and must NOT be allowed to work with edible food products. All food handlers should have clean outer garments or aprons and thoroughly wash their hands before entering a food processing area, especially after using toilets. No jewelry (earrings, pendants, rings etc.) or wrist watches are allowed in the food processing areas as these items may fall into food products unnoticed. Clean, intact gloves as well hair restraints should be used by all personnel in the food processing area.

Physical Plant and Grounds: Food processing facilities should be constructed to segregate food processing activities from the outside environment. The physical building itself should have no gaps which could allow infestation by rodents, insects or birds. Surrounding grounds should be

free of clutter such as equipment, litter, waste, refuse or animal feces. No unpaved or dusty roads should be adjacent to the processing facility and surrounding areas should be adequately drained so that no standing or pooled water is present. Vegetation surrounding the processing plant should be keep down to prevent the formation of breeding grounds for rodents. Rodent traps should be placed on the outside perimeter of the grounds and be inspected and serviced regularly.

Construction and Design : The most important aspect of food processing design is sufficient space for sanitary operation. Processing areas should be designed for easy cleaning and sanitation. Floors, walls and ceilings should be made of a cleanable, noncorrosive, non-absorbent material and be in good repair. Floors should have a rounded corner joints where they meet the wall so as to allow for easy cleaning. Processing facility floors should be constructed of sealed concrete or tile to withstand physical and chemical abuses from machinery and cleaning chemicals. Equipment should be constructed of stainless steel to prevent corrosion. Overhead pipes, ducts and fixtures should not be suspended over work areas and horizontal surfaces of these items should be minimized to reduce the accumulation of dust and water condensation. Adequate lighting should be provided and all light bulbs should be protected to insure that broken glass cannot contaminate food products. All water (rinse, flume, cleaning, ice, etc.) used in food processing must be potable. Plumbing should be of adequate size and design to handle the amount of product being processed. Food processing environments are usually wet, therefore sloping floors with drains should be present of remove excess water from the processing area. Sanitary sewer lines should be separate from floor drains to assure that cross contamination of the processing area from sewage back flow does not occur. An adequate number of toilets and hand washing stations should be available to accommodate all employees. Rest room facilities should not open into processing areas. The restroom is the only room in the processing facility that should have negative air pressure, and it should be exhausted continually from the restrooms. Hot running potable water, soap and hand towels should be available at all times. Signs should be posted to instruct employees to wash their hands after using the restroom. Employee aprons, gloves and knives should never be taken into the restroom and adequate storage space should be available for temporary storage of these items directly outside the restroom door. Heating, ventilation and air conditioning systems (HVAC) should feature filtered

positive air pressure in processing plants because of the potential airborne pathogen contamination. HVAC units should blow air along the ceiling and down the walls to keep them dry and free of condensation.

SANITATION PROCEDURES

Cleaning and sanitation are some of the most important programs in any food processing plant. Regular and scheduled equipment cleaning and sanitizing assures that food products are being processed under hygienic conditions. Adequate time must be given to the sanitation crew to allow for a thorough job. Cleaning and sanitation is best done by a specially trained sanitation and cleaning crew NOT by production personnel. A sanitation program in a food processing plant consists of two elements:

A Master Sanitation Schedule

Monitoring Program

Master Sanitation Schedule: A written master sanitation schedule should be in place to assure that all areas of a food processing facility a.e cleaned on a regular basis. The master sanitation schedule should detail the area to be cleaned, the sanitation method, tool, cleaning materials and frequency of cleaning. An example of a portion of a master sanitation schedule is shown below.

Area	*Sanitation Method*	*Tool*	*Cleaning Materials*	*Frequency*
Walls	Foam, Brush, Rinse	Soft Nylon Brush	Chlorine-quat based cleaner	Once / Month
Floor	Wash, Rinse	Hard Bristle Broom, Hose	Chlorine-quat based cleaner	Daily

Cleaning and sanitizing involves five basic steps:

Physical Debris Removal

Rinse

Detergent / Mild Abrasion

Post Rinse

Sanitizing

It is critical that cleaning (i.e. the removal of debris and food particles) is done prior to any sanitation steps, since many sanitizers are inactivated by organic materials. Once large pieces of food are removed, equipment should be rinsed with potable water to remove smaller particles. Then soaps and detergents should be applied. Mild abrasion should be used to scrub equipment clean and remove caked on food particles as well as biofilms (layers of bacteria). It is recommended that warm water (NOT steam) be used for cleaning, since steam may actually promote the formation of biofilms. All soaps and detergents used should be approved for use on food contact surfaces. After cleaning soaps and detergents should be removed by rinsing equipment with potable water. After rinsing equipment should be sanitized to kill microbes which reduce product shelf-life and may cause food borne illness. Sanitizing consists of rinsing all food contact surfaces with bactericidal compounds such as chlorine, iodine or quaternary ammonia followed by a potable water rinse. Sanitizer and cleaning chemical manufacturer product directions should be strictly followed.

Specific pieces of equipment which are cleaned on a regular basis should have written standard operating procedures (SOP's) for cleaning and sanitation. This assures that equipment is cleaned properly regardless of who does the job.

SOP's identify the following:

- What: Identifies task
- Why: Purpose of task
- Who: Responsible Person
- How: Steps for completing the task

Cleaners and Sanitizers: There are numerous cleaning and sanitizing compounds available for use in food processing plants. These compounds fall into 5 categories:

Chelators: Tie up cations or salts (e.g., EDTA)

Alkalines: Detergents (e.g., Soaps and Sodium Hydroxide)

Acids: Remove Mineral Deposits (e.g., Phosphoric Acid)

Wetting Agents: Emulsify and Penetrate Soil (e.g., Alkyl Sulfates)

Sanitizers: Kill Microbes (e.g., Sodium Hypochlorite)

Sanitizers are important to reduce microbial populations on all food contact surfaces after cleaning. The most common sanitizers are chlorine, iodine and quaternary ammonia compounds. Each of these compound classes have advantages and disadvantages to their use. It is advisable to rotate or not use any one sanitizer for long periods of time since bacteria can become resistant to chemical sanitizers. Also some sanitizers such as quaternary ammonia compounds are more effective against certain food borne pathogens such as *Listeria monocytogenes*. Listed below are some of the advantages and disadvantages of using each sanitizer;

Chlorine Compounds: Low Cost, Good Germicide, Corrosive to Equipment, Irritating aroma

Iodine Compounds: Heat Stable, Non Irritating, Non Corrosive, Stains equipment

Quaternary Ammonia Compounds: Non Corrosive, Heat Stable, Expensive

Chlorine by far is the most commonly used sanitizer. Liquid household bleach may be used as a source of chlorine as it typically contains 5.25% by volume sodium hypochlorite. Chlorine is used as a sanitizer at concentrations of between 100 and 200 parts per million. It is important that the water containing chlorine be free from organic matter and have a pH between 6.0 and 7.0. If either of these conditions are not meet then the chlorine is ineffective as a sanitizer.

MONITORING

The processing facility should be evaluated on a daily basis to assure that conditions are hygienic before processing begins. Visual inspection should assure that no food particles or foreign matter are present on processing equipment. In particular, hard to clean spots should be inspected such as the underside of conveyors and peeling equipment. Unfortunately, visual inspection is not enough to assure that equipment has been sanitized properly. The number of microbes present on processing equipment after sanitation operations should be determined on a

regular basis to evaluate sanitation crew performance via the one of the following methods.

Petri Contact Plates

Surface Swabbing

Biolumenesce

Petri Contact Plates

Plastic petri plates or films contain sterile agar with growth media for microbes. The type of microbes that will grow on these plates is determined by the type of media used. In this method numerous petri plates or films are take to the processing area and pressed up against a food contact surface and this information is noted. The plates are then placed at room temperature in the laboratory and if microbes where present they will grow on the petri films or plates. After a day or two the microbes on each plate can be counted. The number of microbes present should be noted and charted for comparison over time. A low bacteria count per square centimeter means that the sanitation crew is doing a good job at cleaning and sanitizing. If the number microbes dramatically increases an evaluation of sanitation procedures is in order.

Surface Swabbing

A variation of the petri plate method is to use sterile swabs in water to collect samples of food contact surfaces. Wet sterile swabs are used to brush an area of a food contact surface. The swab is then placed back in the sterile water container. Bacteria are washed off into the sterile water and this water is then plated on to petri plates of films and counted after incubation as above.

Both of these methods are fairly simple, sterilizing (20 min at 250 °C) agar, swabs water and media may be done in a pressure cooker. Petri films from 3M corporation offer convenience of not having to prepare media or petri plates. Water may be rendered sterile by boiling it vigorously for 20 min and allowing it to cool in a container sealed with aluminum foil. Processing plants are never completely sterile even after the best sanitation efforts. Below are listed microbial counts on food processing equipment which can routinely be achieved by a good sanitation program in a food processing plant.

Microbial Counts After Effective Sanitation:		
Total Plate Count	<	200 cfu / 25 cm^2
Yeast and Molds	<	50 cfu / 25 cm^2
Coliforms	<	10 cfu / 25 cm^2

Bioluminescence

Both the contact petri plate or swab methods are good for monitoring sanitation crew performance but results are not available immediately. Another microbe detection method called bioluminescence is capable of detecting the presence of microbes immediately. This method relies on measuring the amount ATP that is present on food contact surfaces as it is a good indicator of the number of microbes present. This test is similar to the swab testing method except that the cleanliness of equipment is determined within minutes after the swab is taken. In this test, equipment is swabbed with a sterile swab and then the amount of ATP present is determined by a chemical test kit. These test kits are available from a number of suppliers that are listed below. Bioluminescence is slightly more expensive than other methods but because test results are immediate it provides a new level of security since it can determine immediately if cleaning and sanitation procedures must be repeated before processing begins.

Microbiological Test Suppliers

3M Microbiological Products 3M Center Building 275-5W-05 St Paul, MN 55144-1000 USA Tel: 612-733-9558	Rapid Micro Testing Films
IDEXX One Idexx Drive Westbrook ME 04092-2040 USA Tel: 207-856-0496	Microbiology Media and Bioluminescence Testing Systems

Biotrace Inc. 666 Plainsboro Rd Suite 1116 Plainsboro, NJ 08356 USA Tel: 609-897-0282	Bioluminescence Testing Systems
GEM Biomedical Inc. 925 Sherman Ave Hamden, CT 06514 USA Tel: 203-248-4008	Bioluminescence Testing Systems
HACH Company P.O. Box 608 Loveland, CO 80539 Tel: (970) 669 3050 FAX (970) 669 2932	Quick reference guide, MEL portable labs presence/absence testing.

HACCP

The seven HACCP principles outlined in chapter 10 should also be applied for processing of produce. The prevention of physical, chemical and microbial contamination of produce during processing is essential to assuring the production of a safe product. A HACCP program is only effective if sanitation and good manufacturing processes are implemented and verified. It is recommended that each food processor identify one person in their operation to have formal HACCP training and be in charge of a team that is responsible for implementing the HACCP program. HACCP programs should be a simple as possible, without an excessive number of critical control points. Each HACCP program is unique and must be tailored to your specific operations needs. A model for dried apples has been provided as an example of a HACCP program which can be used as a starting point for you to develop a HACCP program for your food processing operation.

Model HACCP Plan for Dried Apple Slices

Description: Apple slices packed in food grade plastic bags, 200 g to 1 kg units; with an optimal shelf-life of 6 months; product is distributed to foodservice and retail markets. Bag and/or box contains a "processed on" or "use by" date to be used in case of product recall or lot traceability.

Ingredients: Apple

Potential Microbiological Hazards to be Monitored:

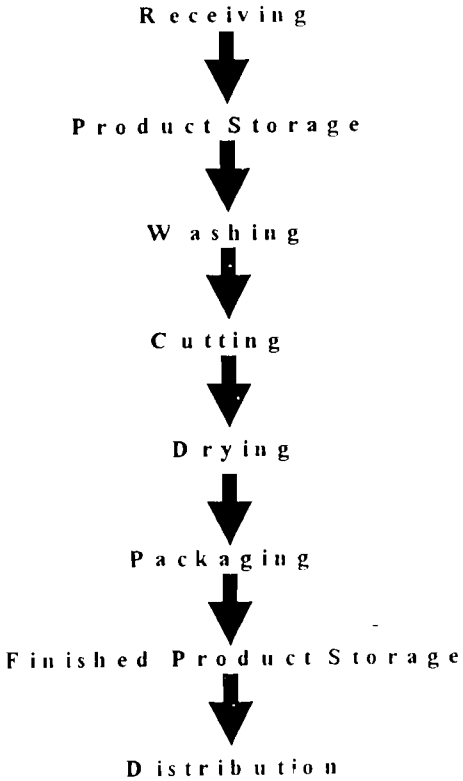
Potential Human Pathogens: Pathogenic *E. coli*, *Salmonella*, *Shigella*, and foodborne viruses.

Sanitation Monitoring Organisms:

E. coli, aerobic plate count

Critical Control Points:

7 CCPs were identified, critical limits established, monitoring methods established and corrective action identified (see table on the next page).



Flow Diagram for a fruit or vegetable drying operation.

Model HACCP Plan for Dried Apple Slices:

Flow Process	Hazard Catagory	Critical Control Point	Critical Limit	Monitoring	Frequency	Corrective Action	Record Keeping	Verification
Raw Product Storage	Microbial	#1 - Room Temperature	0 to 5°C	Thermometer or continuous strip chart	Hourly	Inform maintenance Repair equipment Evaluate product Reject/Release	Temperature record Thermometer calibration record	Random sampling QA audit
Washing	Microbial	#2 - Chlorination water pH	Free Chlorine 2 to 7 ppm free residual after contact Total chlorine maximum of 100 to 150 ppm pH = 6.0 to 7.0	Test Kit or continuous strip chart	Three times per shift	Manually adjust water chemistry Repair system Hold product from last correct reading. Rewash product	Chlorine/pH records	Random sampling QA audit Microbe counts
Cutting	Physical	#3 - Employee Handling and visual inspection	No foreign objects	Visual	Continuous	Remove foreign object	Incident Foreign Object Report	Random sampling QA audit
Drying	Microbial	#4 - Water content of finished product	Product water activity is low enough to prevent bacteria growth	Determine product water activity	Once per hour	Dry product	Water activity records	Random sampling QA audit
	Microbial	#5 - Dryer tray cleanliness	Trays are clean and functional	Visual	Each time product is loaded	Repair system Discard product	Inspection Record	
Packaging	Chemical	#6 - Food Contact Packaging	Food Grade	Certification letter	Annually or with new product	Resolve the problem or withdraw supplier certification	Certification Letter	Random sampling QA audit
	Physical	#7 - Metal Detector	No metal	Calibrate machine with metal sample	Hourly	Inform maintenance Repair equipment Hold product from last correct reading Rerun product	Metal detector record	

REFERENCES

Brackett, R.E. 1992. Shelf stability and safety of fresh produce as influenced by sanitation and inspection. *Journal of Food Protection* 55:808-814.

Brackett, R.E. 1993. Microbial quality. In: R.L. Shewfelt and S.E. Prussia (eds) *Postharvest Handling: A Systems Approach.* New York: Academic Press.

International Fresh-cut Produce Association. *Food Safety Guidelines for the Fresh-cut Produce Industry* (3rd Edition). Alexandria, VA: IFPA.

Nguyen-the, C. and F. Carlin. 1994. The microbiology of minimally processed fresh fruits and vegetables. *Critical Reviews in Food Science and Nutrition* 34(4) 371-401.

WORKSHEETS

PART II: COSTS AND BENEFITS of SMALL-SCALE PROCESSING

Comparison of estimated costs and expected benefits related to adopting postharvest technology for small-scale processing and marketing.

If you need more facts to fill out any worksheet, it is recommended that you select one specific commodity that you produce, and actually use the new processing practice on one row of vegetables or on a small group of trees for one season or any suitable period of time. During this time collect information on yields, losses, grades of produce harvested, costs of labor, materials and equipment for handling and processing, and power requirements or fuel costs for the new processing operation in comparison to your current practice. Some of your expenses will not be affected at all, while others will be added or no longer be necessary when you change practices.

INSTRUCTIONS

Make copies of these blank worksheets and use a complete set for each commodity you process and market. If you want to compare various postharvest technologies you may need to use several copies of the worksheets for each commodity.

Overhead costs should be reported by month, by season or by year, depending upon how you generally allocate costs of operation. The idea is to be able to determine how much of your overhead costs can be assigned to the commodity of interest. For example, if you produce, handle and process only one commodity, it will take on 100% of your overhead. If you process and market equal amounts of 3 commodities, each can be assigned 1/3 of the total overhead.

Most of the costs for the topics listed in Worksheet 6 will have several components including capital costs (equipment or facilities), and recurring costs (supplies, labor and purchased power or fuel for running equipment). If you purchase produce for processing from other growers, use the actual cost of produce , plus any costs associated with handling, processing, packaging and marketing processed product (from Worksheet 6) when completing Worksheet 8.

Worksheet 5: Collect some basic information

Commodity _____
Variety _____

1. Overhead Costs:

Salaries (managers, office staff, etc.)	Rs_____
Office expenses and supplies	Rs_____
Maintenance, parts and repairs	Rs_____
Utilities (gas, electric)	Rs_____
Communications (Telephone, FAX, e-mail)	Rs_____
Rent	Rs_____
Other	Rs_____
Total =	Rs_____

Overhead costs affiliated with this commodity
(base on percent of your total processed product)

_____% Rs_____*

2. General information related to each practice:

Base upon previous experience with the commodity, your CSAM results (see Appendix A) or estimates provided by other producers/shippers, buyers, published literature on postharvest technology, cost/benefit examples provided in each chapter of this workbook or information available from your local Extension Service. Many recommended PHTs will reduce losses by minimizing decay, mechanical damage, and weight loss during fresh handling, and optimizing product quality during processing.

Current Practice (describe)_____

New Practice (describe)_____

	Current practice	New practice
Expected yields	_____kg	_____kg
Estimated physical losses		
amount of culls during pre-sorting	_____%	_____%
losses due to pests	_____%	_____%
losses due to mechanical damage	_____%	_____%
weight loss during handling/storage	_____%	_____%
Sum of losses	_____kg	_____kg
Expected grades		
highest	_____kg	_____kg
second	_____kg	_____kg
lowest	_____kg	_____kg

How much fresh produce will you have available for processing?
(lowest grade is usually not acceptable quality for processing)

(Expected yields - Estimated sum of losses)	_____kg	_____kg
How much processed product will you have to sell?	_____units	_____units

3. Market Prices (obtain from your buyers or past history): Units may be by weight (lbs, kgs, etc.), by volume (pints, quarts, liters, etc.) or both.

Expected prices per unit (wholesale)

highest category Rs / (unit?)

second category_____ Rs_____/ _____

Expected prices per unit (retail)

highest category_____ Rs_____/ _____

second category_____ Rs_____/ _____

Worksheet 2: Comparison of Direct Costs

Does one practice cost more than the other for production, preparation for processing, postharvest handling (temporary storage or transport), materials, power, equipment for processing, marketing, etc.? Calculations should be based on expected yield, postharvest and processing losses, hourly labor costs, and expected volumes to be handled. Specific details for recommended practices are included in the examples found at the end of each chapter of the book, with those costs that are expected to change listed individually under each category. If you find there are additional costs associated with your operation, please add these to the list.

Current Practice _____

New Practice _____

	Current practice	New practice
Pre-Harvest		
seeds or planting materials	Rs_____	Rs_____
land preparation/planting	Rs_____	Rs_____
cultivation (pruning, thinning, mulching, etc)	Rs_____	Rs_____
preharvest treatments (pesticides, etc.)	Rs_____	Rs_____
irrigation	Rs_____	Rs_____

	Current practice	New practice
fertilization	Rs_____	Rs_____
other_____	Rs_____	Rs_____
Harvest and Market Preparation		
labor and equipment for harvesting	Rs_____	Rs_____
other_____	Rs_____	Rs_____
cost of any purchased produce	Rs_____	Rs_____
Packinghouse Operations		
pre-sorting	Rs_____	Rs_____
washing/cleaning	Rs_____	Rs_____
sizing/grading	Rs_____	Rs_____
sanitation	Rs_____	Rs_____
bulk packing	Rs_____	Rs_____
other_____	Rs_____	Rs_____
Temperature/RH Management		
pre-cooling	Rs_____	Rs_____
cooling	Rs_____	Rs_____
storage	Rs_____	Rs_____
other_____	Rs_____	Rs_____
Transportation		
vehicles	Rs_____	Rs_____
fuel	Rs_____	Rs_____
cooling	Rs_____	Rs_____
other_____	Rs_____	Rs_____

	Current practice	New practice
Processing		
ripening	Rs_____	Rs_____
sorting/grading	Rs_____	Rs_____
pre-treatments	Rs_____	Rs_____
processing equipment	Rs_____	Rs_____
materials/supplies for processing	Rs_____	Rs_____
labor	Rs_____	Rs_____
fuel/power costs	Rs_____	Rs_____
packaging	Rs_____	Rs_____
other_____	Rs_____	Rs_____
Other Costs		
marketing (fees, sales labor)	Rs_____	Rs_____
display	Rs_____	Rs_____
promotional activities	Rs_____	Rs_____
food safety program	Rs_____	Rs_____
other_____	Rs_____	Rs_____
Total Direct Costs	Rs_____	Rs_____
*Overhead Costs for this commodity	Rs_____	Rs_____
Total Costs	Rs_____	Rs_____
Total costs per unit of product for sale	Rs_____	Rs_____

Worksheet 7: Comparison of Benefits

Base upon expected yields and quality, amount of product available for sale in various prices categories, and expected prices per unit collected in Worksheet 5. (units of product at each price x price/unit = expected sales at each price category). Do the calculations for either wholesale or retail prices or a combination if you will sell both ways.

Current Practice _____

New Practice _____

	Current practice	New practice
1. Expected sales (wholesale)		
highest category	Rs_____	Rs_____
second category	Rs	Rs
Subtotal Sales (wholesale)	Rs	Rs_____
2. Expected sales (retail)		
highest category	Rs_____	Rs_____
second category	Rs	Rs_____
Subtotal Sales (retail)	Rs	Rs_____
3. Total Expected Sales	Rs	Rs

4. Comparative Advantage
(Total Expected Sales - Total Costs = Comparative Advantage)
refer to the total costs calculated for each practice in Worksheet 6

Current practice Rs_____ **- Rs**_____ **= Rs**_____ (a)

New practice Rs_____ **- Rs**_____ **= Rs**_____ (b)

	Current practice	New practice
Which practice is most profitable, and can provide the best economic opportunity?	Rs_____ (a)	Rs_____ (b)

Worksheet 8: Recovery of Invested Capital (ROIC)

If the new processing technology costs more than your current practice, how long will it take to pay for your investment in the new practice? An excellent return on investment would be a recovery time of less than one month, while a slower return may require an entire season (3 to 5 months). Any longer recovery period usually would not be considered a good return on investment.

Current Practice _____

New Practice _____

1. Difference in total direct costs for new practice = Rs_____
(Actual capital outlay for new equipment and facilities, plus power costs, supplies and labor requirements when compared to costs for the current practice over the entire season: see Worksheet 6). If you purchase produce for processing, use your actual cost plus any handling, processing, packaging and marketing costs.

2. Interest rate (if capital is borrowed) = _____% per annum; or _____% per month
Cost of capital at three months = Rs _____
Cost of capital at six months = Rs _____

3. Difference in sales using the new practice = Rs_____per month
(Subtract total expected sales using the current practice from total expected sales using the new practice: see Worksheet 7; divide the difference by number of months of sales)

4. Calculate ROIC in months to recover invested capital:

(**Difference in total direct costs** + any interest paid)
_____ = Months to pay for investment.

Difference in Sales per month

(Rs_____ + Rs_____)
_____ = _____ Months
Rs _____ per month